7. FORECASTING CHINESE BUSINESS CYCLE USING LONG-TERM INTEREST RATE COMOVEMENTS

Kiryoung LEE[1]
Chanik JO[2]

Abstract

This paper analyses the relationship between time-varying long-term interest rate comovement and the Chinese business cycle. For this purpose, we estimate the dynamic conditional correlation (DCC) between China and 10 of China's neighboring countries and the U.S. long-term interest rate and construct the comovement measures. The empirical results show the first evidence that long-term interest rate comovement indeed has predictive power for future Chinese business cycle for both in-sample and out-of-sample. This result implies the growing importance of the regional factor along with the global factor. Most importantly, our result provides practitioners and academia a novel indicator which is able to predict the future Chinese business cycle beyond the traditional business cycle forecasters – term spread, excess stock returns, leading indicator, Production Manufacturing Index, and U.S. interest rate.

Keywords: dynamic conditional correlations, recession, integrated markets, forecasting accuracy, regional factor, global factor

JEL Classification: F3, F10, F37, F44

1. Introduction

After the 2008 Global Financial Crisis, many central banks, including the U.S. Federal Reserve, the European Central Bank, and Bank of Japan lowered interest rates and started their own bond purchase programs in response to the economic downturn. China followed suit when its Chinese central bank cut its benchmark lending interest rate to stimulate flagging growth. This synchronized policy and integrated market created strong comovements of interest rates in different countries. Fig. 1 highlights an example in a plot of data for 10-year U.S. and Chinese government bond yields. Notably, the two interest rates

[1] *Sejong University, 209 Neungdong-ro, Gunja-dong, Gwangjin-gu, Seoul, Republic of Korea. Email: liqiring@hotmail.com.*

[2] *Rotman School of Management, Ph.D. candidate, University of Toronto, 105 St. George Street, M5S 2E8, Toronto, Canada, E-mail: chanik.jo15@rotman.utoronto.ca.*

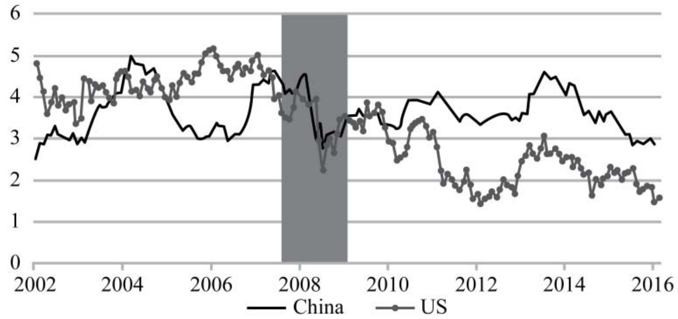
exhibit comovements during the Global Financial Crisis, and continue to vary together afterwards.

It is well known that long-term interest rates change over time in accordance with the business cycle. This is because the long-term interest rates reflect future inflation expectation, real interest rates expectation, and term premia, which crucially depend on the business condition. Furthermore, since there is a common global factor that drives macro aggregates in most countries at the same time (Kose, Otrok and Whiteman, 2003), interest rate fluctuations across countries are correlated. While there are many studies on the unconditional interest rate comovement, there is not much research on the conditional interest rate comovement. In light of this, this paper studies the conditional interest rate comovement, mainly addressing the following three research questions: (1) does the long-term interest rate comovement vary along with the business cycle?; Time-varying interest comovement reflects time-varying business cycle synchronization, which is typically more pronounced in bad economic states because macro shocks are contagious (Antonakakis and Scharler, 2012). Thus, it is natural to ask (2) whether long-term interest rates are more correlated in bad states; finally, given forward looking nature of the interest rates, it is particular of interest to ask (3) whether the comovement even predicts the business cycle.

We pay particular attention to China and its neighbouring countries due to the growing importance of regional factors along with the global factor in the business cycle (Song and Tan, 2011; Hirata, Kose and Otrok, 2013; Park, 2013; Dai, 2014). Given China's massive influence on the neighbouring countries (Das, 2007; Berdiev and Chang 2013; Bhanupong, 2015), looking into the long-term interest comovement of China with neighbouring countries can offer a unique opportunity to address our research questions.

Figure 1

Ten-year Government Bond Yields of China and the U.S. (%)



Source. Datastream.

This paper significantly contributes to the literature in three important ways. First, this paper is the first to show evidence that China's long-term interest rate comovement with neighbouring countries is strongly related to the China's future business cycle. Second, our empirical results show that its time-variation is counter-cyclical, suggesting that long-term interest rate becomes more synchronized during the economic downturns than expansion periods. Most importantly, the extent to which long-term interest rates are synchronized is able to predict future Chinese business cycle for both in-sample and out-of-sample. This result is remarkably robust to control for the conventional economic forecasters – term spread, stock returns, Production Manufacturing Index, and even U.S. interest rate. This is especially important because the long-term interest rate comovement can be considered a novel forecasting indicator to predict Chinese economy, which substantially and increasingly affects the global economy.

The remaining sections are organized as follows. Section 2 reviews the literature, Second 3 describes the econometric methodology. Section 4 discusses the data. Section 5 presents the empirical results, and the last section concludes.

2. Literature Review

Many studies document that an interest rate varies in response to the macroeconomics shocks including the policy shocks (Kuttner, 2001; Ang and Piazzesi, 2003; Dai and Philippon, 2005; Evans and Marshall, 2007). This is because short-term interest rates reflect monetary policy as central banks react to the changing economic condition. Also, future interest rate expectation moves in the same direction as the short-rate. In addition to this, Kose, Otrok and Whiteman (2003) find that there is a global factor strongly driving the macroeconomic condition in most countries at the same time. Combined with the stylized fact that interest rates move as a function of macro shock, a common global shock can drive interest rates across countries at the same time. Indeed, Borio and Filardo (2007) find that the role of global factors on the inflation has been growing over time since the 1990s. Similarly, Henriksen, Kydland, and Sustek (2013) discuss the importance of synchronized business cycle on nominal interest rate correlation across countries. Consistent with this, Kim (2001) and Canova (2005) show that U.S. monetary shock can be transmitted to other countries through the interest rate. Therefore, it is reasonable that interest rates across countries are correlated.

