The duration of Global Financial Cycles (GFCs) have a role in the global financial environment which is shaped by the fluctuations in short-term capital flows, changes in monetary conditions in the center economies and co-movement in asset prices. The duration of GFCs for a set of global financial data – the VIX index, the TED spread and the 3-Month LIBOR-Effective Federal Funds Rate – are analyzed by using a periodogram-based method. Our results suggest that there is a 43-month common cycle for these three series. We obtain eight different cycle periods for 43-month common cycles from our sample period.

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1. Introduction

The Global Financial Cycles (hereafter GFCs) is associated with a set of terms such as global risk appetite, global volatility and uncertainty, global liquidity, and global systemic risk. These terms depict a financial environment where US financial conditions affect developed and emerging market economies (EMEs) [1]. The GFCs is a process characterized by the changes in synchronized global financial factors such as fluctuations in short-term capital flows that adversely affect many EMEs [1–4], changes in monetary conditions in the center economies (especially in the US) [1,5–9] and co-movements in asset prices [1,10–12].

The changes in those global financial factors are affected by the duration of GFCs. In this case, forecasting the duration of GFCs is very important for policymakers as well as investors. Policy actions that policymakers take show their effects with a delay. Thus, taking actions in inappropriate time may increase the volatility of financial markets as well as the real sector, or make the policy actions ineffective. For example, the duration of GFCs is vital for central banks to respond to capital flows and to affect domestic economy with short-term interest rates. Furthermore, the duration of GFCs affects the government borrowing strategies in terms of choosing maturity and denomination of the currency on its borrowing; government may arrange borrowing and repayment schedules by considering the duration of cyclical movements in global financial variables. Moreover, investors may like to know the downturn or upturn of the GFCs for their portfolio adjustments. In this paper, we try to detect the duration of GFCs by focusing on different measures related to the GFCs.

In the literature, the Chicago Board Options Exchange Volatility Index (VIX index), the TED spread and the London Interbank Offered Rate-the Overnight Index Swap spread (LIBOR-OIS spread) are often used as the measure of the GFCs
because these three variables provide a useful framework for defining a set of concepts related to the nature of the GFCs. For example, [1,6,9,12–18] emphasize that the VIX index, TED spread and LIBOR-OIS spread are powerful indices of explaining the GFCs.

The Chicago Board Options and Exchange compiles the VIX index since January 1990. The VIX is the index that explains expected volatility for the S&P 500 index over next 30 days. The VIX index implies the forward-looking measures of the volatility of the S&P 500 index. The VIX index has two components as “expected actual volatility” representing a risk measure and “a variance risk premium” reflecting the risk aversion of investors [19]. The VIX index also reflects the risk premium at the global level (see; [22–24]), the global risk appetite of international investors (see; [1,25–29], the global market uncertainty (see; [30], and the global financial stress (see; [31,32]). Therefore, following the literature, since the VIX index explains risk premium, risk appetite, market uncertainty and financial stress at the global level, we use the VIX index for our analysis in order to measure the duration of GFCs.

The TED spread is provided by the Federal Reserve Bank of St. Louis since January 1986. The TED Spread is the difference between the 3-Month LIBOR Rate on Eurodollars (LIBOR) and the 3-month US Treasury Bill Rate. The TED spread reflects the global systemic risk which is the failure of systemically important institutions and markets and early warning signals of distress as well (see; [30,33,34]), and also gives information about global liquidity conditions (see; [35–37]). Therefore, following the literature, since the TED spread indicates systemic risk and liquidity conditions at the global level, we add to the TED spread to our analysis to evaluate the duration of GFCs.

For the relation of the VIX index and the TED Spread, the VIX index and the TED spread move together with short-term capital flows [38]. These movements explain the expansion and contraction periods of the GFCs. The lower values of the VIX index and the TED spread are related to the expansion period of the GFCs; during the GFCs’ expansion period, risk perception decreases at the global level, the risk appetite of international investors increases and global liquidity expands [39,40]. In parallel to these developments in the global financial markets, an increase in short-term capital inflows towards EMEs led to an increase in the credit volume in these countries, the application of high leverage transactions and the rapid rise in asset prices [1,7]. However, this moderate process mentioned above does not persist. Contraction periods of the GFCs are correlated by the higher values of the VIX index and the TED spread. In a contraction period of the GFCs, unlike the expansion period, the risk perception increases at the global level, the risk appetite of international investors decreases and global liquidity shrinks (risk-averse period). As noted in [23,30,41–44], due to the rise in the TED index and the TED spread in the event of US stock market being more volatile, international investors who abstain risky activity demand higher risk premium, and tighter their balance sheet to move to a risk-off position. This unfavorable environment in the global financial system triggers capital outflows and threatens the EMEs’ economic performance and their domestic financial stability [3]

