Time-frequency Dependency of Exchange Rate and Non-performing Loan in Turkey

Dervis Kirikkaleli (dkirikkaleli@eul.edu.tr)
European University of Lefke https://orcid.org/0000-0001-5733-5045

Melike Torun
Istanbul Universitesi-Cerrahpasa

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Dervis Kirikkaleli
European University of Lefke
Faculty of Economic and Administrative Sciences
Department of Banking and Finance
Lefke, Northern Cyprus
TR-10 Mersin, Turkey
Email: dkirikkaleli@eul.edu.tr

Melike Torun
Istanbul University - Cerrahpasha
Vocational School of Social Sciences
Department of Banking and Insurance
Istanbul, Turkey
Email: melike.torun@gmail.com

Abstract

The present study aims to capture the two-way linkage between non-performing loans (NPL) and the US dollar-Turkish lira exchange rate (USD/TRY) (ER) in Turkey using quarterly data from 1995Q1 to 2017Q4 using wavelet coherence technique. The findings of this study indicate that: (i) significant vulnerability in NPL is detected between 1999 and 2004, while ER significantly fluctuated during the period between 2001 and 2003 and the 2008 global crisis period in the short run; (ii) ER has a strong power to explain NPL at difference frequencies; (iii) NPL and ER were positively correlated in Turkey during the global crisis period. The present study suggests that governors in Turkey should control the exchange rate volatility in order to control NPL volatility in the Turkish banking sector.

Keywords: Non-performing loans; exchange rate; emerging market; banking sector, Turkey; wavelet coherence; causality

JEL Codes: C22; G01; G21; F31

Background

The determinants and consequences of the currency vulnerability and banking crisis have been heavily investigated by scholars. Since the first generation theoretical model of currency crisis developed by Krugman (1979), which identified the inability of the government to control the budget as the key cause of the currency crisis, is the subject has been well-documented by Flood and Garber (1984), Obstfeld (1996), Chang and Velasco (2001), Flood and Jeanne (2005), Bénétrix, Lane and Shambaugh (2015), Nakatani (2017), and Bougheas et al. (2018). Banking crises have also been studied by Demirgüç-Kunt and Detragiache (1998), Hutchison and McDill (1999), Eichengreen and Arteta (2002), and Serwa (2010).

However, the theoretical and empirical literature regarding the linkage between currency vulnerability and banking crisis is very limited. While some scholars - Velasco (1987), Obstfeld (1996), and Calvo (1998) - argued that bank-based indicators are likely to trigger currency vulnerability "if the increased liquidity associated with a government bailout of the banking system is inconsistent with a stable exchange rate" (Shen and Chen, 2008), Miller (1996), Chang and Velasco (2001), and Nakatani (2016) underlined that currency vulnerability is an important predictor of a banking sector crisis. They supported the argument that vulnerability in exchange rate may trigger bank crisis if deposit money is used to speculate in the foreign exchange market and banks are loaned up. The theoretical studies of Champ, Smith and Williamson (1996) and Corsetti, Pesenti, and Roubini (1999) proposed that there is a strong relationship between vulnerability in the financial sector and currency crisis throughout different channels. The study of Kaminsky and Reinhart (1999) found supportive empirical results for the theoretical studies of Champ, Smith and Williamson (1996) and Corsetti, Pesenti and Roubini (1999) via underlining the causal linkage between

financial instability and currency vulnerability. In the finance literature, it has been claimed that because of the deteriorating effect of the banking and currency crises on the economic and financial systems, non-performing loans are negatively affected. Furthermore, the increased possibility of banking failures encourages depositors to withdraw their deposits and move them to safer financial instruments. Additionally, with the expectation that the local currency will depreciate, depositors tend to exchange their local currency deposits into foreign ones. The existing literature clearly underlines that the vulnerability of NPLs became more visible before and during banking crises (Ari & Cergiboza, 2016). Thus, banking and currency crises have significant impacts on public policy.