Bremnes, Gjerde and Sattem (2001) find that both German and Norwegian interest rates vary in response to the U.S. interest rates. Engsted and Tanggaard (2007) also document the comovement of the U.S. and German bond markets and also it is the news about future inflation that mainly drives the comovement. Moon and Perron (2007) examine interest rate co-movement across different maturities in Canada and the U.S. The literature is more extended by research which examines the comovement of short-term and long-term interest rate separately. In particular, many studies find the higher long-term interest rate correlations between a country and the U.S. compared to short-term interest rate correlations (Kulish and Rees, 2011; Wright, 2011; Byrne, Fazio, and Fiess, 2012; Dahlquist and Hasseltoft, 2013; Swanson and Williams, 2014). This is because global macroeconomic factors affect interest rate comovement, not only via policy channel but also via risk compensation which occurs only in the long maturity yield (Chin, Filippeli and Theodoridis, 2015; Jotikasthira, Le and Lundblad, 2015).

Although many studies focus on the unconditional interest rate correlation, there is few research on the conditional interest rate correlation. Lee, Jo, and Kim (2016) is among the few papers examining time-varying interest rate comovement. They find that the conditional correlations between the U.S. and individual countries' long-term interest rates contain information about recessions in individual countries. Although their research is the closest to ours, our paper differs from this paper in the following aspects. First, while they study the correlation between the U.S. and individual countries' in light of the global factor, we study the correlation between the China and its neighbouring countries, motivated by the growing importance of regional factor (Song and Tan, 2011; Hirata, Kose and Otrok, 2013; Park, 2013; Dai, 2014). Second, they test whether a correlation between the influential country and affected countries can predict the recession of affected countries, whereas we study whether the correlation can predict the recession of the influential country. Finally, while Lee, Jo, and Kim (2016) consider only recession, we consider real GDP growth, the Consumer Confidence Index (CCI) along with recession.

3. Econometric Method

3.1. Dynamic Conditional Correlation

Engle's (2002) DCC model is a relatively new dynamic specification based on the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) approach that allows researchers to simultaneously model the variances and conditional correlations of several series. We employ the DCC-GARCH model because of its statistical and computational advantages. The DCC model estimation has two steps. First, we estimate each conditional variance as a univariate GARCH process. Second, we use the standardized regression residuals in the first step to construct the conditional correlation matrix. Specifically, the DCC model is defined as follows.

$$y_{i,t} = \mu_{i,t} + \varepsilon_{i,t}, \text{ where } \varepsilon_{i,t}|\mathcal{F}_t \sim N(0, H_{i,t}) \quad (1)$$

$$\varepsilon_{i,t} = H_{i,t}{}^{1/2} u_{i,t} \text{ where } u_{i,t} \sim N(0, I) \quad (2)$$

$$H_{i,t} = D_{i,t}\rho_{i,t}D_{i,t} \quad (3)$$

where: $\boldsymbol{y_{i,t}} = (\boldsymbol{y_{Chn,t}}, \boldsymbol{y_{i,t}})' \ \forall \boldsymbol{i} = \boldsymbol{HKG}, \cdots, \boldsymbol{USA}$ denotes the matrix of change in the long-term interest rate and $\boldsymbol{\mu_{i,t}} = (\boldsymbol{\mu_{Chn,t}}, \boldsymbol{\mu_{i,t}})'$ is the conditional mean vector of $\boldsymbol{y_{i,t}}$. $\boldsymbol{\varepsilon_{i,t}}$ is the vector of residuals based on the information set $\mathcal{F}_{t-1}$ available at time $\boldsymbol{t-1}$. The residuals are normally distributed with zero mean and conditional covariance $\boldsymbol{H_{i,t}} = (\boldsymbol{h_{Chn,i,t}})$. $\boldsymbol{I}$ is the identity matrix, $\boldsymbol{D_{i,t}} = \boldsymbol{diag}\left(\boldsymbol{h_{Chn,Chn,t}}^{\frac{1}{2}}, \boldsymbol{h_{i,i,t}}^{\frac{1}{2}}\right)'$ is a diagonal matrix of square root conditional variances, and $\boldsymbol{\rho_{i,t}}$ is the time-varying long-term interest rate conditional correlation between country *i* and China, defined as

$$\rho_{i,t} = diag\left(q_{Chn,Chn,t}{}^{-\frac{1}{2}}, q_{i,i,t}{}^{-\frac{1}{2}}\right) Q_{i,t} diag\left(q_{Chn,Chn,t}{}^{-\frac{1}{2}}, q_{i,i,t}{}^{-\frac{1}{2}}\right) \quad (4)$$

where: $\boldsymbol{Q_{i,t}} = (\boldsymbol{q_{Chn,i,t}})$ is a symmetric and positive definite matrix:

$$Q_{i,t} = (1-\alpha-\beta)\bar{Q}_i + \alpha u_{i,t-1}u'_{i,t-1} + \beta\, Q_{i,t-1} \quad (5)$$

where: $\boldsymbol{u_{i,t}} = (\boldsymbol{u_{Chn,t}}, \boldsymbol{u_{i,t}})'$ is the vector of standardized residuals, and $\boldsymbol{\bar{Q}_i}$ is the unconditional covariance matrix of $\boldsymbol{u_{i,t}}$. $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$, which are the autoregressive and variance coefficients, respectively, and are nonnegative scalars satisfying $\boldsymbol{\alpha} + \boldsymbol{\beta} < 1$. We estimate a two-step DCC estimation using the maximum likelihood method.