Another variable that also measures the GFCs is the LIBOR-OIS spread. The LIBOR-OIS spread provided by the Federal Reserve Bank of St. Louis since December 2001 and that is the difference between the 3-Month LIBOR Rate on Eurodollars and the 3-Month Overnight Indexed Swaps (OIS). The LIBOR-OIS spread measures the credit risk for the global banking sector and in this respect, shows the stress in private interbank funding markets at the global level. Therefore, an increase in the LIBOR-OIS spread provides information about soaring stress in the banking sector at the global level [17,48,49]. Fluctuations in the LIBOR-OIS spread is parallel with the VIX index and the TED Spread.

On the other hand, in the literature, the OIS series is assessed as an accurate measure of market expectations on the Effective Federal Funds Rate (see; [50,51]). Therefore, the difference between the 3-Month LIBOR and the Effective Federal Funds Rate (LIBOR-EFF) can also be assessed as a proxy variable instead of the LIBOR-OIS spread [52,53]. Similarly, with the LIBOR-OIS spread, the LIBOR-EFF spread shows the funding liquidity of private interbank funding markets at the global level [54]. In this paper, by considering data non-availability of the LIBOR-OIS spread before December 2001, we employ the LIBOR-EFF spread as another measure to explain the GFCs.

Several studies are employing different methods to identify the sources and durations of cycles in time series. Beveridge and Nelson [55], Nelson and Plosser [56] and Campbell and Mankiw [57], using ARMA or ARIMA processes, decompose the fluctuations in the series as permanent and transitory (cyclical) components. Harvey [58], Watson [59] and Clark [60] examine the cyclical behavior in the series by employing Kalman filtering. Engle and Granger [61] introduce a cointegration specification for macroeconomic variables for identifying the sources of cycles. Granger et al. [62] identify the cycles in the series by using a Smooth Transition Regression (STR) model. Hamilton [63], Chib [64], McCulloch and Tsay [65], Durland and McCurdy [66], Filardo [67], and Filardo and Gordon [68] search for the presence of expansionary and contractionary phases in the cycles by using Markov-Switching models. Bry and Boschan [69] make a non-parametric algorithm procedure to detect the turning points and durations of cycles. Diebold and Rudebusch [70], Watson [71].

1 For detailed information see: [20,21].
2 We calculate that the correlation coefficient between the VIX index and the TED spread variables is 0.51 for the period of January 1990–October 2018 that we use in our analyses.
3 In EMEs with high debt dollarization and high current account deficit is associated with the “sudden stop” problem defined by Calvo et al. [45].
4 The correlation coefficients between the LIBOR-OIS spread and the VIX index, and the LIBOR-OIS spread and the TED spread are 0.38 and 0.67, respectively, for the period of January 1990–October 2018.
5 These studies generally focus on the business cycle.
Diebold et al. [72], Ohn et al. [73], Harding and Pagan [74] and Castro [75] follow Bry and Boschan [69]'s non-parametric method and they try to detect the durations in the cycles.

The other non-parametric method in the literature identifying the duration of cycles in the time series is a periodogram-based analysis which depends on frequency domain methods. Here, periodograms capture the specific periods in the series which are called "periodicity". Unlike the time domain analysis which captures the seasonality in the series, periodograms capture the periodicities beyond the seasonality. Therefore, the periodicity captured by periodogram reflects that the series repeats the same movements over a certain period of time. Cochrane [76], A'Hearn and Woitek [77], Bierens [78] and Al Zoubi and Maghyere [79] use periodogram-based analysis to identify durations of the cycles.

