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Business Cycles in Some Selected Oil Producing Countries: Iran versus Three OECD Members

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Abstract

This paper analyses the fluctuations of the business cycle in selected oil-producing countries of the Organization for Economic Co-operation and Development (OECD) and Iran during the period 1970:Q1–2015:Q4. We start by using a two-stage Hodrick–Prescott filtering process to extract a cyclical component of GDP, then the modified BBQ algorithm is used to identify the chronologies and some measures of business cycle characteristics, and finally the main features of business cycle fluctuations (persistence, volatility, asymmetry, and synchronization) are estimated. The results indicate the difference in the characteristics of business cycle fluctuations in countries with different levels of economic

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development. Both amplitude and severity of Iran as a developing country were high, and average duration of contraction was longer than expansion. As a result, asymmetries in both steepness and deepness are observed in Iran. Meanwhile, output persistence and volatility in Iran were above and below that of three OECD members' average, respectively. The last part is based on the three indices for evaluating synchronization. Other findings reveal a high degree of synchronization between countries except Iran.

Keywords: growth cycle, OECD and Iran, Hodrick–Prescott filter, turning point analysis
JEL Classification: E32, C22, C14, C41, O57

1. Introduction

Burns and Mitchell (1946) believe that a business cycle consists of expansion occurring at about the same time in many economic activities, followed by the same general recessions, contractions, and revivals which merge into the expansion phase of the next cycle. Better economic planning is subject to recognition of the fluctuations of output and the reason for this fluctuation. Einarsson et al. (2013) argue that identification and comparison of the features of business cycles among different countries serve as a useful benchmark for modeling these countries' economies.

According to Ozbilgin (2017), timing matters for better policy-making in the business cycle. It is therefore important to recognize the characteristics of the business cycle such as duration, amplitude, and severity to have a clear view of the current state of the economy in order to make economic policies suitable for improving economic stability and lower production deviation from the long-term path.

Many of the existing studies, for example, Kydland and Prescott (1990), Englund, Persson, and Svensson (1992), Stock and Watson (1998), Pallage and Robe (2001), Castro (2010), and Chauvet (2011), are particularly concerned with the features of business cycles in developed countries. On the other hand, based on the approach developed by Rand and Tarp (2002), Cashin (2004), and Male (2010a), the characteristics of macroeconomic fluctuations in developing countries differ from those of developed nations. Moreover, the impact of fluctuations in the economic growth rate of developed countries like the US can

affect the entire global economy. For example, in the past recent years, several studies, like Katkov (2012), Verick and Islam (2010), and Bartmann (2017), have examined the impact of the 2008 recession on the global economy

More precisely, Rand and Tarp (2002) explain that the effects of technology transfer, financial and business relations, and capital flows between these countries affect business cycles in developing countries, although it depends on the structural characteristics and the degree of openness of these countries' economies.

The US, the UK, and Canada account for around 30 percent of world GDP. Thus, they play a major role in the global economy, and the occurrence of recession and expansion in these countries can significantly affect other countries in general and developing nations (like Iran) in particular. Moreover, all of them have joined the oil-exporting countries group over time, and therefore play an important role in oil market and oil price setting as well. On the other hand, many studies such as Farzanegan and Markwardt (2009), Delavari et al. (2011), Emami and Adibpour (2012), and Shahnazi and Afrasiabi (2018) argue that oil revenues are the major cause of the development of business cycles in Iran. Consequently, these countries can affect Iran's economy not only by their business cycles but also through their significant influence on world oil price because of the high dependence of Iran's public budget on oil export earnings. Furthermore, according to Kaihatsu et al. (2019), international country comparisons are needed in order to explore the interactions between business cycles and economic growth and their macroeconomic impacts. As a result, it can be of great importance especially in term of policy-making to compare these countries' business cycle characteristics and key features with those of Iran.

Our first effort in this direction is to determine the chronology of turning points in real GDP of countries surveyed, namely, the United States, the United Kingdom, Canada and Iran, in the period 1970:Q1–2015:Q4 and to determine the main features in the cycle of real GDP by using the method of Harding and Pagan (2002). Another effort of this study is to analyze its cyclical characteristics like persistence, volatility, asymmetry and synchronization. To evaluate the synchronicity of business cycles, our analysis is based on three methods: correlations of cyclical components of GDP, output gap synchronicity calculation, and measuring the similarity of output gap amplitude.