3.2. Econometric Methods

We start by assessing the in-sample predictive ability of the comovement measures we develop. To predict Chinese recessions, we first consider the following predictive probit regression form for the in-sample test:

$$Pr(recession_{t+k} = 1) = F(\alpha + \beta\rho_t + \gamma' X_t + u_{t+k}) \ \forall\ k = 3, 6 \quad (6)$$

where: $\boldsymbol{recession_{t+k}}$ is a dummy variable with a value of one if China is in recession and zero otherwise; $\boldsymbol{\rho_t}$ is the regional long-term interest rate comovement obtained by taking the average of 11 countries' comovement time-series estimated with the DCC model; $\boldsymbol{X_t}$ is a vector of control variables (Term, LI, PMI, and Ex_R) observed at *t*; $\boldsymbol{\gamma'}$ is the vector of coefficient estimates on the control variables; and $\boldsymbol{F}(\cdot)$ is the standard normal cumulative distribution function.

To check the robustness of the comovement measures continuously, we also consider the following Ordinary Least Squares (OLS) regression form using the real GDP growth rate and CCI as dependent variables:

$$y_{t+k} = \alpha + \beta y_t + \gamma\rho_t + \delta' X_t + u_{t+k} \quad \forall\, k = 1, 2 \text{ for GDP}; k = 3, 6 \text{ for CCI} \tag{7}$$

where: $\boldsymbol{y_{t+k}}$ is the real GDP growth rate or CCI. To mitigate potential statistical problems, we use the robust standard error in all regressions. We use quarterly data for the real GDP and monthly data for recession and CCI because only quarterly data are available for the real GDP growth rate.

We use the same model for the out-of-sample test. We conduct rolling out-of-sample predictions using rolling data windows of fixed sizes. In this test, the estimates of the forecast models are updated in each time series, using the most recent additional data that became available at the time the forecast was being made and excluding the data of the very first period. In this way, we forecast the future business cycle 3, 6, 9, and 12 months ahead. To evaluate the accuracy of the forecast with the regional long-term interest rate comovements relative to the four business cycle forecast indicators, we calculate the ratio of the Root Mean Square Errors (RMSEs) of the model with and without the comovement measures.

The association between the regional long-term interest rate comovements and the future economic fundamentals may have reverse causality; that is, the realized economic conditions drive the comovements. To address this concern, we also perform the Granger causality test in the following the Vector Autoregression (VAR) framework as a part of the in-sample test.

$$y_t = \sum_{k=1}^{p} \alpha_k y_{t-k} + \sum_{k=1}^{p} \beta_k \rho_{t-k} + u_t \tag{8}$$

$$\rho_t = \sum_{k=1}^{p} \alpha_k y_{t-k} + \sum_{k=1}^{p} \beta_k \rho_{t-k} + u_t \tag{9}$$

where: $\boldsymbol{y_t}$ is the real GDP growth rate or CCI, and *p* is the lag order. Since the recession indicator is a binary variable, we exclude it for this test. Additionally, since we perform the tests using a VAR framework, we select the lag length for the VAR model that minimizes the Schwartz–Bayesian criterion.

4. Data and Description

4.1. Regional Comovement Measures

The study period is from June 2002 to June 2016.[3] First, we choose China's 10 neighbouring countries: Hong Kong (HKG), Indonesia (IDN), India (IND), Japan (JPN), South Korea (KOR), Malaysia (MYS), the Philippines (PHL), Singapore (SGP), Thailand (THA), and Taiwan (TWN) whose government bonds data is available in Datastream along with that of the U.S. (USA). Next, we obtain data on these countries' monthly 10-year government bonds to represent long-term interest rates from Datastream. Pairing these with China's 10-year government bond yields it results in 11 interest rate comovement series. We construct one regional long-term interest rate comovement measure by taking the equal-weighted average of these 11 series. Because Lee, Jo, and Kim (2016) show that interest rate comovement behaves differently along the business cycle depending on the extent of market integration with respect to trade, we also take the trade-weighted average using the ratio of the trading volume of country *i* with China and the sum of the trading volumes of all 11 countries with China as the weight ($\boldsymbol{w_i} = \frac{trade\_Vol_i}{\sum_{j=1}^{11} trade\_Vol_j}$). We collect all trade data from the United Nations Statistical Division (COMTRADE).

In Table 1, we present the descriptive statistics and time span for the long-term interest rate conditional correlations by country and two comovement measures (We also plot the time-series of two comovement measures in Figure. A1 of Appendix.). China has rather high correlations with Hong Kong (0.23) and Taiwan (0.32), which is not a surprise given the high integration between these markets. The correlations with South Korea (0.27) and Thailand (0.29) are also fairly high. Notice that the mean correlation with the U.S. is incredibly low, despite the trade integration of the two countries[4]. This suggests that the variation in correlation levels is not fully determined by the trade channel and there could be another mechanism, such as regional factors. Skewness and Kurtosis of co-movement series indicate that the measures are far from normal distribution.

