Chapter 6
When the US Sneezes, Will China Catch a Cold?

6.1 Introduction

A common saying is that “When America sneezes, the rest of the world catches a cold.” Commonly used sayings sometimes represent distilled wisdom whilst at other times they represent mistaken inference. Next only to the United States, China is now the second largest economy in the world, and accounts for 16% of global GDP. China is also the world’s second-largest importer, so any weakness, however temporary, is felt far and wide. As the year 2020 gathers pace, there has been an outbreak of coronavirus (COVID-19). With the pandemic spreading around the world, it has pushed economies into a Great Lockdown, which has triggered the worse recession since the Great Depression. At the time of writing (June 2020), the US is still combating the coronavirus. So a ‘natural’ question is: When the US sneezes, will China catch a cold?

In this chapter, we refine this broad question down into a set of research questions: How synchronized are the business cycles between China and the US? Does the US business cycle lead that of China, or the other way around? If the US economy goes into a recession, will China automatically follow? The rest of this chapter is structured as follows: In Sect. 6.2, we measure business cycles and find the turning points in the business cycles for China and the US. In Sect. 6.3, we conduct tests of business cycle synchronization. A GMM framework is presented, with a discussion on the moment conditions and estimation methods. Both single synchronization tests (with an extension) and joint synchronization tests are conducted to examine the degree of synchronization of business cycles between China and the US. Section 6.4 concludes.
6.2 Measurement of Business Cycles

In the classical work on “Measuring Business Cycles” by Burns and Mitchell (1946), they defined specific cycles in a time series $y_t$ in terms of the turning points along its sample path. This tradition has been central to the work by the business cycle dating committee at the National Bureau of Economic Research (NBER), which determines the turning points in the business cycles of the US economy. Other institutions, such as the International Monetary Fund (IMF) in Washington DC, and the Organisation for Economic Co-operation and Development (OECD) in Paris also follow this tradition and measure the business cycles through locating the turning points in the time series that are taken to represent the aggregate level of economic activity.

The key idea behind business cycles is that a turning point occurs when one phase of expansion (or contraction) ends and another phase of contraction (or expansion) starts. In order to detect the cycle with a single series, we can therefore think of business cycles in terms of turning points in the time series on aggregate activity in the economy. However, this is a visual exercise, that is, it is done by eye and judgment. Examples include the charts by Burns and Mitchell (1946), Boehm and Moore (1984), and the business cycle dating committee at the NBER. As modern economists, we would like to go beyond this eye inspection and subjective judgment. To avoid this subjectivity, we have to check the time-series data with closer inspection, need considerable amount of scientific judgment, and have to resort to computational methods on the final selection of the turning points.

Bry and Boschan (1971) followed the steps in Burns and Mitchell (1946), and produced an algorithm that largely replicates BM’s decision on the selection of turning points in a given set of time series. In BB’s algorithm, there were three key components. The first key component was to incorporate various smoothing rules and to find an initial set of turning points. The second key component was to eliminate enough of these turning points, so as to ensure that expansion and contraction phases exceed 5 months in duration, while completed cycles exceed 15 months in duration. These are generally referred to as censoring operations. The third key component was to delete multiple sequential occurrences of peaks and troughs, in order to ensure the alternation of peaks and troughs, that is, a peak should be followed by a trough, and a trough should be followed by a peak.

Bry and Boschan (1971) were interested in analyzing monthly data. They also suggested a method for working with quarterly data, which involved treating the monthly data in a quarter as one third of the quarterly value. Harding and Pagan (2002) developed the quarterly adaption of Bry-Boschan (BB) algorithm, which is called “Bry-Boschan Quarter” (BBQ). The BBQ program omitted the smoothing

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1 See https://www.nber.org/cycles.html.
2 See IMF (2002).
3 Phases are the periods of expansions and contractions between turning points.
4 For information on BB’s business cycle dating algorithm, see Chap. 2 of “Cyclical Analysis of Time Series: Selected Programs and Computer Program” in Bry and Boschan (1971).
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rule in the BB algorithm, but retained the three key principles of the BB algorithm. It sets the minimum phase and cycle lengths to be 2 and 5 quarters, respectively.