The remainder of the paper proceeds as follows: in Section 2, data and the methodology are explained briefly. Section 3 presents the results, including the business cycle chronology, the main characteristics and properties of business cycle fluctuations (persistence, volatility, asymmetry and synchronization) computed concerning the deviation or growth cycle definition of the business cycle. Section 4 presents the conclusion.

2. Methodology and data

The study proceeds by using quarterly real GDP data for the US, the UK, Canada, and Iran over the period 1970–2015. The quarterly data come from three different sources, namely the Federal Reserve Bank of St. Louis, World Bank Open Data and the Main Economic Indicators published by the OECD. The quarterly data are expressed in logarithms and are seasonally adjusted.

There are two distinct methodologies for the description of business cycles. The first method of determining the turning point is based on the Burns and Mitchell (1946) definition of the classical cycle. The second method is the growth cycle, which can be defined, following Lucas (1977), who wrote, "movements about trend in gross national product (GNP) in any country can be well described by a stochastically described difference equation of very low order." In this method, the output growth data are generally detrended to obtain the "growth cycles", which can be defined as the deviation of output from its long-term trend.

In general, a number of methods have been proposed for separating the trend from the cyclical component of an economic time series. The most common and widely used ways are the Hodrick–Prescott (HP) filter (1997), the Baxter–King (BK) band pass filter (1999) the Christiano and Fitzgerald (CF) band pass filter (2003) and the first-order difference (FOD). Based on De Haan, Inklaar, and Jong-A-Pin (2008), the filter should have the ability to eliminate unit roots and the capabilty of removing the cyclical component. In other words, the filter should isolate fluctuations of the data at a certain frequency. Baxter and King (1999) compare HP, FOD and BK on US quarterly and annual macroeconomic data sets. Their overall conclusion is that FOD diverges considerably from the other two

filters, but HP and BK extract similar cyclical components for quarterly data. Similarly, Larsson and Vasi (2012) show the similarity of HP, BK and CF for quarterly data cycles. However, when considering annual data, HP diverges from BK and CF, and FOD extracts cycles that are not similar to those of the other three examined filters. Besides, Marcet and Ravn (2001) argue that a natural requirement in cross-country applications is that similar procedures are applied to data for different countries. Partly for that reason, and partly due to ease of computation and reproduction, many researchers have adopted the HP filter for data detrending. As a result, this method is used in our study to obtain a smoothed nonlinear representation of considered time series.

2.1. The Hodrick–Prescott filter (HP)

The cyclical components of GDP (Y_t) are obtained through the double Hodrick–Prescott filter. The adjustment of the sensitivity of the trend to short-term fluctuations is achieved by modifying a multiplier denoted by $\boldsymbol{\lambda}$. The method minimizes the variance of the time series around the trend. To obtain a cyclical movement, other components of the GDP cycle should be removed. The logarithm of GDP (y_t), including long-run trend (T_t), cyclical movements (C_t) and irregular movements (shocks) (I_t) all in logarithmic form will be as follows:

$$y_t = T_t + C_t + I_t \qquad (1)$$

The HP filter is used in two steps to separate these components; first, the GDP time series is decomposed, and the long-run trend (T_t) is eliminated:

$$min\left\{\sum_{t=1}^{T}(y_t - T_t)^2 + \lambda \sum_{t=2}^{T-1}[(T_{t+1} - T_t) - (T_t - T_{t-1})]^2\right\} \qquad (2)$$

By subtracting the trend from the original series (y_t), we get a new series (Z_t) that contains the cyclical and irregular components:

$$Z_t = y_t - T_t = C_t + I_t \qquad (3)$$

In the second step, using again the HP filter on ($\mathbf{Z_t}$), we will obtain the smooth component, which is a cycle (C_t). The difference between ($\mathbf{Z_t}$) and (C_t) represents shocks or irregular components ($\mathbf{I_t}$) calculated according to the following equation:

$$min\left\{\sum_{t=1}^{T}(Z_t - C_t)^2 + \lambda\sum_{t=2}^{T-1}[(C_{t+1} - C_t) - (C_t - C_{t-1})]^2\right\} \qquad (4)$$

$$I_t = Z_t - C_t \qquad (5)$$

2.2. The Bry-Boschan algorithm

Canova (1994) argues that in a growth cycle, a contraction is defined as a phase where output is below its trend, while an expansion is a phase where output is above its trend. The methods used to identify peaks and troughs in the growth rate cycle are equivalent to those used in identifying classical business cycle turning points, the only difference being that they are applied to growth rates of the same time series, rather than their levels.

