THE SYNCHRONISATION BETWEEN FINANCIAL AND BUSINESS CYCLES: A CROSS SPECTRAL ANALYSIS VIEW

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Abstract. Our study bridges the gap between in previous research on the synchronization between financial and business cycles over a long period. Using the data for the UK from 1270 to 2016 we analyze the synchronization between financial and business cycles using spectral Granger causality (Breitung & Candelon, 2006). Our paper brings several important findings to the discussion on the financial and business cycle link. Our paper is the first one (to the best of our knowledge) that use data over a long period spanning several centuries. We use spectral analysis and advanced spectral analysis (SSA) and (MSSA) to study the relationship between financial and business cycles in the long run. Paper results show financial and business cycles series moves along over the medium-term spectrum. We find a strong link between the cyclical component in the output (real GDP series) and the cyclical component in the financial series (housing price, credit).

Introduction

This paper identifies and monitors financial and business cycles coherence in the UK over eight centuries 1270–2018. We can trace the concept of financial cycles in Fisher (1933), Keynes (1936), Kaldor (1940), Hudson (1957), Minsky (1964, 1986). Financial cycles after the year 2000, especially after the financial crisis of 2008 continues to attract attention in the academic field. High economic and opportunity costs of the crisis to government, business and people, ignited the fear that the event could repeat. Secular stagnation, appearing immediately after the crisis, slowing down of the global economy, private debt peaking beyond 2008's level seem like clear warning signs. Majority in the academic field expect the new crisis will be the outcome of the rising global trade wars and Brexit struggle in Europe. However, the question is, since the crisis of 2008 being a financial one, why the next business cycle will

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not be a consequence of a new financial crisis (or cycle)? To answer this question, we need to monitor a change in the dynamics of the business and financial cycles over the long run (search for a permanent component in the data series). Do financial cycles lead or lag business cycles? What is the level of synchronization between the two? How long and how often they happen and interact? Prior study (Porada-Rochon & Škare, 2020) of the business and financial cycles interaction from 1270–2016 in the UK looks at the spectral Granger causality dynamics. In this study we explore in deep the cross spectral analysis over four different synchronicity (cross-spectra) indicators.

The effort to measure financial cycles starts with the novel empirical research of Borio et al. (2001), Drehman et al. (2012, 2013). While the body of literature on financial cycles is increasing, the issue of the proper method for measuring financial cycles remains. Methods range from traditional business cycles turning point analysis (Burns & Mitchell, 1946; Claessens et al., 2012; Hiebert et al., 2018) to structural trend-cycle decomposition (Bonis & Silvestrini, 2013), univariate spectral analysis (Aikman et al., 2015; Skare & Porada-Rochon, 2019b), multivariate spectral analysis (Strohsal et al., 2018; Schüler et al., 2014) unobserved component models (Koopman & Lucas, 2005; Galati et al., 2016), wavelet analysis (Scharnagl & Mandler, 2019).

The theory and mechanism behind financial cycles are still missing. This paper attempts to narrow a gap in the literature on financial and business cycles using extensive time-series data (annual data from 1270 to 2018) and (MSSA) Multi-Channel Singular-Spectrum Analysis (Vautard & Ghil, 1989). This approach shows to be robust to the red noise we encounter in extensive data generating processes allowing more precise cycle length identification. We apply our multi-channel singular spectrum model on data for the United Kingdom from 1270 to 2018. We use individual time series variables to isolate the pattern representing the UK financial cycle. Following Drehmann et al. (2013), we use data on the real house price index, credit and credit to GDP ratio in England. We isolate oscillatory patterns in individual time series. Using (MSSA), we reconstruct the three series applying isolated patterns and averaging reconstructed series to get a financial cycle in the UK. Empirical results in this paper point to three important facts. First, singular spectrum analysis allows robust identification of oscillatory patterns (cycles) in the house price index, credit and credit to GDP ratio. Second fact, cycles in house prices, credit and credit to GDP ratio vary over time (over eight centuries of data). Cycles in the individual series show high similarities (length, spectrum).