The modified BBQ program selects the turning points in each coincident series, and imposes restrictions in one step. The dating rule is that a peak is greater than the turn phase on either side, and a trough is less than the turn phase on either side.

To locate turning points in a time series, it is necessary to provide some way of recognizing them in a given data set, which usually involves the detection of local maxima and local minima in the series under study. These turning points are the peaks and troughs in the cycles, and the expansions and contractions are the periods between them. Peaks are local maxima and troughs are local minima in the series $y_t$. This involves a change in the sign of the first derivative in discrete time, and it is taken to be the first difference of the time series. To illustrate this dating rule, we focus on a change in the variable $y_t$, $\Delta y_t$, and estimate the derivative by using an average of the $y_t$ over some window around the potential turning point. A peak in a series $y_t$ at time $t$ is detected by examining whether the following sequence holds:

$$\{\Delta_2 y_t > 0, \Delta y_t > 0, \Delta y_{t+1} < 0, \Delta_2 y_{t+2} < 0\}$$

Likewise, a trough in $y_t$ at time $t$ is detected by examining whether the following sequence holds:

$$\{\Delta_2 y_t < 0, \Delta y_t < 0, \Delta y_{t+1} > 0, \Delta_2 y_{t+2} > 0\}$$

Turning Points in Business Cycles

Measurement of business cycles provides us with a benchmark against which macroeconomic theories and policy assessment can be applied. This process requires an operational definition of a business cycle. In the literature, there are several different notions of business cycles, among which classical cycles and growth cycles are the most common ones. A classical cycle is identified by finding the turning points in the level of the variable, and a growth cycle is identified as the turning points in the level of the variable less a permanent component. In addition, an acceleration cycle is identified by locating the turning points in the growth rate of the variable, which could be either a quarterly growth rate, or an annual growth rate.

(a) Classical Cycle

From a historical perspective, one major concern of the NBER’s Business Cycle Dating Committee is the classical cycles in the US economy. A classical cycle refers to the recurrence of expansions and contractions in the aggregate level of economic activity. In a classical cycle, the peaks measure the dates from which economic activity suffers a sustained decline; and the troughs measure the dates from which economic activity ends its decline and begins a sustained increase. According to
NBER, an expansion starts at the trough of a business cycle and ends at the peak of the cycle, while a contraction (recession) starts at the peak of a business cycle and ends at the trough of the cycle. In other words, an expansion is a period between the trough and the peak of a business cycle with increasing economic activity spread across an economy, and a recession is a period between the peak and the trough of a business cycle with declining economic activity across an economy, which usually lasts for a minimum of two consecutive quarters.

As per the definition of a classical cycle, China has not experienced any economic recessions, which is due to the fact that the level of China’s GDP does not fall, even during economic downturns, and therefore, the notion of a classical cycle is not appropriate to describe the business cycles for the Chinese economy.

(b) Growth Cycle

Burns and Mitchell (1946) simply referred to the time series $y_t$ as the aggregate level of economic activity. Mintz (1969, 1972) had difficulty locating turning points in the aggregate level of economic activity in surging economies such as West Germany at that time. This led Mintz to first extract a permanent component $p_t$ from $y_t$, and then examine the turning points in $z_t = y_t - p_t$. It is the cycle in $z_t$, rather than $y_t$, that is then examined, with the requisite indicators being derived from observations on $z_t$. A growth cycle reflects the fluctuation in the rate of economic growth, which takes into account the long-run trend rate of growth in the economy (Boehm and Moore 1984). In a growth cycle, the peaks measure the points at which economic growth moves from above the trend rate to below the trend rate, and the troughs measure the points at which growth moves from below the trend rate to above the trend rate for a sustained period of time.