The dating algorithm follows the computerized method developed by Bry and Boschan (1971) to emulate the methodology NBER applies in dating business cycles for the US economy for monthly frequency (BB algorithm). Subsequently, the BB algorithm was adjusted for quarterly data by Harding and Pagan (2002) — the BBQ algorithm. The BBQ algorithm identifies a turning point when:

$$y_t > (<)y_{t\pm k} \qquad k = 2\ quarters \qquad (6)$$

The algorithm identifies a local maximum (minimum) as a peak (trough) relative to the 2 quarters on either side. A screening process is, furthermore, imposed on the initial turning points. The main restrictions are:

• A phase, the period between turning points, must last at least 2 quarters.

• A complete cycle (i.e. peak-to-peak and trough-to-trough) should last at least 5 quarters. This ensures that the periods of expansions and contractions are of a certain length.

• A peak and a trough must alternate. If two peaks (troughs) occur in a row, the higher (lower) one is chosen.

• In addition, the algorithm makes sure that no turning point can be determined within a 2-quarter length of the endpoints of the series.

2.3. Analysis of main characteristics

Harding and Pagan (1999) identify four characteristics: the duration, the amplitude, the cumulative loss or gain, and the excess. They present the recessionary phase by a triangle XYZ. Figure 1 shows a stylized recession with A being the peak and C being the trough:

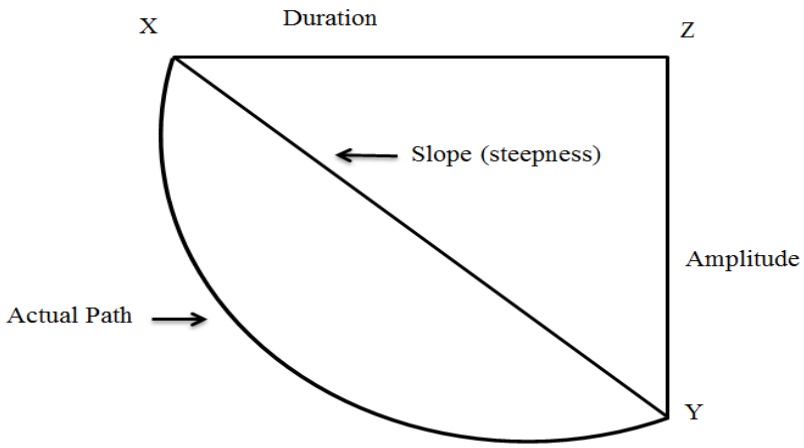

Figure 1: Stylized recession phase

Source: Harding and Pagan (1999).

The duration (D) is presented as the base of triangle XYZ (XZ) that shows how long it takes (in quarters) for the phase to be completed. The amplitude (A) is presented by the height of the triangle XYZ (ZY) which is given by the total change in output as the economy moves from its peak to its trough. Considering the amplitude and duration forming a triangle, then the area of the triangle can be seen as the welfare loss (gain) of a recession (contraction). That is the cumulated loss of output when compared to the value of output just before the turn. The 'triangle approximation to the cumulative movements' is given by:

$$C_{Ti} = 0.5(D_i \times A_i) \qquad (7)$$

where D_i represents the duration, and A_i represents the amplitude, for the i^{th} phase. The triangle approximation to the cumulative movement represents the cumulative change in output that would result if the economy evolved at a constant rate over a phase.

In practice, the actual cumulative movements ($\mathbf{C_i}$) may differ from the triangle approximation to the cumulative movements ($\mathbf{C_{Ti}}$) since the actual path through the phase may not be well approximated by a triangle so we need the index to describe the shape of the actual business cycle relative to the triangle approximation. The difference between the actual ($\mathbf{C_i}$) and triangle can be measured by the excess cumulated movement's index defined by:

$$E_i = (C_{Ti} - C_i + 0.5 \times A_i)/D_i \qquad (8)$$

The term $0.5 \times A_i$ removes the bias due to the approximation of a triangle by a sum of rectangles (C_i). A null excess index implies a linear level within a phase (contraction or expansion), thus a constant acceleration (negative or positive).