Table 1

Descriptive Statistics of the Long-term Interest Rate Comovement

Variable	Mean	Median	Std. Dev.	Skewness	Kurtosis	Period
HKG	0.23	0.23	0.02	–0.08	2.04	2002–2016
IDN	–0.07	–0.08	0.08	2.05	11.33	2003–2016
IND	0.23	0.22	0.07	1.55	5.81	2002–2016
JPN	0.03	0.07	0.09	–0.78	2.46	2002–2016
KOR	0.27	0.23	0.14	0.59	2.10	2002–2016
MYS	0.15	0.15	0.06	–2.47	19.59	2002–2016
PHL	0.11	0.10	0.10	3.53	36.94	2002–2016
SGP	0.15	0.15	0.03	0.92	5.53	2002–2016
THA	0.29	0.34	0.21	–0.75	2.45	2004–2016
TWN	0.32	0.33	0.15	–0.32	7.48	2002–2016
USA	0.07	0.06	0.10	3.26	28.41	2002–2016
ρ_{equal}	0.16	0.16	0.04	0.31	2.49	2002–2016
ρ_{trade}	0.15	0.14	0.04	0.25	3.52	2002–2016

[3] *The sample period is limited by data availability on Datastream.*

[4] *The U.S. is China's biggest trading partner in terms of volume (US$561 billion), followed by Hong Kong (US$347 billion), Japan (US$279 billion), and South Korea (US$ 276 billion).*

4.2. Macro Variables

To measure China's business cycle, we consider the following three business cycle measures: recession indicator, CCI, and real GDP growth rate. Along with the recession indicator, real GDP growth rate directly captures the current business activity. In addition, CCI is closely linked to economic fundamentals (Goh, 2003; Doms and Morin, 2004; Lemmon and Portniaguina, 2006; Taylor and McNabb, 2007). We obtain data on China's recession indicator for the period from June 2002 to September 2014 from the Federal Reserve Bank of St. Louis.[5] Following Estrella and Trubin (2006), we define our recession indicator as the period following a peak through the trough. Furthermore, we also obtain CCI and real GDP growth rate data from Datastream for June 2002 to June 2016. We use the conventional definition of real GDP growth rate as the percentage change of seasonally adjusted real GDP.

4.3. Business Cycle Forecasting Indicators

To assess whether the regional long-term interest rate comovement provides additional information about future macro fundamentals, we control for other business cycle forecasting indicators: Term, LI, PMI, and Ex_R. We collect the related from Datastream. To construct China's term spread, we use 10-year government yields and 3-month government yields for the long- and short-term interest rates, respectively (Estrella and Trubin, 2006). The leading indicator[6] is designed to take a lead before the coincident index and is used for forecasting the future economic trend. In addition, previous studies note that PMI has predictive power for future business conditions. The leading indicator and PMI data are from the National Bureau of Statistics of China. Finally, we calculate Ex_R as the return on the Shanghai stock exchange index in excess of the 3-month yield.

Table 2

Unconditional Correlations among Forecast Indicators and Macro Variables

	Business cycle forecasting indicators						Macro	
	ρ_{equal}	ρ_{trade}	Term	LI	PMI	Ex_R	Recess	CCI
ρ_{trade}	0.83							
Term	–0.55	–0.56						
LI	–0.09	–0.11	0.32					
PMI	–0.44	–0.31	0.42	0.08				
Ex_R	–0.21	–0.08	0.32	0.18	0.29			
Recess	0.51	0.46	–0.66	–0.23	–0.56	–0.39		
CCI	–0.53	–0.36	0.33	–0.17	0.44	0.15	–0.41	
GDP	–0.60	–0.40	0.57	0.44	0.76	0.50	–0.67	0.81

Combining all macro and business cycle forecasting indicators, Table 2 reports the unconditional correlation matrix among these variables. All unconditional correlations have the predicted coefficient signs. Notably, a positive (negative) coefficient on the correlation between the comovement measures and recession indicators (CCI and GDP) indicates that the level of comovement is higher during recession periods (counter-cyclical time variation). Consistent with this, the comovement measures are negatively related to the four business

[3] *OECD-based recession indicators are available from https://fred.stlouisfed.org/series/CHNREC.*

[6] *The leading indicator consists of (1) a share turnover value, (2) ratio of sales value to gross output value, (3) Money supply, (4) investment (5) freight traffic, (6) cargo handled at major seaports, (7) consumer expectation index, and (8) differences in the national debt interest rate.*

cycle forecasting indicators, which vary pro-cyclically. This result confirms our conjecture that interest rates are more synchronized during the economic downturn because it is the time when business cycle is more synchronized (Antonakakis and Scharler, 2012). It should be also noted that a negative correlation with term spread is higher than other forecasters, suggesting that interest rate comovement contains quite similar information as term spread.

5. Empirical Results

5.1. In-sample Test

We first analyse the in-sample predictive ability of the comovement measures by estimating equations (6) and (7).

Table 3 shows the results for the probit regression. Each row represents one regression result. First, we include only one variable with different lags to forecast the recession. In the last four rows, we add all of the variables. We see that the coefficients on both comovement measures ($\boldsymbol{\rho_{equal}}, \boldsymbol{\rho_{trade}}$) are highly significant in all lags. Term, LI, PMI, and Ex_R are also significant. Consistent with the univariate result in Table 2, comovement measures vary counter-cyclically. As for other forecasters, they have the predicted signs when we include each separately as an independent variable. However, in the last four rows, when we add these simultaneously, except for the term spread, the other measures almost lose significance or have unpredicted signs, while the comovement measures remain significant.

Table 3

In-sample Test: Predicting Future Recessions

Lag	ρ_{equal}	ρ_{trade}	Term	LI	PMI	Ex_R	$Pseudo\ R^2$
3	0.12*** (0.04)						0.07
6	0.15*** (0.04)						0.11
3		0.09** (0.04)					0.05
6		0.12*** (0.04)					0.09
3			–0.79*** (0.13)				0.26
6			–0.75*** (0.13)				0.24
3				–0.93*** (0.25)			0.07
6				–0.46* (0.24)			0.02
3					–0.14** (0.06)		0.09
6					–0.09* (0.05)		0.04
3						–0.04*** (0.01)	0.05
6						–0.03** (0.01)	0.04