We organize the remainder of the paper as follows. Section two reviews the existing literature on the link between financial and business cycles. We present the research framework in part three, along with the data we use in the study, findings of the article we give in section four. The article concludes with a summary of the paper research contribution and recommendations for future research and policymakers.

1. Literature review

While we can consider research on business cycles as a developed area of research, financial cycles are in the initial phase. We observed more intensive discussion in financial cycles with the crisis in the year 2008. The financial cycle concept is rather new and originates from

work carried out by Borio, Kennedy, and Prowse (Borio et al., 1994). These over two decades of theoretical and empirical studies confirm that the financial cycle plays a crucial role not only as a source of business cycle fluctuations but also in macro – and micro-prudential policymaking.

Despite relatively narrow literature on the financial cycle, there is no agreed definition of it. There is a consensus among researches that the financial cycle is longer than the business cycle and has a higher amplitude. Existing analyses on characterizing financial cycles remain scarce and describe their nature, length (duration), amplitude, slope, asymmetry. We must note it that international studies, and advanced countries' data dominating over national ones.

The limitations of recent researches include small research sample to the number of countries (hardly available data or lack, therefore), lack of consensus on the methods, relevant financial indicators. Above all, the theory about the financial cycle is still undiscovered. Consumers' home buying attitudes in the US strongly affects housing market demand and prices (Gupta et al., 2019). European house price deviation is highly contagious and affected by the rising inflation (Tsai, 2019).

The literature review will cover only relatively new results of research since the last decade, and it covers national and international ones. Following approaches comprise researches examine the existence of the financial cycle and some individual feathers and synchronization between the cycles and countries.

The global cycle, driven by US monetary policy, triggers domestic financial cycles, was evidence from Strohsal et al. (2019). They introduce parametric spectrum estimation to confirm the existence of a national financial cycle in the US, with slightly weaker evidence for the UK, and the weakest statistical evidence for Germany. Financial and economic development in the European Union countries also show tight connections (Ginevičius et al., 2019). Investor sentiment have a significant impact by behavioral bias on assets prices influencing equity markets (Rashid et al., 2019).

Extensive research was done by Adarov (2018) who adopt dynamic factor models and state-space techniques on a sample of 34 advanced and developing countries from 1960 to 2015. The findings confirm the existence of the financial cycle and evidence of highly persistent and recurring nature of financial cycles, and frequencies 9–15 years on average. He notices notable intraregional synchronization, and nontrivial co-movement tendencies between European, American and Asian financial cycles. The evidence that the financial cycle is strongly synchronized with banking crises and business cycles was obtained by Harding and Pagan (2016). Skare and Porada-Rochon (2019a), using singular spectrum analysis (SSA) techniques isolate financial cycles for ten selected economies (Belgium, Denmark, Finland, France, Germany, Italy, Japan, Switzerland, Spain, USA) in the period 1970–2018 and also confirm synchronization with business cycles. On average, the financial cycle lasts nine years with long memory properties (no mean reversion after the shock). The findings also show longer oscillations in the credit and property price series, which can explain 37.7–49.9% of the variance of the total financial cycle fluctuations. Based on sample of 17 advanced economies Jorda et al. (2017) pinpoint co-movements of financial and business cycles. Vasicek and Monteiro did cross cross-country comparison (2018) in the context of Euro area. In most

countries, synchronization occurs to both business and financial cycles; however, to a lesser extent, this applies to financial cycles. From a national perspective, El-Baz (2018) using BBQ cycle dating algorithm and the Vector Autoregression (VAR) model, in Saudi Arabia over the period (1970–2016), highlighted that business and financial cycles had been synchronized to a considerable degree although not perfectly synchronized.

Bilan et al. (2019) point the role of trust in explaining the causal mechanism between financial and business cycles and confirm therefore the synchronization of both cycles through the trust cycle but with a certain delay in terms.