3. Results and discussion

3.1. The chronology of growth cycles

In order to detect the turning point of the growth cycle, Figure 2 plots the series of cyclical components of each country resulted from HP filtering process.

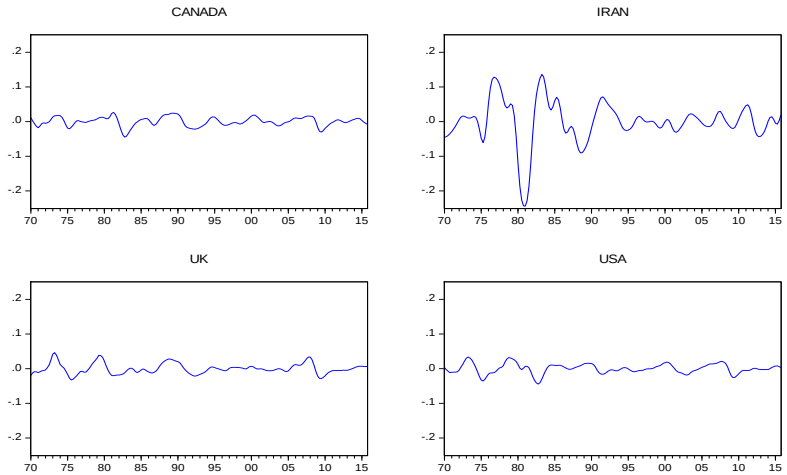

Figure 2: Cyclical components generated by HP filter

Note: Each figure applies in log of RGDP

The reference dates and durations in quarters for growth cycles are represented in the following tables:

Table 1: Turning points of the growth cycle.

Turning point	US	UK	Canada	Iran
peak/trough	73,Q2-75,Q2	73,Q2-75,Q3	73,Q4-75,Q2	72,Q3-73,Q3
peak/trough	78,Q4-80,Q3	79,Q2-81,Q2	76,Q3-77,Q3	74,Q1-75,Q2
peak/trough	81,Q1-82,Q4	83,Q3-84,Q3	79,Q4-80,Q2	76,Q4-78,Q3
peak/trough	84,Q3-87,Q1	85,Q2-86,Q3	81,Q2-82,Q4	79,Q1-81,Q1
peak/trough	89,Q3-91,Q3	88,Q4-92,Q2	85,Q4-86,Q4	83,Q2-84,Q3
peak/trough	92,Q4-93,Q3	94,Q4-96,Q3	89,Q2-92,Q2	85,Q2-86,Q3
peak/trough	94,Q3-95,Q4	97,Q3-99,Q2	94,Q4-96,Q3	87,Q2-88,Q3
peak/trough	00,Q2-03,Q1	00,Q1-02,Q3	97,Q4-98,Q3	91,Q3-94,Q4
peak/trough	07,Q4-09,Q2	03,Q4-04,Q4	00,Q2-01,Q4	96,Q3-97,Q3
peak/trough	10,Q4-11,Q2	06,Q1-06,Q3	02,Q3-03,Q4	98,Q2-99,Q2
peak/trough	12,Q2-13,Q2	07,Q4-09,Q3	06,Q1-06,Q3	00,Q2-01,Q3
peak/trough		11,Q2-11,Q4	07,Q4-09,Q3	03,Q3-06,Q1
peak/trough			11,Q4-12,Q4	07,Q3-09,Q2
peak/trough				11,Q2-12,Q4
peak/trough				14,Q3-15,Q2

Table 2: Summary statistics concerning growth cycles.