Lag	ρ_{equal}	ρ_{trade}	Term	LI	PMI	Ex_R	$Pseudo\ R^2$
3	0.10* (0.06)		–0.98*** (0.23)	–0.68** (0.31)	0.02 (0.07)	–0.01 (0.02)	0.47
6	0.21*** (0.05)		–0.88*** (0.20)	0.15 (0.29)	0.13** (0.06)	–0.02 (0.02)	0.44
3		0.12* (0.07)	–0.99*** (0.25)	–0.79** (0.34)	0.03 (0.07)	–0.02 (0.02)	0.48
6		0.14** (0.06)	–0.87*** (0.19)	0.19 (0.307)	0.091 (0.057)	–0.02 (0.02)	0.40

Notes: *(1) ***, **, and * indicate the rejection of the null hypothesis at the 1%, 5%, and 10% levels, respectively. (2) Robust standard errors are reported in parentheses below the coefficient estimates. (3) We use monthly data in Panels A and B and quarterly data in Panel C. (4) The same notes apply to Tables 4 and 5.*

Table 4

In-sample Test: Predicting Future Consumer Confidence

Lag	CCI_lag	ρ_{equal}	ρ_{trade}	Term	LI	PMI	Ex_R	$Adj\ R^2$
3	0.61*** (0.11)	–0.002** (0.001)						0.51
6	0.33*** (0.10)	–0.01*** (0.001)						0.35
3	0.66*** (0.09)		–0.001 (0.001)					0.49
6	0.42*** (0.10)		–0.003* (0.002)					0.29
3	0.67*** (0.09)			0.01* (0.001)				0.51
6	0.43*** (0.11)			0.01*** (0.003)				0.29
3	0.74*** (0.08)				0.02*** (0.01)			0.54
6	0.54*** (0.10)				0.02** (0.01)			0.31
3	0.63*** (0.07)					0.004*** (0.001)		0.62
6	0.38*** (0.00)					0.01*** (0.00)		0.46
3	0.71*** (0.08)						0.0002 (0.0003)	0.52
6	0.51*** (0.10)						0.001* (0.0003)	0.29
3	0.62*** (0.08)	–0.001 (0.001)		–0.003 (0.003)	0.01** (0.01)	0.004*** (0.001)	0.00004 (0.0002)	0.63
6	0.32*** (0.12)	–0.004** (0.002)		–0.004 (0.003)	0.01 (0.01)	0.01*** (0.001)	0.0003 (0.0003)	0.51
3	0.65*** (0.08)		–0.001 (0.001)	–0.002 (0.003)	0.01** (0.01)	0.004*** (0.001)	0.0001 (0.0002)	0.63
6	0.390*** (0.11)		–0.001 (0.001)	–0.01 (0.01)	0.01 (0.01)	0.01*** (0.001)	0.0004 (0.0003)	0.48

To shed more light on the significance of the comovement measures, we repeat the same analysis using CCI and real GDP growth rate as dependent variables in the OLS regression setting. Table 4 shows the result when CCI is the dependent variable. In particular, the equal-weighted comovement (ρ_{equal}) exhibits stronger predictive power than the term spread in terms of R^2. When added simultaneously, the trade-weighted comovement (ρ_{trade}) and term spread lose significance.

Finally, Table 5 shows that in the last four rows, while the comovement measures are significant for all lags and specifications, only PMI and Ex_R retain significance in one specific lag for each measure among the four forecasting indicators. Overall, the regional long-term interest rate comovements we consider have strong predictive power for the future business cycle, and their significance is stronger than that for the common forecasting indicators. Moreover, this result is quite robust to different business cycle measures.

Table 5

In -sample Test: Predicting Future Real GDP Growth Rate

Lag	GDP_lag	ρ_{equal}	ρ_{trade}	Term	LI	PMI	Ex_R	$Adj\ R^2$
1	0.77*** (0.08)	–0.16*** (0.06)						0.82
2	0.56*** (0.13)	–0.27*** (0.10)						0.64
1	0.84*** (0.08)		–0.08 (0.05)					0.81
2	0.65*** (0.13)		–0.18** (0.09)					0.62
1	0.86*** (0.08)			0.17 (0.14)				0.80
2	0.66*** (0.16)			0.46** (0.19)				0.60
1	0.88*** (0.07)				0.06 (0.07)			0.79
2	0.79*** (0.14)				–0.02 (0.09)			0.56
1	0.79*** (0.10)					0.17** (0.07)		0.86
2	0.73*** (0.16)					0.10 (0.10)		0.61
1	0.87*** (0.07)						0.01 (0.01)	0.80
2	0.72*** (0.15)						0.02 (0.02)	0.58
1	0.66*** (0.09)	–0.14** (0.07)		0.03 (0.14)	0.01 (0.07)	0.14** (0.06)	0.01 (0.01)	0.88
2	0.46*** (0.15)	–0.28** (0.11)		0.17 (0.20)	–0.10 (0.08)	0.06 (0.12)	0.02 (0.02)	0.71
1	0.71*** (0.10)		–0.10* (0.05)	0.04 (0.14)	0.03 (0.07)	0.011 (0.07)	0.01 (0.01)	0.87
2	0.56*** (0.16)		–0.21** (0.08)	0.18 (0.18)	–0.06 (0.09)	–0.002 (0.10)	0.03* (0.02)	0.69

In addition to the significance of the measures, a few things are noteworthy. First, the regional long-term interest rate comovements vary counter-cyclically for all results. Since strong interest rate comovements reflect strong real-economy comovements, this result is consistent with the existing literature showing that highly integrated economies strongly co-move in bad states (Antonakakis and Scharler, 2012). Second, throughout the in-sample analysis, the equal-weighted long-term interest comovement appears to have a stronger association with the business cycle than the trade-weighted measure. As shown in Panel B of Table 2, trade-weighted comovement is associated to a greater extent with the U.S. This implies that economic integration is driven not just by the U.S., namely by the global factor, but also by regional factors. Finally, although the four forecasting indicators have a less significant association with the future business cycle than the comovement measures, they are significant when used separately. However, there is scant evidence thus far showing the significance of these forecast indicators in the Chinese context. For example, Su and Fleisher (1999) and Jarrett, Pan and Chen (2009) show that Chinese stock exchange returns are not a good barometer of changes in the Chinese macro-economy. Therefore, our result provides very important evidence in this regard and adds to the literature on forecasting the Chinese macro-economy.