Slightly opposite results, showing a lack of synchronization of the financial cycle in Eurozone between the years 1970–2018 were got by Coussin (2019). Using classical method, he also finds that after introducing the Euro, the consistency and similarity of the amplitudes between financial cycles have decreased.

Empirically the extent of the length and duration of financial cycle was researched by Antonakakis et al. (2015) using VAR models over the period 1957–2012 in G7 countries, find that the magnitude and direction of spillovers between financial cycles and business cycles vary over time along with changes in the economic environment. Using Continuous Wavelet Transform (CWT) techniques, Altar et al. (2017) confirm frequent evidence that financial cycles are significantly longer than business cycles, with developed economies. Hong Kong, Malaysia, the Philippines and Thailand were researched by Pontines (2017) via spectral analysis. Evidence suggests that except for the equity price growth in Hong Kong, the period of the proxy measures for financial cycles is slightly longer than the period of the business cycle. Confirmation of greater length and amplitude than business, using a frequency-based filter get Aikman et al. (2015).

Applying Bayesian Structural Time Series Models of unobserved components (STM) and Singular Spectrum Analysis (SSA) followed by Fourier-based Spectral Analysis for 28 countries Gonzalez et al. (2015) show that most countries in the sample have financial cycles between 13 and 20 years, but less often get results were more close to business cycle, i.e., 3 to 7 years.

Also, different results concerning the length and size of financial cycles between the United States and France, Germany, Italy, Spain and the United Kingdom were obtained by Rünstler and Vlekke (2016). Using a multivariate time-series approach, they find that financial cycles are closely related to a medium-term component in the GDP cycle.

Valuable strand of the literature on exploring the interaction between business and financial cycles fluctuations point that the duration of the financial cycle is longer and usually differ across the countries. There has been growing evidence of the inter-linkages between financial and business cycles. Differences in evidence may also result from the method used and the limitation of data. While the number of researches on financial cycles is increasing, the proper method for measuring financial cycles remains and a real theory explaining the financial cycle. Financial cycles are linked to crises; therefore, closed regular monitoring of the financial cycle is essential to enhance macroeconomic and financial stability. Moreover Borio and Drehmann (2019) find evidence that financial cycle measures have significant forecasting power.

2. Materials and methods

Our study is novel (in the best of our knowledge) since it uses extensive time-series data on house price index, credit and credit to GDP ratio. The primary source of data is the Bank of England research data repository (Ryland & Dimsdale, 2017) and Broadberry et al. (2015) Clark (2010), Jordà et al. (2017). Here is the list of the variables we use in the modelling:

- RGDPC = Real GDP of England at market prices (£mn, Chained Volume measure, 2013 prices)
- HPRICE = House price index (using building costs as a rough proxy for missing periods) available from the Bank of England over 1845–2016.
- LOAN = Credit to Private non-financial sector from Banks, total at Market value – calculated using a trend in financial services production (Broadberry et al., 2015) until 1870 and later data from macro-financial database Schularlik, deflated, real-time series, £mn, Chained Volume measure, 2013 prices.
- LOAN% = Credit to Private non-financial sector from Banks, total at Market value – (percentage of GDP) calculated using a trend in financial services production (Broadberry et al., 2015) until 1870 and later data from macro-financial database Schularlik, deflated, real-time series, £mn, Chained Volume measure, 2013 prices.

To identify statistically significant oscillatory patterns in the series, we use univariate and multivariate singular spectrum model developed in Broomhead and King (1986a, 1986b), Vautard and Ghil (1989), Vautard et al. (1992), Allen and Smith (1996), Michael (2002), Andreas and Michael (2015). We follow

$$c(j) = \frac{1}{N} \sum_{i=1}^{N-j} x_i x_{i+j};$$

$$c(j) = \frac{1}{N-j} \sum_{i=1}^{N-j} x_i x_{i+j}, \tag{1}$$

where: c_{ij} – lag covariance matrix; N – number of data points in a time series; i, j – time indices; t – continuous time $t \in R$; x_t – observed time series.