Statistics	US	UK	Canada	Iran
Sum duration				
Expansion	107	87	106	80
Contraction	71	79	68	91
Average duration				
Expansion	8.92	7.25	7.57	5.71
Contraction	6.45	6.58	5.23	6.07
Proportion (%)				
Expansion	58.03	52.42	59.14	48.47
Contraction	41.97	47.58	40.86	51.53

Max. duration				
Expansion	19	15	12	12
Contraction	11	14	12	13
Min. duration				
Expansion	2	3	3	2
Contraction	2	2	2	3

The results show that Iran is the only country with an average of the contraction (6.07) longer than the average of the expansion (5.71). Consequently, the proportion of time in contraction is greater than that of expansion. The average duration of the expansion or contraction phase differs widely across countries. The longest expansions are registered in the US, then in Canada, UK and Iran, and also the longest contractions are registered in the UK, then in the US, Iran and Canada. The longest duration of expansion, with 19 quarters, has occurred in the United States, and the longest duration of contraction is in the UK, with 14 quarters. Of the 184-quarter survey period, the highest number of expansion phases is 107 quarters in the US, and the highest number of contraction phases is 91 quarters in Iran. Also, the lowest number of expansion phases is 80 quarters in Iran, and the lowest number of contraction phases is 68 quarters in Canada. Our results support the previous findings of Castro (2010) and Craigwell and Maurin (2005), who demonstrate that expansion in developed countries is longer than contraction is, or, in more detail, the duration of expansion is higher on average. However, Du Plessis (2006) and Male (2010a) show that there is no clear pattern in business cycle duration.

3.2. Analysis of main characteristics

The cycle dating reported in Tables 1 and 2 is used to retrieve the country-specific business cycles characterizing expansion and contraction phases. The characteristics of the growth cycle are represented in Table 3.

Table 3: The main characteristics of the growth cycle

	SD	AC	Amplitude		Quarterly amplitude (steepness)		Deepness		Cumulative movements		Excess	
			PT	TP	PT	TP	PT	TP	PT	TP	PT	TP
US	0.014	0.94	-2.77	2.70	-0.43	0.29	-1.06	1.11	-11.12	15.61	-3.27	-0.09
UK	0.015	0.93	-2.60	2.28	-0.39	0.30	-0.98	1.33	-12.43	10.61	-3.99	-3.68
Canada	0.013	0.92	-2.35	2.37	-0.44	0.32	-1.04	1.04	-8.75	12.80	6.06	-2.41
Iran	0.060	0.94	-7.46	7.83	-1.24	1.37	-4.18	3.67	-29.85	36.09	-3.80	1.68

Notes: PT means the phase peak-to-trough and is therefore synonymous to the contraction phase. Similarly, TP is synonymous to the expansion phase. SD means the standard deviation of the cyclical components. AC means autocorrelation.

The first remarkable result is that the cycle amplitude of expansions and contractions is almost everywhere the same, but the amplitude of contractions and expansions are highest in Iran (almost 7.5%), and other countries' contraction and expansion amplitudes are just a third of that of Iran. According to the results, the hypothesis of Male (2010b), Du Plessis (2006) and Gallegati et al. (2004) was confirmed, which is the result of severe fluctuations in Iran's gross domestic product as a developing country compared to three selected developed countries.

Differences across countries can be found in the measures of cumulated movement in expansions and contractions. The average cumulative movement in contraction phases in Iran, the US and Canada is less than that of expansions. As a result, losses incurred in the expansion phase will be compensated, while in the UK this will not happen. For a contraction phase, a positive excess index means that the loss of growth is greater than it would be with linear growth. Therefore, the cumulative movements are less than the triangular approximation, and a negative index indicates that the loss is lower. Thus, the cumulative movements are larger than the triangular approximation. For the expansion phase, a positive excess index means that the gain of growth is greater than it would be with a linear growth so the cumulative gain is considerably less than that of the triangle approximation, and a negative index indicates that the gain is lower so the cumulative gain

is considerably more than that of the triangle approximation. The negative excess measure of cumulated output in the contraction phase in the US, UK and Canada shows that the cumulative movements are larger than the triangular approximation, indicating a more rapid subsequent decline in growth. Unlike these countries, the index is positive in Iran. On the other hand, for the expansion phase, a positive excess index in Canada shows that the cumulative gain is considerably weaker than that of the triangle approximation. In contrast, the negative excess index in the US, UK and Iran indicates that there is a much larger gain in output during expansions than that measured by the triangular representation.