In this study, in order to identify the duration of GFCs, we use a periodogram-based analysis, which allows finding hidden cycles in the time series. There are several reasons to use periodogram-based analysis. Brockwell and Davis [80], Fuller [81], Wei [82] and Akdi and Dickey [83] list advantages of using periodogram-based analysis that (i) The periodograms are calculated by trigonometric transformations without depending on any model specifications; also, the method is invariant to the mean. (ii) The fact that the critical values of the distribution do not depend on the sample size provides more efficient estimates for small samples. (iii) There is no need for estimating any parameters other than the variance of the white noise series. (iv) The analytical power function exists for the test since the normalized periodogram is asymptotically distributed as $\chi^2$ with two degrees of freedom [80–82], namely, (v) If the data have periodic components, then results seem to be robust.

Unlike the previous studies, this is the first study to focus on the calculation of the duration of cycles in the global financial system. According to periodogram-based analysis for the VIX index, the TED spread and the LIBOR-EFF spread, at the period from January 1990 to October 2018, we calculate the duration of cycle in the global financial system as a 43-month corresponding to three and a half years. Thus, we obtain eight different cycle periods for the 43-month common cycle from our sample period.

The remainder of this paper is organized as follows. In Section 2, we introduce the method. Section 3 presents the empirical evidence. Finally, in Section 4, we conclude.

### 2. Method

This study searches for the duration of GFCs by employing a periodogram-based analysis. In order to capture the periodic components in the series, a trigonometric regression model can be written as

$$Y_t = \mu + R \cos(w_k t + \phi) + e_t, \quad t = 1, 2, \ldots, n$$

(1)

where $Y_t$ represents the time series of interest, $\mu$, $R$, $\phi$ and $w_k$ are the expected value, the amplitude, phase, and frequency of the $Y_t$ series, respectively. Also, $e_t$ is the white noise error sequence. From the properties of the cosine function, $a = R \cos(\phi)$ and $b = R \sin(\phi)$, the model given in Eq. (1) can be written as

$$Y_t = \mu + a \cos(w_k t) + b \sin(w_k t) + e_t, \quad t = 1, 2, \ldots, n.$$  

(2)

When $w_k = 2\pi k/n$ is selected, the OLS estimators of $\mu$, $a$ and $b$ can be calculated as

$$\hat{\mu} = \frac{1}{n} \sum_{t=1}^{n} Y_t, \quad \hat{a} = \frac{2}{n} \sum_{t=1}^{n} (Y_t - \bar{Y}_n) \cos(w_k t) \quad \text{and} \quad \hat{b} = \frac{2}{n} \sum_{t=1}^{n} (Y_t - \bar{Y}_n) \sin(w_k t).$$

(3)

Here $a_k$ and $b_k$ estimators are known as the Fourier coefficients. Because of the properties of trigonometric functions, then one can write

$$\sum_{t=1}^{n} \cos(w_k t) = \sum_{t=1}^{n} \sin(w_k t) = 0.$$  

(4)

Note that the Fourier coefficients are invariant to the mean; therefore, the Fourier coefficients can also be calculated as

$$a_k = \frac{2}{n} \sum_{t=1}^{n} Y_t \cos(w_k t) \quad \text{and} \quad b_k = \frac{2}{n} \sum_{t=1}^{n} Y_t \sin(w_k t).$$

(5)

From these OLS estimators based on the model given in Eq. (2), the periodogram ordinate at the frequency $k$ is calculated as

$$I_n(w_k) = \frac{n}{2} (a_k^2 + b_k^2).$$

(6)

Since the Fourier coefficients are invariant to the mean, the periodogram ordinates are also invariant to mean. If the time series is stationary with a spectral density function $f(w_k)$, then the normalized periodogram ordinate is asymptotically distributed as chi-square with two degrees of freedom [80–82], namely,

$$I_n(w_k)/f(w_k) \xrightarrow{D} \chi^2_2 \quad \text{as } n \to \infty.$$  

(7)
where \( \xrightarrow{D} \) stands for convergence in distribution.

The periodograms are often used to search for hidden periodicities for stationary time series. They are also used to test for a unit root and estimation and testing for cointegration for a multivariate time series.