In our analysis on the growth cycle, we use the logarithm of the aggregate level of economic activity, that is, the real GDP level, $\ln(GDP_t)$; and we use the turning points in $\ln(GDP_t - a - b_t)$, where $(a + b_t)$ is the permanent component in the real GDP data, to measure the growth cycle. Binary random variables are used to summarize the expansion and contraction phases of the growth cycle. We let $S_{CN,t}^G$ be the binary variable that represents the growth cycle for China, and let $S_{US,t}^G$ be the binary variable that represents the growth cycle for the US. $S_{CN,t}^G$ and $S_{US,t}^G$ take the value of unity if the country is in a growth cycle expansion at time $t$, and they take the value of zero if the economy is in a growth cycle recession at time $t$.

In Table 6.1 and Chart 6.1, we report our finding of the turning points in the growth cycles of China and the US. The source for China’s quarterly GDP is CEIC database and China’s National Bureau of Statistics (NBS). The source for the US quarterly GDP data is Federal Reserve Economic Data (FRED), and the data series is real gross domestic product, billions of chained 2012 dollars, with seasonal adjustment. We choose the common start date of 1992Q1, and the end date of 2019Q4, which is before the outbreak of the COVID-19 pandemic.

From Table 6.1, there are two main observations. The first observation is that in terms of the number of growth cycles, China has experienced much fewer growth cycles than the US, with its earliest trough occurred in 2008Q1 when the Global
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Table 6.1  Turning points in the growth cycles–China and the US

|  | China |  |  | US |
|---|---|---|---|---|
| Trough | Peak | Trough | Peak |
|  |  | 1993Q1 | 1993Q4 |
|  | 1995Q1 | 1995Q3 |
|  | 2000Q3 | 2002Q1 |
|  | 2002Q3 | 2003Q2 |
| 2008Q1 | 2009Q2 | 2006Q2 | 2009Q4 |
| 2012Q1 | 2019Q2 | 2010Q4 | 2011Q4 |
|  | 2012Q2 | 2014Q2 |
|  | 2015Q3 | 2017Q3 |
|  | 2018Q4 |

Financial Crisis (GFC) happened. The second observation is that in terms of the duration of growth cycles, the US growth cycle is usually short in duration, ranging from two quarters to three years and a half. By comparison, China has only experienced two growth cycles, with the first one during the GFC, and a very long growth cycle expansion from 2012Q1 to 2019Q2.

(c) Acceleration Cycle

An acceleration cycle is identified by locating the turning points in the growth rate of the variable. In an acceleration cycle, the peaks measure the dates at which the rate of economic growth begins to slow down, whilst the troughs measure the dates at which the rate of economic growth begins to increase. In our analysis on the acceleration cycle, we use the turning points in \( \ln(GDP_t) - \ln(GDP_{t-4}) \), where the subscript 4 represents four quarters, which is one year. We let \( S_{CN,t}^A \) be the binary variable that represents the acceleration cycle for China, and let \( S_{US,t}^A \) be the binary variable that represents the acceleration cycle for the US. \( S_{CN,t}^A \) and \( S_{US,t}^A \) take the value of one if the country is in an acceleration cycle expansion at time \( t \), and they take the value of zero if the economy is in an acceleration cycle recession at time \( t \).
Table 6.2  Turning points in the acceleration cycles—China and the US

| China     | US       |
|-----------|----------|
| Trough    | Peak     | Trough    | Peak     |
| 1992Q1    |          | 1999Q1    |          |
| 1994Q3    | 1998Q3   | 1994Q4    | 1996Q1   |
| 1999Q1    | 1999Q4   | 1997Q1    | 1997Q3   |
| 2001Q2    | 2002Q1   | 1999Q1    | 1999Q3   |
| 2004Q3    | 2005Q4   | 2000Q3    | 2002Q1   |
| 2007Q4    | 2009Q3   | 2002Q4    | 2003Q2   |
| 2011Q3    | 2012Q4   | 2004Q1    | 2007Q2   |
| 2014Q1    | 2016Q1   | 2007Q4    | 2009Q3   |
| 2018Q2    |          | 2010Q4    | 2011Q4   |
|           |          | 2012Q2    | 2013Q3   |
|           |          | 2015Q2    | 2016Q3   |
|           |          | 2018Q3    |          |

In Table 6.2, we present our finding of the turning points in the acceleration cycles of China and the US. There are two main observations. First, compared with growth cycles, there are many more acceleration cycles for both China and the US, which also have shorter duration. This indicates that acceleration cycles occur more frequently than growth cycles, which is confirmed in Chart 6.2. Second, in terms of the number of acceleration cycles, China has experienced fewer acceleration cycles than the US, but both China and the US experienced contractions in the early 1990s.