3.3. Asymmetry

Business cycle asymmetry is the reason that the economy fluctuates differently over the contraction and expansion phases of the business cycle. According to the definition by Sichel (1993), an asymmetric cycle is one in which some phase of the cycle is different from the mirror image of the opposite phase. He described two types of business cycle asymmetry: deepness and steepness. *Steepness asymmetry*, referred to as longitudinal asymmetry, exists when contractions are steeper and shorter-lived than expansions. In order to illustrate the meaning of the other measures, it may be useful to think of the phase of a business cycle as a triangle with the amplitude as the height and the duration as the base. The quarterly amplitude or steepness is measured as the ratio of the average amplitude of the average duration of the period as follows:

$$STEEPNESS_{REC(EXP)} = \frac{AMPLITUDE_{REC(EXP)}}{DURATIN_{REC(EXP)}} \qquad (9)$$

Deepness asymmetry, which is also called transversal asymmetry, implies that the troughs are deeper than the peaks. *Deepness* pertains to relative average levels of peaks and troughs, as it refers to the characteristic that those troughs are further below trend than peaks are above. Hansen and Prescott (2005) use the verbal definition of deepness, that is, in a series that exhibits deepness, the peaks are shorter than the troughs are deep. In line with this definition, a ratio D can be calculated from data on the growth cycle, y:

$$D = \frac{mean(y>0)}{|mean(y<0)|} \qquad (10)$$

If $D< 1$, the series exhibits deepness, because then the average negative deviations from trend are bigger in amplitude than the positive deviations from trend. The lower value indicates more asymmetry in deepness.

The results of the analysis of asymmetry in Table 3 and the ratio D show that there is no evidence of deepness in the US (D=1.04) and Canada (D=1). There is evidence of inverse deepness in UK (D=1.36) while for Iran (D=.88), cycles exhibit deepness. In the UK, Canada and the US there is evidence of steepness but the inverse steepness in Iran. The highest values of the quarterly amplitude or steepness in both contraction and expansion phase are in Iran. The analysis of asymmetry reveals that, unlike the other studied countries, Iran's contractions are longer in duration than expansions are. Also higher amplitude of expansions and contractions were found in the case of Iran. There are many factors causing severe fluctuations in Iran's GDP relative to other countries and, as a result, leading to asymmetry. Among them are the shock to the oil market, the incidence of Islamic revolution, the eight-year-long imposed war between Iran and Iraq and, in recent years, international sanctions against Iran's nuclear activities (Madanizadeh, Karimirad, & Rahmati, 2019). The international trade sanctions restrain oil exports and imports of goods by imposing extra trade costs. Furthermore, exchange rate fluctuation leads to an increase in the cost of production, and, as a result, the price of domestic goods goes up. In terms of interest rates, like other developing countries the political risks are hardly predictable in Iran, and the country's international financing cost fluctuates a lot over time. Delavari et al. (2011) argue that besides oil revenue, which is a major cause of the development of business cycles, political tools, i.e., both fiscal and monetary policies, have a more influential role in the creation of business cycles.

3.4. Persistence and volatility

Output persistence can be measured in the time domain by the autocorrelation (AC), which computes the correlation of GDP with its own past previous periods, while a simple measure of economic volatility for all countries may be represented by the standard deviation (SD) of the cyclical component of the output. Technically, it measures how much

the series deviates from its average value. The values of output persistence and volatility are shown in Table 3.

The analysis of persistence shows there is a high degree of autocorrelation in country data. The persistence is above the average in Iran and below in Canada and also close to the average in the US and the UK. Except for Iran, in other countries the volatility was lower than its average. The lowest standard deviation was found in Canada, then in the US and UK. In general, Canada, UK, and the US have low volatility and high persistence, while in Iran, both indicators are high. Boroumand et al. (2019) argue that the very high contribution of the oil sector to the GDP of Iran explains its high volatility. Furthermore, the volatility of the non-oil sector is significantly related to fluctuations in the oil sector. Neumeyer and Peril (2005) and Aguiar and Gopinath (2007) show that, on average, the volatility of output is larger in developing countries than in developed countries. The latter study considers these features of business cycles in developing countries as a sign of extreme shocks to stochastic trends. According to Einarsson et al. (2013), there are, however, other potential explanations, such as the small resource-based nature of the economy, which tends to coincide with greater economic volatility, the relatively underdeveloped domestic financial system making consumption smoothing relatively costly, low saving rate and high debt levels.