The normalized periodogram ordinate is asymptotically distributed as chi-square with two degrees of freedom as it is given in Eq. (7). Akdi and Dickey [83] calculate the distribution of the normalized periodogram ordinates for a time series with a unit root for fixed \( k \) and propose a method to test for a unit root based on the periodogram ordinates. The asymptotic distribution is valid for any fixed \( k \), but it is recommended to use \( k = 1 \). The test statistics for each fixed \( k \),

\[
T_n(w_k) = \frac{2(1 - \cos(w_k))}{\hat{\sigma}^2} I_n(w_k),
\]

is defined as a test statistic to test for a unit root. Under the null hypothesis that the time series has a unit root,

\[
T_n(w_k) = \frac{2(1 - \cos(w_k))}{\hat{\sigma}^2} I_n(w_k) \xrightarrow{D} Z_1^2 + 3Z_2^2 \text{ as } n \to \infty
\]

where \( Z_1 \) and \( Z_2 \) represent independent standard normally distributed random variables and \( \hat{\sigma}^2 \) is for any consistent estimator of the error variance. That is, the asymptotic distribution of \( T_n(w_k) \) is a mixture of chi-squares (namely, \( T_n(w_k) \) \( \xrightarrow{D} \chi_1^2 + 3\chi_2^2 \) as \( n \to \infty \)). Therefore, the null hypothesis of a unit root is rejected if the value of \( T_n(w_k) \) is small.

On the other hand, periodograms can be used to examine the hidden cycles based on the largest periodogram ordinate in the data for a stationary time series. A test statistic based on the largest periodogram ordinate

\[
V = I_n(w_{(1)}) \left[ \sum_{i=1}^{m} I_n(w_k) \right]^{-1}
\]

is defined where \( I_n(w_{(1)}) \) denote the largest periodogram values.

Under the null hypothesis that there is no periodic component, \( P(V > c_\alpha) \cong m(1 - c_\alpha)^{m-1} \) where \( m = (n - 1)/2 \) if \( n \) is odd; and \( m = (n/2) - 1 \) if \( n \) is even. If the value of \( V \) is bigger than the critical values \( c_\alpha \) for a given significance level \( \alpha \), then we reject the null hypothesis \( H_0: a = b = 0 \) that the data has no periodic component.\(^6\) Then, we can say that the model contains a periodic component [82].

In order to search for further periodic components in the series, let \( I_n(w_{(i)}) \) be the \( i \)th largest periodogram ordinate and define a test statistic as

\[
V_i = I_n(w_{(i)}) \left[ \sum_{i=1}^{m} I_n(w_k) - \sum_{s=1}^{i-1} I_n(w_{(s)}) \right]^{-1}
\]

where \( V_i \) is the test statistics for determination of a periodic component in series. If \( V_i > c_\alpha \), then we reject the null hypothesis of no periodic component and conclude that the series has a periodic component at the corresponding frequency [82], [295].

3. Empirical evidence

In this paper, we aim to calculate the duration of GFCs by using a periodogram-based analysis. We, following the literature, choose the VIX index, the TED spread and the LIBOR-EFF spread as proxy variables for the GFCs. The series of the TED spread and the LIBOR-EFF spread are calculated by the Federal Reserve Bank of St. Louis and they are available from January 1986. However, the VIX index series issued by the Chicago Board Options Exchange is available from January 1990. Therefore, when we consider the availability of common data time span, then our data span comprising 346 observations covers January 1990–October 2018. We gathered all datasets from the Federal Reserve System Bank of St Louis (FRED).

Table 1 reports the descriptive statistics of the three series that we consider. Even if the VIX index has the highest average, the coefficient of variations (the standard deviation divided by the mean) suggests that the VIX index is the most dispersed.

\(^6\) We can test \( H_0: a = b = 0 \) with the Fisher’s test based on the periodogram. Since the frequency of \( w_k \) is unknown, using a standard \( F \) distribution is not appropriate [82].
The time series plots, Autocorrelation Function (ACF), and Partial Autocorrelation Function plots (PACF) of the VIX index, the TED spread and the LIBOR-EFF spread are given in Fig. 1. Autocorrelation functions of these series suggest that these series do not have a unit root. Furthermore, each series shows periodic fluctuations.