Using (1) we identify cycle periods in the financial and real activity data over the 1270–2016 periods. Using principal components methods following Ricardo (1981), Floris, (1981), Vautard et al. (1992)

$$\begin{pmatrix} x_{(1)} & x_{(2)} & \cdots & x_{(M)} \\ x_{(2)} & x_{(3)} & \cdots & x_{(M+1)} \\ \cdots & \cdots & \cdots & \cdots \\ x_{(N-M+1)} & x_{(N-M+2)} & \cdots & x_{(N)} \end{pmatrix}, \tag{2}$$

with M – embedded dimension; X – univariate time series (house prices, loans, GDP).

Principal component modelling takes the form (Groth & Ghil, 2011):

$$A_\kappa(t) = \sum_{j=1}^{M} \sum_{i=1}^{L} x_l(t+j-1) E_k^l(j), \tag{3}$$

where: E_k – Eiegenvectors $(1 < k \le LM)$; $A_\kappa(t)$ – computed single-channel time series.

To reconstruct the dynamical behavior of the original input series (RCs 1-4) we use:

$$R_l^k(t) = \frac{1}{M_t} \sum_{j=L_t}^{U_t} A^k(t-j+1) E_l^k(j),$$ (4)

where: M_t – normalization factor; L_t, U_t – lower and upper bounds.

Figure 1 shows Monte Carlo singular spectrum of the UK business cycle series with the 2.5 and 97.5 error bands (red noise) over the 1270–2016 period.

In the Figure (1), points above the upper tick (grey) error bars show the significant eigenvalue pairs corresponding to cycles in the time domain. We can observe isolated business cycles with a periodicity of 12.5 years, 5–5.6 years, 3–4 years. Our results are in line with the business cycles theory observing average cycles between 5–12 years with shorter cycles about 3–4 and longer 12.5 years. Data also show that business cycles dynamics vary over time (we do not fix it as assumed in theory) and that economic systems (as they developed) exhibit different cyclical patterns. We isolate business cycles in the UK using the real GDP series for individual 100 years period starting from 1270 until 2016 (figures not presented here).

We apply the same methods to isolate financial cycles but now using (MSSA) applied on the three financial series–house price index, the credit to the private non-financial sector, credit to private non-financial sector share in % of the GDP. Figure 2 shows the results of the single (MSSA) using all three-time series (aggregate).

Figure (2) shows an interesting pattern in the cyclical patterns of the financial series in the UK over the observed time. Statistically significant oscillatory pattern (dots over the grey error bars) are isolated at 0.09 (corresponding to 11 years), 0.2 (5 years), 0.3 (3 years) and 0.4 (2.5 years). Financial cycles in the UK dominate in the medium term, and their dynamics significantly change. The most critical financial cycles (dominating frequencies) in the UK are around 0.09 corresponding to 11 years period. Figure 3 shows financial cycles change in the UK for different periods under observation revealing changes in cycles length and persistence.
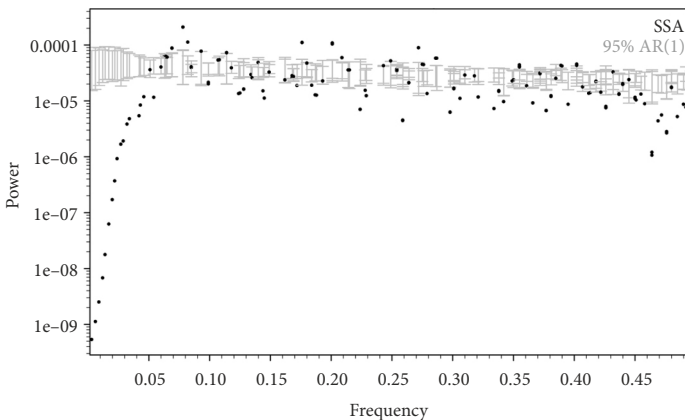