3.5. Synchronization

Synchronization refers to the tendency of contractions and expansions in a country to occur at about the same time as in other countries. With greater synchronization of the business cycle, the probability of incidence of supply or demand shocks, which are asymmetric, declines. In this paper, three indices are used for measuring business cycle synchronization.

The first index is correlation analysis, which measures how the variables are related. The most widely used technique is the Pearson correlation coefficient (r_{xy}). The Pearson correlation coefficient is a measure of the linear correlation between two variables (in here, a cyclical component of a country such as x with a cyclical component such as y) and is formally expressed as:

$$r_{xy} = \frac{s_{xy}}{s_x s_y} \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \qquad (11)$$

where s_{xy} is the covariance x and y, s_x is the standard deviation of x, and s_y is the standard deviation of y. $\bar{x}$ is the mean of x, and $\bar{y}$ is the mean of y. The correlation coefficient has a value between +1 and -1. A value of 1 (total positive linear correlation) implies the perfect relationship between x and y.

A value of -1 (total negative linear correlation) implies the perfect negative relationship, and a value of 0 implies that there is no linear correlation between x and y. The results for the correlation coefficient of the countries are presented in the lower triangle of Table 4.

Table 4: Correlation (lower triangle) and synchronicity index (upper triangle)

	US	UK	Canada	Iran
US		0.77	0.8	0.47
UK	0.76		0.73	0.52
Canada	0.79	0.63		0.43
Iran	-0.14	-0.02	-0.44	

The highest positive correlation of the cyclical component is between the US and Canada, then between the US and the UK, and then between Canada and the UK. This shows that if the cyclical component of one of these countries increases (decreases), the cyclical component of another country will also increase (decrease). The cyclical component of Iran is not correlated with UK and US. Nevertheless, there is a negative correlation between the cycle of Iran and the cyclical cycle of Canada.

The second index used in this paper is the synchronicity index, which is based on the concordance index (Harding and Pagan, 2002), and it is expressed as follows:

$$I_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left[S_{it}S_{jt} + (1 - S_{it})(1 - S_{jt})\right] \qquad (12)$$

In this equation, the time series must be converted into a binary series in order to calculate this index. S_{it} denotes an output gap of a country i at time t, and S_{jt} denotes an

output gap of a country j at time t. The positive output gap has a value of 0, and the negative output gap has a value of 1. The index indicates how many percentages two countries have their output gap above or under their potential product at the same time. The results for the synchronicity index are presented in the upper triangle of Table 4.

The highest synchronicity of business cycles is between the US cyclical component with Canada and the UK. After that, there is a higher synchronicity between Canada and UK. Iran's synchronicity with Canada and the US is less than half, and with the UK it is about half. This indicates that there is no synchronicity between the cyclical component of Iran and other countries.

The third index, the similarity index, is based on Mink, Jacaobs, and De Haan (2007). This index works with differences of the magnitude of cycles, so the index evaluates the total distance between the cycles of country (i) and the reference country (r) in the period t as follows:

$$\gamma(t) = 1 - \frac{\sum_{i=1}^{n} |g_i(t) - g_r(t)|}{g_i(t)} \qquad (13)$$

where $\mathrm{g_i(t)}$ indicates an output gap of the country i in time t, and $\mathrm{g_r(t)}$ indicates an output gap in the reference country r in time t. The similarity index is computed in relation to the US as the reference country in Table 5, because the US is the economically strongest country in the global economy and the impact of its business cycle on other countries is greatest. A higher index indicates a higher level of similarity of business cycles.

Table 5: Similarity index between the US and other countries.

Country	Value
Canada	0.48
UK	0.35
Iran	0.09

Canada and the UK have the highest value and similarity in relation to the US. In contrast, Iran achieved the lowest similarity. With regard to the positive rate of the index obtained for these countries, it can be said that most of their output gap was in relation to the output gap in the US.

4. Conclusion

In order to obtain and recognize expansion and contraction phases, we need to recognize the return points of the business cycle. In doing so, we took the smoothed trend determined by the double-HP filter to specify the growth cycles, and then we proposed quarterly turning point chronologies through the non-parametric dating algorithm proposed by Bry and Boschan (1971) and adjusted for quarterly data by Harding and Pagan (2002).