Chart 6.2:  Turning points in the acceleration cycles—China and the US. Source CEIC, FRED.
6.3 Synchronization of Business Cycles

6.3.1 Analytical Framework

In Sect. 6.2, we date the business cycles and find the turning points in the growth cycles and acceleration cycles for China and the US. In this section, we use the binary states from the cycle dating and estimate the parameters that are related to the measurement of cycle synchronization between China and the US. The mathematical notations and computer codes are based on and adapted from Hamilton (1994), and Harding and Pagan (2006). In what follows, we use generalized methods of moments (GMM), because we would like to seek a model that is free in measuring synchronization, and to obtain estimates that are robust to serial correlation and heteroscedasticity. Economic theory only provides us with information about the moments, but no information is provided about the distribution from which the shocks are drawn. Unless one is willing to go beyond the information provided by economic theory, it is not possible to use maximum likelihood (ML) to estimate these models. Hence, we use GMM in our analysis.

For the two binary series, the correlation between them is:

$$\rho_{CN,US}^{j} = \text{Corr}(S_{CN,t}^{j}, S_{US,t}^{j}) = \frac{\text{Cov}(S_{CN,t}^{j}, S_{US,t}^{j})}{\sqrt{\text{Var}(S_{CN,t}^{j})\text{Var}(S_{US,t}^{j})}}$$

where $j = \text{growth cycle, acceleration cycle}$.

The covariance between the two binary series is:

$$\text{Cov}(S_{CN,t}^{j}, S_{US,t}^{j}) = E(S_{CN,t}^{j} - \mu_{CN}^{j})(S_{US,t}^{j} - \mu_{US}^{j}) = E(S_{CN,t}^{j}S_{US,t}^{j}) - \mu_{CN}^{j}\mu_{US}^{j}$$

The variance in each binary series is:

$$\text{Var}(S_{i,t}^{j}) = \mu_{i}^{j}(1 - \mu_{i}^{j})$$

where $i = \text{China, US}$.

6.3.1.1 Moment Conditions

We have the following moment conditions in the system.

$$E(S_{i,t}^{j}) - \mu_{i}^{j} = 0$$
where $i = \text{China, US}$; $j = \text{growth cycle, acceleration cycle}$.

\[
E \left[ \frac{(S_{CN,t}^j - \mu_{CN}^j)(S_{US,t}^j - \mu_{US}^j)}{\sqrt{\mu_{CN}^j(1 - \mu_{CN}^j)\mu_{US}^j(1 - \mu_{US}^j)}} - \rho_{CN,US}^j \right] = 0
\]

where $j = \text{growth cycle, acceleration cycle}$.

Let $\theta' = (\mu_{CN}^j, \mu_{US}^j, \rho_{CN,US}^j)$ be a vector of parameters for the population means $(\mu_{CN}^j, \mu_{US}^j)$ in the Chinese and US binary states, and the population correlation $(\rho_{CN,US}^j)$ between these two binary states. Let $S$ be a $T \times 2$ matrix with elements $S_{CN}^j$ and $S_{US}^j$ in the two columns, respectively.

Then we can write the moment conditions as follows:

\[
m_t(\theta, S_t) = \begin{pmatrix}
S_{CN,t}^j - \mu_{CN}^j \\
S_{US,t}^j - \mu_{US}^j \\
\sqrt{\mu_{CN}^j(1 - \mu_{CN}^j)\mu_{US}^j(1 - \mu_{US}^j)} - \rho_{CN,US}^j
\end{pmatrix}
\]

where $m_t$ is a $T \times 3$ matrix, and

\[
g(\theta, \{S\}_{t=1}^T) = \frac{1}{T} \sum_{t=1}^T m_t(\theta, S_t)
\]

In the $m_t$ matrix, we have 3 moment conditions, and we also have 3 parameters in the system, $\theta' = (\mu_{CN}^j, \mu_{US}^j, \rho_{CN,US}^j)$, so it is a just identified system.