Figure 1. Oscillatory behavior (cycle) of the UK GDP series 1270–2016
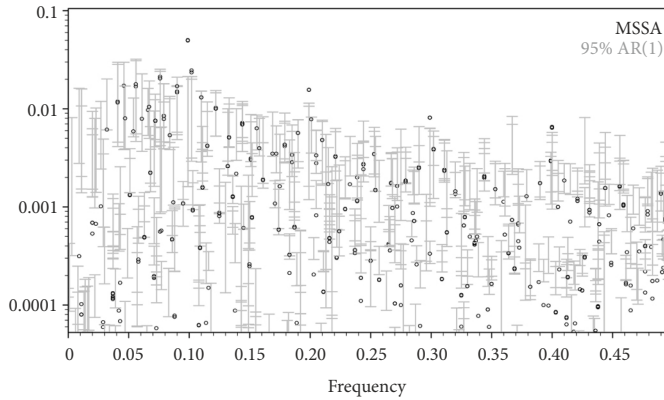(source: Authors' calculation)

Figure 2. Oscillatory behavior (cycle) in the UK financial series 1270–2016
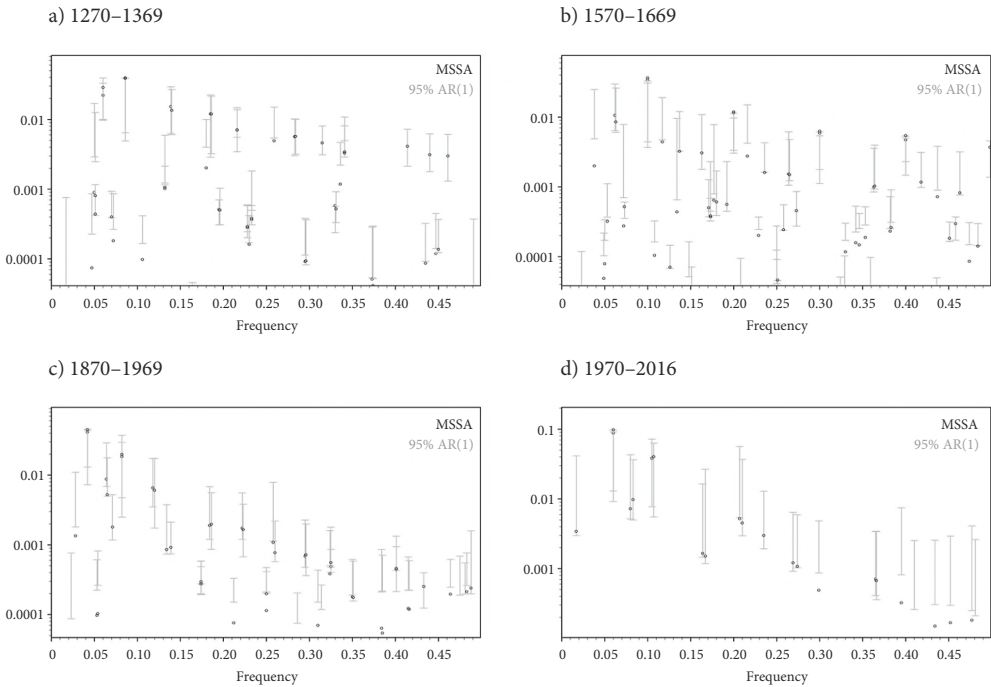(source: Authors' calculation)

a) 1270–1369   b) 1570–1669

c) 1870–1969   d) 1970–2016

Figure 3. Isolated financial cycles frequencies in the UK 1270–2016
(source: Authors' calculation)

From Figure 3, we can see that financial cycles in the UK over the observed period change in dynamics and length. During the 1270–1369 period, the length of average financial cycles was around 11–12 years (one statistically significant cycle period). Within 1570–1669 we identify several statistically significant cycle lengths. That means that in that time, several distinct financial cycles were present. We find evidence on ten years average financial cycle, five

years average cycle and three years average cycle. A different pattern is present in the financial series from 1870 to 1969. During this time, we identify just one 25 years average financial cycle. After 1970, the average length of the financial cycle was 16–17 years. We can conclude that there is no universal fit for the financial cycles with changing nature and dynamics in time. Since financial cycles change over time and space, it is significant to explore how these changes impact the economy (spectral coherence between financial and business cycles).