5.2. Causality

While we are primarily interested in the time variation in the regional long-term interest rate comovements that reflect the future macroeconomic conditions, there could be a reverse causality in which the realized economic fundamentals affect the interest rate comovements. To the best of our knowledge, there are no existing studies that consider the macroeconomic conditions preceding the interest rate comovements. Rather, most studies assume that macro-conditions and interest rate comovements vary contemporaneously. Therefore, it is worth analysing whether the long-term interest rate comovements also reflect information about the already realized economic fundamentals. We address this issue directly by conducting Granger causality tests. To this end, we return to the specification and use only the comovement and business cycle measures in Equations (8) and (9).

Table 6

Granger Causality Tests

Panel A : CCI			
H_0 : CCI $\nrightarrow$ ρ_{equal}		H_0 : CCI $\nrightarrow$ ρ_{trade}	
χ^2 : 0.76(1)	P-value : 0.38	χ^2 : 0.57(1)	P-value : 0.45
H_0 : ρ_{equal} $\nrightarrow$ CCI		H_0 : ρ_{trade} $\nrightarrow$ CCI	
χ^2 : 5.37(1)**	P-value : 0.02	χ^2 : 1.29(1)	P-value : 0.26
Panel B : GDP			
H_0 : GDP $\nrightarrow$ ρ_{equal}		H_0 : GDP $\nrightarrow$ ρ_{trade}	
χ^2 : 1.67(2)	P-value : 0.20	χ^2 : 3.56(2)*	P-value : 0.06
H_0 : ρ_{equal} $\nrightarrow$ GDP		H_0: ρ_{trade} $\nrightarrow$ GDP	
χ^2 : 12.13(2)***	P-value : 0.00	χ^2 : 8.02(2)***	P-value : 0.01

Notes :

(1) ***, **, and * indicate the rejection of the null hypothesis at the 1%, 5%, and 10% levels, respectively.

(2) The numbers in parentheses are the optimal lag using the Schwartz–Bayesian criterion.

Panel A of Table 6 presents the results of the Granger causality tests between CCI and the regional comovement measures. We see that we cannot reject the null hypothesis that CCI *does not* Granger cause ρ_{equal} (CCI $\nrightarrow$ ρ_{equal}), whereas we can reject the hypothesis that ρ_{equal} *does not* Granger cause CCI (ρ_{equal} $\nrightarrow$ CCI) at the 5% level. However, for the Granger causality test between CCI and ρ_{trade}, both hypotheses cannot be rejected. In Panel B of Table 6, we perform the same tests for the real GDP growth rate. For the equal-weighted comovement measure, we find support for Granger causality from ρ_{equal} to the real GDP growth rate, and no evidence of reverse causality. However, for the trade-weighted comovement measure, while we find support for Granger causality from ρ_{trade} to the real GDP growth rate at the 1% level, there is also evidence of reverse causality from the real GDP growth rate to ρ_{trade} at the 10% level. One potential reason for this result is that ρ_{trade} is less strongly associated with the business cycle measures than ρ_{equal}, as we show in the previous section, resulting in a less informative and noisy measure. Overall, the tests in Table 6 demonstrate strong support for one-way Granger causality from ρ_{equal} to the business cycle, and weaker Granger causality from ρ_{trade} to the business cycle than that for ρ_{equal}.

5.3. Out-of-sample Test

In the previous section, we find that regional long-term interest rate comovement varies strongly in response to future economic conditions, even after controlling for the four forecast indicators. We also conduct an out-of-sample test to evaluate: (1) the stability of this relationship over time in different periods and (2) the usefulness of the measures as new business cycle forecast indicators for China. We need this additional test because the association between the interest rate comovements and business cycle found through the in-sample test cannot guarantee these two aspects.

For our out-of-sample analysis, we consider rolling out-of-sample predictions. Additionally, since the recession indicator, CCI, and real GDP growth rate have different time spans and data frequencies, we adopt estimation windows of different fixed widths for each test.[7] We exclude the PMI measure in this test due to the short time span. To show our result is not driven by other external factors, we add 3-month U.S. T-Bill as an additional forecast indicator following Ang, Piazzesi, and Wei (2006). Finally, to test whether comovement measures have a predicting power beyond the conventional forecasters, we calculate the ratio of the RMSEs of the forecasters with and without a comovement measure.

Table 7 presents the results. With regard to forecasting a future recession (Panel A), relative to the term spread, ρ_{equal} and ρ_{trade} improve the accuracy of the 6- and 9-month-ahead and 9- and 12-month-ahead forecasts, respectively. For a model with the lead indicator, excess stock return, or U.S. T-bill, adding the regional long-term interest rate comovements substantially improves the accuracy of all future forecasts. Panel B of the table shows that as for ρ_{trade}, it worsens the forecast performance for all forecasts relative to the term spread and U.S. T-bill, also for the 9-month-ahead forecast relative to the lead indicator. By contrast, ρ_{equal} adds to the forecasting performance except for the 3-month ahead beyond the U.S. T-bill. The result in Panel C is the most striking. Both measures improve forecast accuracy in all cases. Overall, these results imply that the association between the regional long-term interest rate comovement and the business cycle is indeed highly stable over time. Furthermore, the measures can serve as a business cycle forecast indicator for future

[7] *The monthly recession data covers June 2002 to September 2014. Although both the CCI and the real GDP growth cover June 2002 to June 2016, the respective frequencies for CCI and real GDP growth are monthly and quarterly. Therefore, we adopt 70 months, 80 months, and 30 quarters as the fixed widths of the estimation windows.*

economic conditions, and they outperform the traditional business cycle indicators found in the literature.