### 6.3.1.2 Moment Estimation

Since we have an exactly identified model, we can use the method of moments. The estimators can be solved analytically via the following equations.

\[
\mu_i^j = \frac{1}{T} \sum_{t=1}^T S_{i,t}^j
\]

\[
\rho_{CN,US}^j = \frac{1}{T} \sum_{t=1}^T (S_{CN,t}^j S_{US,t}^j - \mu_{CN}^j \mu_{US}^j) \sqrt{\mu_{CN}^j(1 - \mu_{CN}^j)\mu_{US}^j(1 - \mu_{US}^j)}
\]

Let $\hat{\theta}' = (\hat{\mu}_{CN}^j, \hat{\mu}_{US}^j, \hat{\rho}_{CN,US}^j)$ be the vector of parameters for the sample means in the Chinese and US binary states, and the sample correlation between these two binary states. The next step is to obtain the $S$ matrix.
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The Newey-West (1987) estimate of the \( S \) matrix is\(^5\):

\[
\hat{S}_T = \Gamma_{0,T} + \sum_{v=1}^{q} (1 - \frac{v}{q + 1}) (\hat{\Gamma}_{v,T} + \hat{\Gamma}_{-v,T})
\]

where \( q \) is the window width.

\[
\hat{\Gamma}_{v,T} = \frac{1}{T} \sum_{t=v+1}^{T} [m_t(\hat{\theta}, S_t)][m_t(\hat{\theta}, S_{t-v})]'
\]

where \( \hat{\theta} \) is an initial consistent estimator of \( \theta \).

6.3.2 Single Synchronization Tests

In this section, we test for the synchronization of business cycles between China and the US. \( \rho_{CN,US}^j = \text{Corr}(S_{CN,t}^j, S_{US,t}^j) \). To test the correlation of business cycles between China and the US, we have the null hypothesis (\( H_0 \)) and the alternative hypothesis (\( H_1 \)) as follows:

\[
H_0 : \rho_{CN,US}^j = 0
\]

\[
H_1 : \rho_{CN,US}^j \neq 0
\]

where \( j = \) growth cycle, acceleration cycle.

Following Sect. 6.3.1, we let \( \hat{\theta}' = (\hat{\mu}_C^j, \hat{\mu}_U^j, 0) \) be the restricted parameter vector for the (strict) non-synchronization (SNS) case, where \( \rho_{CN,US}^j = 0 \).

Under the null hypothesis \( H_0 \), the test statistic is:

\[
W = \sqrt{T} g(\theta, [S]_{t=1}^T) \hat{S}_T^{-1} \sqrt{T} g(\theta, [S]_{t=1}^T)
\]

Under the alternative hypothesis \( H_1 \), the model is exactly identified, and hence \( \bar{m}(\theta) = 0 \). The test statistic is a \( J \) test, the form of which is: \( J = \bar{m}(\theta)S_T^{-1} \bar{m}(\theta)' \). The \( J \) test is distributed \( \chi^2_1 \) asymptotically. For both types of business cycles, the test statistic is for the null hypothesis of non-synchronization. As there is only one restriction here, the test statistic has a \( \chi^2_1 \) distribution at 1 degree of freedom.

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\(^5\)See Hamilton (1994: p. 414), equations [14.1.19] and [14.1.20].
The Results:

In Table 6.3, we present the results from the single synchronization tests in the growth cycles and acceleration cycles between China and the US, for the sample time period from 1992Q1 to 2019Q4, which is before the outbreak of the coronavirus.

For the growth cycles, we find evidence of positive correlation with a coefficient of 0.27, a $\chi^2_1$ test statistic of 3.4, and a p-value of 0.06 at the 10% significance level. Hence, we reject the null hypothesis of non-synchronization, accept the alternative hypothesis and conclude that the growth cycles are synchronized between China and the US. Recall the definition of a growth cycle from Sect. 6.2. In a growth cycle, the peaks measure the points at which economic growth moves from above trend rate to below trend rate, while the troughs measure the points at which growth moves from below trend rate to above trend rate for a sustained period of time. So the positive correlation of their growth cycles between China and the US implies that when the US economy grows above its trend rate, the Chinese economy will also grow above its own trend growth rate.