3. Empirical results

To study the synchronization between financial and business cycles in the UK from 1270 to 2016, we use Tastan (2016) bivariate cross-spectral analysis (see Figure 4).

We use coherency spectrum (correlation coefficient) of the form (Iacobucci, 2005):

$$\hat{K}_{12}\left(k\right)=\frac{\left|\hat{s}_{12}\left(k\right)\right|}{\sqrt{\hat{s}_1\left(k\right)\hat{s}_2\left(k\right)}}=\frac{\sqrt{\hat{c}_{12}(k)^2+\hat{Q}_{12}(k)^2}}{\sqrt{\hat{s}_1\left(k\right)\hat{s}_2\left(k\right)}}. \tag{5}$$

Taking the square of Equation (5), we get the coherence squared representing R^2 in time domain notation. From Figure 4, we can see that squared coherence (bottom right) is statistically significant (5% threshold) at 0.1 and 0.3, 0.35 frequencies. The squared coherence reach peak (highest level around 0.45) at 0.1 frequency or ten years. The synchronization between financial and business cycles in the medium term (10 years) is quite robust. In the medium term, when financial and business cycles move together (10 years average), financial cycles can explain almost 50% (R^2) of the variance in the business cycle series. We find a strong link between the cyclical component in the output (real GDP series) and the cyclical component in the financial series (housing price, credit). Strongest synchronization between financial and business cycles is present at ten-year intervals. Cyclical components of the financial series have a statistically significant impact on business cycles (over the medium-term changes in the financial variables explain around 50% of changes in the dynamics of real activity). Phase difference spectrum helps us validate the results of the coherency squared analysis.

The coherence squared reach the highest values (around 0.50) at ten years interval when the phase difference between financial and business cycles (top left in Figure 4) is close to zero. Therefore, the financial and business cycles series have the same phase relationship (highest coherence at ten-year interval). After that, the phase difference between the two series remains constant–close to zero (see the top left panel in Figure 4). We measure the phase difference using the phase spectrum (time-lag) of the form (Iacobucci, 2005):

$$\hat{\Phi}_{12}\left(k\right)=\arctan\left(-\frac{\hat{Q}_{12}\left(k\right)}{\hat{c}_{12}\left(k\right)}\right), \tag{6}$$