Table 7

Out-of-sample Tests: Predictive Power of Long-term Interest Rate Comovements

Unrestricted model	Restricted model	3-months-Ahead	6-months-Ahead	9-months-Ahead	12-months-Ahead
Panel A : Forecasting Recession					
ρ_{equal}, Term	Term	1.06	0.92	0.95	1.03
ρ_{trade}, Term	Term	1.13	1.02	0.91	0.86
ρ_{equal}, LI	LI	0.91	0.84	0.88	0.95
ρ_{trade}, LI	LI	0.93	0.90	0.85	0.81
ρ_{equal}, Ex_r	Ex_r	0.91	0.84	0.87	0.92
ρ_{trade}, Ex_r	Ex_r	0.93	0.89	0.84	0.85
ρ_{equal}, r_us3m	r_us3m	0.97	0.92	0.90	0.89
ρ_{trade}, r_us3m	r_us3m	0.99	0.98	0.90	0.89
Panel B : Forecasting Consumer Confidence Index					
ρ_{equal}, Term	Term	0.87	0.82	0.80	0.79
ρ_{trade}, Term	Term	1.00	1.02	1.04	1.01
ρ_{equal}, LI	LI	0.81	0.77	0.73	0.71
ρ_{trade}, LI	LI	0.96	0.98	1.01	0.98
ρ_{equal}, Ex_r	Ex_r	0.83	0.79	0.78	0.76
ρ_{trade}, Ex_r	Ex_r	0.97	0.98	0.99	0.96
ρ_{equal}, r_us3m	r_us3m	1.01	0.97	0.93	0.91
ρ_{trade}, r_us3m	r_us3m	1.02	1.02	1.01	1.00
Panel C : Forecasting Real GDP growth rate					
ρ_{equal}, Term	Term	0.79	0.70	0.59	0.65
ρ_{trade}, Term	Term	0.91	0.83	0.75	0.76
ρ_{equal}, LI	LI	0.72	0.57	0.49	0.55
ρ_{trade}, LI	LI	0.75	0.69	0.67	0.69
ρ_{equal}, Ex_r	Ex_r	0.64	0.63	0.59	0.54
ρ_{trade}, Ex_r	Ex_r	0.76	0.73	0.69	0.66
ρ_{equal}, r_us3m	r_us3m	0.85	0.76	0.73	0.79
ρ_{trade}, r_us3m	r_us3m	0.78	0.74	0.69	0.69

6. Conclusion

We study the extent to which the regional long-term interest rates are synchronized is associated with the future business cycles in China. Our study contributes significantly to the literature by providing novel empirical observations, which literature has not documented. First, our in-sample test shows a strong association between the regionally constructed comovement measures and the Chinese future business cycles. This result implies that the regional factor plays a crucial role in driving the synchronization of economies along with the global factor. Second, we document that comovement measures move counter-cyclically, suggesting a higher correlation during bad economic times than the peaks. The economic interpretation of this result is business cycles are more synchronized during bad states, which leads to the higher correlation. Finally, we provide evidence that the relation between time-varying comovement and business cycle is considerably stable enough over time that it is able to predict the future economic fundamentals. Most strikingly, the out-of-sample test is robust to control for the conventional economic forecasters – term spread, stock returns, Production Manufacturing Index, and even U.S. interest rate. This result is particularly important because our result offers both practitioners and academia a novel forecasting indicator to predict Chinese economy, which substantially and increasingly affects the global economy.

As of October 2017, our empirical model based on the long-term interest rate comovement predicts a recession in China with 42% within a year. The comovement measure has risen, over the last three years, suggesting increasing chance of future recession. This result is consistent with increasing concern for the future crisis in China. However, our measures should be viewed cautiously. We have not pinned down the channels through which the long-term interest rates are correlated. It can be the inflation expectation, future expectation on real interest rate, or risk-premia. Also, as another limitation, the results might not be generalized to other regional settings such as Germany for neighbouring countries, U.S. for Canada and Mexico. This is beyond the scope of our research and we leave it for future work.

Acknowledgements

This work was supported by National Research Foundation of Korea [grant number NRF-2014-S1A5B4038370].

References

Ang, A. and Piazzesi, M., 2003. A no-arbitrage vector autoregression of term structure dynamics with macroeconomic and latent factors. *Journal of Monetary Economics,* 50(4), pp.745–787.

Ang, A. and Piazzesi, M. and Wei, M., 2006. What does the yield curve tell us about GDP growth?. *Journal of Econometrics,* 131(1), pp.359–403.

Antonakakis, N. and Scharler, J., 2012. The synchronization of GDP growth in the G7 during US recessions. *Applied Economics Letters,* 19(1), pp.7–11.

Berdiev, A.N. and Chang, C.P., 2013. How synchronized is China with the other Asia-Pacific countries?*. Bryant University Center for Global and Regional Economic Studies working paper No.2013-14* [online] Available at: < https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2345300>[Accessed in Feb 2018].

Bhanupong, N., 2015. The ASEAN business cycle and China's slowdown. *Philippine Review of Economics,* 52(2), pp.192–209.

Borio, C. and Filardo, A., 2007. Globalisation and inflation: New cross-country evidence on the global determinants of domestic inflation. *BIS Working Papers 227, Bank for International Settlements.* [online] Available at: < https://ideas.repec.org/p/bis/biswps/227.html>[Accessed in Feb 2018].

Bremnes, H. Gjerde, O. and Sattem, F., 2001. Linkage among Interest Rates in the United States, Germany and Norway. *The Scandinavian Journal of Economics,* 103(1), pp.127–145.