For the acceleration cycles, we find that their contemporaneous cycle correlation is 0.19 with a $\chi^2_1$ test statistic of 2.0 and a p-value of 0.15, which is not significant. Thus, we fail to reject the null hypothesis and conclude that the acceleration cycles are non-synchronized between China and the US.

6.3.3 Single Synchronization Tests—Extension

In Sect. 6.3.2, we conduct single synchronization tests in the contemporaneous binary states of the business cycles, and find evidence of growth cycle synchronization between China and the US. In this section, we conduct correlation tests in the leads and lags of the binary states for the US, through which we would like to investigate further the relationship in the business cycles between China and the US. In the extension, we fix the binary states for China, but lag and lead the binary states for the US by 1, 2, 3, 4, 5, 6, 7, 8 periods, respectively. As an illustration, if we lag the US binary states by 8 periods, and if we find evidence of synchronization, then this means the US business cycle leads that of China by 2 years. Conversely, if we lead the US binary states by 8 periods, and if we find evidence of synchronization, then it means the US cycle lags that of China by 2 years.
The correlation between the binary states becomes:

\[ \rho_{CN,US}^{s,j} = Corr(S_{CN,t}^j, S_{US,t+l}^j) \]

where \( l = -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8. \)

The Results:

In Table 6.4 and Chart 6.3, we provide a summary of the results from the cross-time correlation tests between the binary states in the growth cycles and acceleration cycles for China and the US, for the sample time period from 1992Q1 to 2019Q4.

For the growth cycles, we find strong evidence of positive correlation between China and the US, from the lags of 3 quarters to the leads of 8 quarters. The interpretation of this finding is that the US growth cycle leads that of China by 3 quarters, and China’s growth cycle leads that of the US by 8 quarters. So there is interdependence and synchronization between China and the US in their growth cycles, with spillover effects on each other. If one economy grows above its trend rate, then the other economy will also grow above its own trend rate.

For the acceleration cycles, we find evidence of negative correlation between China and the US at the lags of 7 to 8 quarters, and at the leads of 5 to 7 quarters. In an acceleration cycle, the peaks measure the dates at which the rate of economic growth accelerates or decelerates. The results suggest that there is a tendency for China and the US to be in phase with each other during accelerations, implying that each country is likely to experience similar economic growth rates during these periods.

### Table 6.4  Cross-time correlation tests–China and the US, (1992Q1–2019Q4)

|                | Growth cycle | Acceleration cycle |
|----------------|--------------|--------------------|
|                | Correlation  | p-value            | Correlation  | p-value            |
| – 8            | 0.08830845   | 0.547861442       | – 0.417693169 | 0.004359366       |
| – 7            | 0.072362723  | 0.630452263       | – 0.288905647 | 0.022720696       |
| – 6            | 0.086539496  | 0.558373424       | – 0.124281609 | 0.324469145       |
| – 5            | 0.140843798  | 0.31313083        | – 0.038420927 | 0.752660013       |
| – 4            | 0.193223737  | 0.163577994       | 0.008304548  | 0.939608          |
| – 3            | 0.256263692  | 0.075357762       | 0.016986967  | 0.899129749       |
| – 2            | 0.299931722  | 0.048350697       | 0.06208416   | 0.644190047       |
| – 1            | 0.303857887  | 0.04127607        | 0.142674524  | 0.274754811       |
| 0              | 0.26877586   | 0.063716701       | 0.185695338  | 0.154333571       |
| 1              | 0.237819465  | 0.107721399       | 0.08559073   | 0.495277512       |
| 2              | 0.246017934  | 0.104056812       | – 0.052668352 | 0.702343201      |
| 3              | 0.294233716  | 0.042746686       | – 0.119026416 | 0.389857421       |
| 4              | 0.343345708  | 0.01742395        | – 0.149071198 | 0.175262109       |
| 5              | 0.393402211  | 0.008396904       | – 0.254657556 | 0.013926339       |
| 6              | 0.389948681  | 0.008499649       | – 0.324037319 | 0.01142625        |
| 7              | 0.386387056  | 0.013213564       | – 0.261682248 | 0.059152465       |
| 8              | 0.300476479  | 0.038402066       | – 0.120717495 | 0.375118574       |
growth begins to slow down, whilst the troughs measure the dates at which the rate of economic growth begins to increase. The interpretation of the negative correlation in their acceleration cycles is that if the rate of economic growth in the US economy starts to slow down, the Chinese economy will be resilient. So when the US sneezes, China will not catch a cold.