measuring the number of leads ($\hat{\Phi}_{12}\left(k\right)>0$) or lags ($\hat{\Phi}_{12}\left(k\right)<0$). From Figure 4, we can see that financial cycles influence the movements in the business cycles. Influence is strong at ten years average period (medium-term). In the short term 3–4 years, the financial cycle also shows a significant impact on the business cycle. However, the impact we register at 3–4 average years period is statistically significant but half as strong to the medium-term impact.
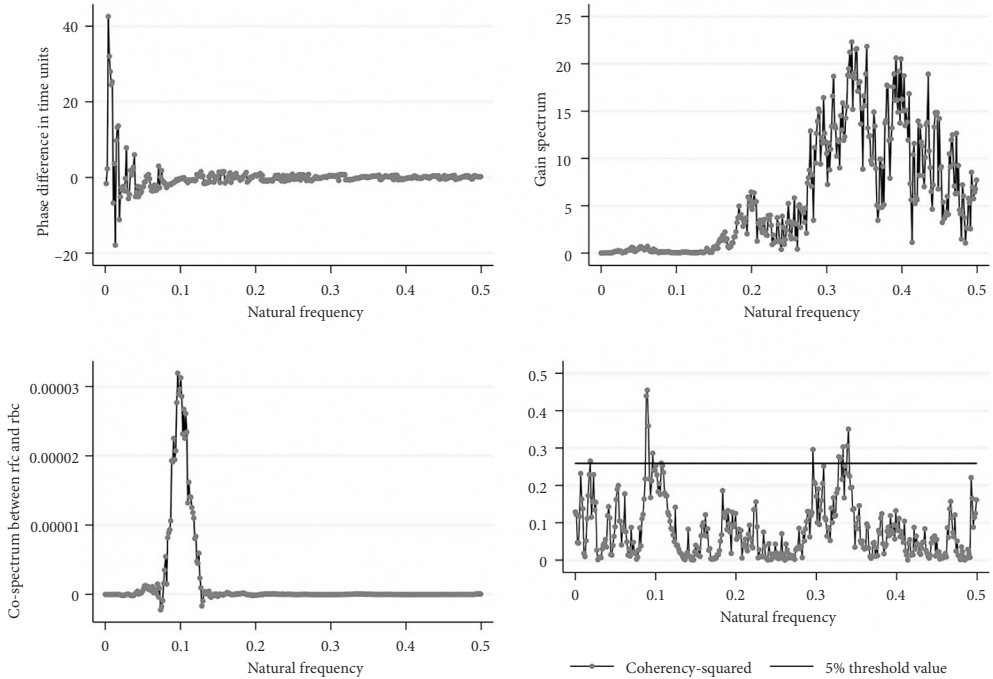
Figure 4. Cross spectral analysis of financial and business cycles in the UK 1270–2016
(source: Authors' calculation)

The gain (regression coefficient) follows (Iacobucci, 2005):

$$\hat{G}_{12}(k) = \frac{\left|\hat{s}_{12}(k)\right|}{\hat{s}_1(k)}, \qquad (7)$$

showing the impact of the spectrum (financial cycle series $u_1(k)$) on the business cycle spectrum ($u_2(k)$). The gain coefficient demonstrates that financial cycles strongly impact business cycles in the medium term (10 years). Variance in the business cycle (see Figure 4 bottom left) is strongly influenced by the variance (change) in the financial cycles. The co-spectrum shows financial and business cycles series covariance is concentrated in the medium term (10 years average). Financial and business cycles series move along over the medium term spectrum as we can see from the bottom left panel in Figure 4. We can see that the two series are related since we find a non-random distribution in their phase differences. In the long run, financial cycles lead business cycle while in the medium term they move together (phase difference close to zero).

Conclusion

Prior study (Porada-Rochoń & Škare, 2020) of the business and financial cycles interaction from 1270–2016 in the UK looks at the spectral Granger causality dynamics. In this study we explore in deep the cross spectral analysis over four different synchronicity (cross-spectra) indicators.

Financial cycles continue to dominate the finance/economic body of literature in the recent time demanding a new approach and studies in the field. Current financial cycles studies are limited by the data availability ranging from 40 years to 150 years. Our paper is the first one (to the best of our knowledge) that use data over a long period spanning several centuries applying cross spectral analysis. We use cross spectral analysis and advanced cross spectral analysis (MSSA) to study the relationship between financial and business cycles in the long run. Cross spectral analysis methods show to be more robust to the stationarity, non-linearity issues and efficient in the long time-series study. The theory and mechanism behind the financial and business cycles connection are still pending.

Our paper brings several important findings to the discussion on the financial and business cycle link. Around (and behind) a single business cycle, we can find a financial cycle. It is an important finding since the issue on "do financial cycles influence (impact) business cycles?" remains still mostly unexplained. Not only, since the studies on the issue are limited by data availability, but more questions also arise. Are financial cycles product of the modern capitalist system or they are inherent to financial markets? Is the link between financial and business cycles constant or changes over time? Do financial and business cycles move together always or occasionally?

Paper findings are important for policy makers for fighting financial and business cycles. Study results we present here should encourage them to take into the account interaction that exists between financial and business cycles when designing macroeconomic policies.

Results of the study were limited by the data availability over a long period and future research's should try to incorporate more financial and business cycles determinants.

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