Byrne, J. Fazio, G. and Fiess, N., 2012. Interest rate co-movements, global factors and the long end of the term spread. *Journal of Banking and Finance,* 36(1), pp.183–192.

Canova, F., 2005. The Transmission of US shocks to Latin America. *Journal of Applied Econometrics,* 20(2), pp.229–251.

Chin, M. Filippeli, T. and Theodoridis, K., 2015. Cross-country co-movement in long-term interest rates: a DSGE approach. *Working Papers 753, Queen Mary University of London, School of Economics and Finance.* [online] Available at: <https://ideas.repec.org/p/qmw/qmwecw/wp753.html> [Accessed in Feb 2018].

Dahlquist, M. and Hasseltoft, H., 2013. International bond risk premia. *Journal of International Economics,* 90(1), pp.17–32.

Dai, Y., 2014. Business cycle synchronization in Asia: The role of financial and trade linkages*. ADB Working Paper Series on Regional Economic Integration, No. 139, Asian Development Bank*. [online] Available at: <http://www.adb.org/sites/default/files/publication/82795/reiwp-139-business-cycle-synchronization-asia.pdf> [Accessed on Feb 2018]

Dai, Q. and Philippon, T., 2005. Fiscal Policy and the Term Structure of Interest Rates. *No 11574 NBER Working paper,* 90 [online] Available at: < https://econpapers.repec.org/paper/nbrnberwo/11574.htm> [Accessed in Feb 2018]

Das, D.K., 2007. Foreign direct investment in China: Its impact on the neighbouring Asian economies. *Asian Business & Management,* 6(3), pp.285–301.

Doms, M. and Morin, N., 2004. Consumer sentiment, the economy, and the news media*. Staff Working Paper in the Finance and Economics Discussion Series, No. 51, Federal Reserve Bank of San Francisco*. [online] Available at: <https://www.federalreserve.gov/pubs/feds/2004/200451/200451pap.pdf> [Accessed in Feb 2018]

Engle, R.F., 2002. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroscedasticity models. *Journal of Business Economic Statistics,* 20(3), pp.339–350.

Engsted, T. and Tanggaard, C., 2007. The comovement of US and German bond markets. *International Review of Financial Analysis,* 16(2), pp.172–182.

Estrella, A. and Trubin, M., 2006. The yield curve as a leading indicator: some practical issues. *Federal Reserve Bank of New York,* 12(5), pp.1–7.

Evans, C.L. and Marshall, D., 2007. Economic determinants of the nominal treasury yield curve, *Journal of Monetary Economics,* 54(7), pp.1986–2003.

Goh, K.L., 2003. Does consumer confidence forecast consumption expenditure in New Zealand?*. Treasury Working Paper Series 03/22 New Zealand Treasury*. [online] Available at: <http://www.treasury.govt.nz/publications/research-policy/wp/2003/03-22> [Accessed in Feb 2018]

Henriksen, E. Kydland, F.E. and Sustek, R., 2013. Globally correlated nominal fluctuations. *Journal of Monetary Economics,* 60(6), pp.613–631.

Hirata, H. Kose, M.A. and Otrok, C., 2013. Closer to home. *Finance and Development,* 50(3), pp.40–43.

Jarrett, J.E. Pan, X. and Chen, S., 2009. Do the Chinese bourses (stock markets) predict economic growth? *International Journal of Business and Economics,* 8(3), pp.201–211.

Jotikasthira, C. Le, A. and Lundblad, C., 2015. Why do term structures in different currencies co-move? *Journal of Financial Economics,* 115(1), pp.58–83.

Kim, S., 2001. International transmission of U.S. monetary policy shocks: Evidence from VAR's. *Journal of Monetary Economics,* 48(2), pp.339–372.

Kose, M.A. Otrok, C. and Whiteman, C.H., 2003. International business cycles: world, region, and country-specific factors. *American Economic Review,* 93(4), pp.1216–1239.

Kulish, M. and Rees, D., 2011. The yield curve in a small open economy. *Journal of International Economics,* 85(2), pp.268–279.

Kuttner, K., 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics,* 47(3), pp.523–544.

Lee, K. Jo, C. and Kim, H., 2016. The long-term interest rates correlations: A new indicator predicting recession. *Journal of Korea Trade,* 20(3), pp.259-280.

Lemmon, M. and Portniaguina, E., 2006. Consumer confidence and asset prices: Some empirical evidence. *The Review of Financial Studies*, 19(4), pp.1499–1529.

Moon, H.R. and Perron, B., 2007. An empirical analysis of nonstationarity in a panel of interest rates with factors. *Journal of Applied Econometrics*, 22(2), pp.383–400.

Park, Y. J., 2013. Regional business cycles in East Asia: Synchronization and its determinants. *Journal of East Asian Economic Integration,* 17(2), pp.103–128.

Song, L.L. and Tan, S.L., 2011. Business cycle co-movement between Australia and East Asia. *Australian Economic Review,* 44(4), pp.427–436.

Su, D. and Fleisher, B.M., 1999. Why does return volatility differ in Chinese stock markets? *Pacific-Basin Finance Journals,* 7(5), pp.557–586.

Swanson, E.T. and Williams, J.C., 2014. Measuring the effect of the zero lower bound on yields and exchange rates in the U.K. and Germany. *Journal of International Economics,* 92(Supplement 1), pp.S2–S21.

Taylor, K. and McNabb, R., 2007. Business cycles and the role of confidence: evidence for Europe. *Oxford Bulletin of Economics and Statistics,* 69(2), pp.185–208.

Wright, J.H., 2011. Term premia and inflation uncertainty: Empirical evidence from an international panel dataset. *American Economic Review,* 101(4), pp.1514–1534.

Appendix

Figure A1

Time-varying Regional Long-term Interest Rate Comovements (%)