### 6.3.4 Joint Synchronization Tests

In this section, we conduct joint non-synchronization tests, with the null hypothesis that both the growth cycle and the acceleration cycle are jointly non-synchronized, and the alternative hypothesis that these two business cycles are jointly synchronized.

$$H_0 : \rho_{CN,US}^G = \rho_{CN,US}^A = 0$$

In this joint non-synchronization test, the moment conditions become:

$$m_t(\theta, S_t) = \begin{pmatrix} S_{CN,t}^G - \mu_{CN}^G \\ S_{US,t}^G - \mu_{US}^G \\ S_{CN,t}^A - \mu_{CN}^A \\ S_{US,t}^A - \mu_{US}^A \\ \frac{S_{CN,t}^G S_{US,t}^G - \mu_{CN}^G \mu_{US}^G}{\sqrt{\mu_{CN}^G(1-\mu_{CN}^G)\mu_{US}^G(1-\mu_{US}^G)}} - \rho_{CN,US}^G \\ \frac{S_{CN,t}^A S_{US,t}^A - \mu_{CN}^A \mu_{US}^A}{\sqrt{\mu_{CN}^A(1-\mu_{CN}^A)\mu_{US}^A(1-\mu_{US}^A)}} - \rho_{CN,US}^A \end{pmatrix}'$$
### Table 6.5 Joint Synchronization Tests–China and the US, (1992Q1–2019Q4)

|            | Growth cycle | Acceleration cycle |
|------------|--------------|--------------------|
| $\mu^G_{CN}$ | 0.6964       | $\mu^A_{CN}$ 0.5179 |
| $\mu^G_{US}$ | 0.5268       | $\mu^A_{US}$ 0.4286 |
| $\rho^G_{CN,US}$ | 0.2688   | $\rho^A_{CN,US}$ 0.1857 |
| Test statistic | 4.5977       | p-value 0.2037     |

where $\theta' = (\mu^G_{CN}, \mu^G_{US}, \mu^A_{CN}, \mu^A_{US}, \rho^G_{CN,US}, \rho^A_{CN,US})$, and $S = (S^G_{CN} \sim S^G_{US} \sim S^A_{CN} \sim S^A_{US})$.

In Table 6.5 the results for the joint non-synchronization tests are summarized. We find that the test statistics is 4.6, which is distributed Chi square with 3 degrees of freedom $\chi^2_3$, and it has a p-value of 0.20. So we fail to the reject the null hypothesis and conclude that their growth cycles and acceleration cycles are not jointly synchronized for China and the US. This is consistent with what find in the single synchronization tests (as reported in Table 6.3), in which we find that their growth cycles are synchronized but their acceleration cycles are non-synchronized.

### 6.4 Conclusion

In this chapter, we examine the synchronization of business cycles between China and the US. To that end, the concept of business cycles is explored and the comparison among them is made with various definitions that exist in the literature. We then measure their business cycles and apply the turning point approach to date the business cycles for China and the US. With the binary states from cycle dating, we conduct single synchronization tests (with an extension) and joint synchronization tests under a GMM framework. From our synchronization tests, we find strong evidence of positive correlation in the growth cycles between China and the US, with spillover effects on each other. In addition, we find evidence of negative correlation in the acceleration cycles between China and the US across time, which implies that when the rate of US economic growth begins to slow down, the Chinese economy will be resilient and will not follow the US into a contraction. So when the US sneezes, China will not catch a cold.
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