To determine whether these series have a long-run constant mean, we perform a set of unit root tests. Table 2 reports the Augmented Dickey–Fuller (ADF) and the Phillips–Perron (PP) unit root tests. According to both ADF and PP tests, we reject the null of unit root for the VIX index and the LIBOR-EFF spread series at the 1% level. We reject the null of unit root for the TED spread series according to the ADF test at the 5% level and the PP test at the 1% level. Thus, we treat all series as stationary I(0). We also applied a periodogram-based unit root test [83]. The results of unit root tests based on a periodogram-based approach are reported in Table 3. The value of the test statistics for the VIX index is less than the critical value at the 5% level, and the values of test statistics for the TED spread and the LIBOR-EFF spread are less than the critical value at the 1% level. Thus, we reject the null of a unit root, and then we conclude that all series are stationary at the 5% level.
In order to search the cycles in the VIX index, the TED spread and the LIBOR-EFF spread, we use the periodogram analysis. The corresponding values of the $V$ statistics and periods are tabulated in Table 4. We find a 43-month common cycle among these three series. This cycle duration corresponds about three and a half years. Fig. 2 plots these series with the corresponding cycle breaks. We also find different cycles of 69-month for the VIX index and 87-month for the TED spread and 21-month for the LIBOR-EFF spread.

The common cycle of 43 months may need to be evaluated with a further analysis for its. This 43-month GFCs may need to be synchronized with the cycles of real variables (business cycles). Namely, authorities take actions to stabilize
their economies. When an economy is in a downturn or in an upturn, then loose and tight monetary policies will be implemented to stabilize these economies, let us say, until cycles reach to their midpoints of downturns and upturns of an economy. In other words, during a full business cycle, financial variables that are related to the stance of monetary policy need to be set to its neutral positions of monetary policy stance twice. If the cycles are symmetric, then duration of financial cycles should be half of the business cycles or business cycles duration should be double of financial cycles duration. In order to entertain this idea, we perform analyses with the US unemployment rate. The estimates are reported in Table 5. The evidence suggests that this cycle is 86 month (exactly double of the common GFC).

On the other hand, as a robustness check, we repeat the analyses for the TED spread and the LIBOR-EFF spread for January 1986-October 2018. Thus, we have performed the analysis for the common periods of these series. The corresponding values of the V statistics and periods are tabulated in Table 6. We again find a 43-month common cycle for both series and we also find different cycles of 78-month for the TED spread and 21-month for the LIBOR-EFF spread. Therefore, since the duration of common cycle does not change even if the sample size changes, we can say that our results are robust to capture the common cycles.

### 4. Conclusion

The Global Financial Cycles (GFCs) is the term being related to the changes in the global financial environment and depicts the changes in global risk appetite, global volatility and uncertainty; as well as global liquidity and global systemic risk. The duration of GFCs is important because of affecting the global financial environment shaped by fluctuations in short-term capital flows, changes in monetary conditions in the center economies and co-movement in asset prices.

In the literature, the VIX index, the TED spread and the LIBOR-EFF spread are considered as a proxy for the global financial cycles. When these time series are examined, it is shown that these series move together. Therefore, calculating the duration of the cyclical movements of these three series is important to understand the global financial cycles.

In this paper, for the period from January 1990 to October 2018, we examine the cycles in these three series by using a periodogram-based analysis which allows us to search for the hidden cycles in the series. Our estimates suggest that the 43-month common cycle which corresponds about three and a half years are observed for these three series. Therefore, we observe eight different cycle periods for 43-month common cycles from our sample period.

Our analyses have several policy implications for policymakers: (i) Policymakers may consider the duration of global financial cycles for timing of their policy actions; (ii) Our results may also be useful to forecast the end of the current cycle or where the economy is in the current cycle; and (iii) Once similar duration cycles are observed for real and financial variables, and if there is a long-run relationship between the GFCs and the real variable cycles, then magnitude and timing of policy actions may be set more appropriately. As further research, our analysis may be applied for different financial variables as well as real variables. Finding different duration may also lead to determining what kind of factors such as technology, labor market frictions and price indexation may affect these differences in the duration of the cycles.

### References


### Table 6

<table>
<thead>
<tr>
<th>Period</th>
<th>TED spread</th>
<th>LIBOR-EFF spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>–</td>
<td>0.7493 0.0467</td>
</tr>
<tr>
<td>43(^a)</td>
<td>1.3383 0.0537</td>
<td>0.9397 0.0527</td>
</tr>
<tr>
<td>78</td>
<td>5.8832 0.1497</td>
<td>– –</td>
</tr>
</tbody>
</table>

Note: The critical values are $c_{0.01} = 0.0492$, $c_{0.05} = 0.0414$ and $c_{0.10} = 0.0380$ [62, 294].

\(^a\) is for the duration of the common cycle.