Next, we analyzed the main characteristics of these cycles that are approximated by their measures of duration, amplitude, cumulative loss or gain, and excess. The results show that Iran is the only country with an average of the contraction phase longer than the average of the expansion phase, although in other countries, it is reversed. In addition, the cyclical amplitude of expansions and contractions is almost everywhere the same; however, the highest value is registered in Iran. In other countries, we found that the periodicity and amplitude of cycles are greater than that commonly found in other countries.

Iran records the highest values of the cumulated measure in expansion and contraction. The negative excess in a contraction phase in the US, Canada, and the UK shows larger cumulative movements, but the positive index in Iran shows larger triangular approximation. Also, the negative excess index in the US, UK and Iran indicate that there is a much larger gain in output during expansions than measured by the triangular representation, and the positive excess index in Canada shows that the cumulative gain is considerably weaker than that of the triangle approximation. In general, it can be said that the main characteristics of the developed countries studied are almost the same but differ from those of Iran.

Two types of business cycle asymmetry — deepness and steepness — were investigated. There is no evidence of deepness in the US and Canada as the level of peaks and troughs is identical. Also, there is evidence of inverse deepness in the UK as peaks are further above trend than troughs are below. Iran's cycles exhibit deepness as the highest value is registered in Iran. For the UK, US and Canada, there is evidence of steepness as expansions are longer and the phase's amplitude is similar, but there is evidence of inverse

steepness in Iran as the smaller severity of contraction over expansion due to contraction duration is longer.

Indeed, there is an inverse relationship between the selected countries' development level in our study and the amplitude and slope of business cycle fluctuations. In fact, in Iran as a developing country, both business cycles' amplitude and quarterly amplitude or steepness are greater than in other selected countries. It is clear, of course, that obtained results for Iran cannot simply be generalized to other developing nations as it requires more investigation. This is due to severe fluctuations in Iran's GDP relative to other countries, and it can be attributed to internal and external factors that have had an important role in its direction. In more detail, the shock to the oil market, the occurrence of war and revolution, international sanctions against Iran's nuclear activities, exchange rate fluctuation, and fiscal and monetary policies have a more influential role in the creation of business cycles.

The other investigated characteristics of business cycle fluctuations in this paper are output persistence and volatility. The results show that there is a strong tendency for persistence in the fluctuations of the business cycle before turning to the long-term trend. Most countries' persistence is close to the mean and possesses low volatility, except Iran, which has relatively more persistent fluctuations and more volatile fluctuations than average. The reason for the difference could be that Iran's economy is based on GDP that depends largely on a single product (oil). The other reason could be the greater incidence of exogenous shocks affecting Iran's output. These findings are consistent with prior studies, including Agénor, McDermott, & Prasad (2000), Loayza et al. (2007), Hakura (2009), Male (2010a), and Ajide and Osode (2017).

Finally, in order to examine the evolution of synchronization, our analysis is based on three methods: correlation, synchronicity and the similarity of output gap amplitude. The highest positive correlation of the cyclical component is between the US and Canada, then between the US and the UK, and then between Canada and the UK.. The results of the synchronicity index confirm the estimated values of correlation coefficients. The highest synchronicity is between the US and Canada, then the US and UK, and then between

Canada and the UK. The highest value and similarity in relation to US as the reference country is in Canada and the UK.

As a result of the magnitude of business between the US and its neighbor, Canada, and considering that the UK was one of the largest trading partners of the US in the European Union (EU) for most of the reviewed period, synchronicity and similarity of the business cycle have been expected. In Iran, the results show that there is no evidence for synchronization and correlation of cyclical components of GDP with other countries. The main reason is being a single-product economy as well as the lack of a strong business relationship with these countries, especially after the revolution in Iran.

In general, the results show that similarity in characteristics of countries is based on their difference in development and/or geographical closeness. More precisely, many of Iran's characteristics and key features are similar to other developing countries reviewed in other studies but differ from selected developed countries. Although the achieved results for Iran are not easily generalizable to other developing countries, this study can be regarded as an empirical evidence for the dependence of business cycle characteristics on the level of economic development. So, further studies on different groups of countries are recommended as complements to our findings. Moreover, development of non-oil sectors of the Iranian economy as a way of getting more synchronized with leading economies is another suggestion which can be raised based on obtained results.

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