Turkey, as an emerging market, is a special case since the country has experienced the 1988 stock market and currency crisis, the 1994 economic crisis, the 1998 textile crisis, the 2000 banking crisis, the 2001 economic crisis, the 2007-08 global economic crisis, and the 2018 exchange rate crisis over the last three decades. The Turkish lira depreciated by around 85% quarterly on average against the US dollar, during the period from 1995Q1 to 2017Q4 due to economic, financial and political reasons. At the end of 2017, the NPL was recorded as 3.38%, while the ratio was around 20% in 2001 when Turkey was impacted by both banking and currency crises simultaneously. Although there was an upward trend in the exchange rate, particularly after 2012, the non-performing ratios varied in a narrow band - 2.7% and 3.2% - between 2012 and 2017. The reasons behind this were that: (i) strict supervision and regulation activities in the Turkish banking sector were conducted by the Banking Regulation and Supervision Authority (BRSA) and the Central Bank of the Republic of Turkey (CBRT); (ii) Transformation in the banking activities and market-oriented acitivities of the CBRT; (iii) a attempt was made to decrease interest rates through monetary policy within the financial

stability program by the CBRT; (iv) a reserve option mechanism (ROM) was allowed in 2011 by the CBRT to influence foreign exhange supply without selling.

Exploration of the linkage between the banking sector fragility and currency exchange has recently drawn renewed attention in emerging markets. Therefore, investigation of the time frequency dependency of non-performing loans in the Turkish banking sector and the US dollar-Turkish lira (USD/TRY) exchange rate from 1995Q1 to 2017Q4 is likely to open a debate in the literature since no previous study has explored the two-way linkage between non-performing loans and exchange rate using the wavelet coherence approach. Thus, the main contribution of this present study is that it aims to fill this gap in the finance literature by establishing wavelet coherence-based models to explore the possible long-run and short-run causal/or correlation connections between NPL and ER in Turkey. In line with the main contribution of this study, the findings present noteworthy implications for Turkish policymakers and bankers.

Data and Methodology

The data used in this study are NPL in the Turkish banking sector and ER. The data of these two variables are gathered from the Central Bank of the Republic of Turkey and the Banks Association of Turkey. The time series variables used in the empirical tests of this study consists of quarterly data for the period 1995Q1 to 2017Q4. Table 1 reports the descriptive statistics and codes of the time series variables used in this study.

Table 1. Descriptive Statistics

Code	NPL	ER
Varaible	Non-performing Loans	US dollar-Turkish lira exchange rate (USD/TRY)
Source	Central Bank of the Republic of Turkey	The Banks Association of Turkey
Mean	0.0461	1.3654
Median	0.0333	1.4012
Maximum	0.1986	3.5847
Minimum	0.0080	0.0410
Std. Dev.	0.0402	0.8637
Skewness	2.4315	0.4259
Kurtosis	8.7310	3.0211
Jarque-Bera	2.7539	2.7539
Probability	0.2523	0.2523

To explore the time-frequency dependence of NPL and ER in Turkey, the wavelet coherence approach, initially proposed by Goupillaud, Grossmann, and Morlet (1984), is used in this study. The main innovation of wavelet techniques "appears where the decomposition of one-dimensional time data into the bi-dimensional time-frequency sphere is allowed" (Pal and Mitra, 2017).

In this study, a wavelet (ψ) is based model that is part of the Morlet wavelet family. The equation is as follows: $\psi(t) = \pi^{-\frac{1}{4}} e^{-i\omega_0 t} e^{-\frac{1}{2}t^2}$, p(t), t=1, 2, 3….., T.

Put simply, time or location (*k*) and frequency (*f*) are the two parameters of a wavelet. The main role of the *k* parameter is to define a wavelet`s particular location in time by exchanging the wavelet while *f* controls the distended wavelet for localizing various frequencies. $\psi_{k,f}$ can initially be created by transforming ψ. The equation of this transformation is shown below:

$$\psi_{k,f}(t) = \frac{1}{\sqrt{h}} \psi\left(\frac{t-k}{f}\right), \quad k, f \in \mathbb{R}, f \neq 0 \qquad (1)$$

The continuous wavelet can be generated from ψ as a function of k and f given time series data p(t) as follows:

$$W_p(k,f) = \int_{-\infty}^{\infty} p(t) \frac{1}{\sqrt{f}} \psi\left(\frac{t-k}{f}\right) dt, \tag{2}$$

The regenerated initial times series p(t) with the ψ coefficient is shown in equation three:

$$p(t) = \frac{1}{C_\psi} \int_0^{\infty} \left[\int_{-\infty}^{\infty} \left|W_p(a,b)\right|^2 da\right] \frac{db}{b^2}. \tag{3}$$

Using the wavelet power spectrum (WPS) brings more information about the amplitude of the time series.

$$WPS_p(k,f) = \left|W_p(k,f)\right|^2. \tag{4}$$

In this study, the wavelet coherence approach is implemented. The main novelty of wavelet coherence over the standard correlation is that the approach allows the present study to picture any correlation between two time series p(t) and q(t) in combined time-frequency based causalities. The cross wavelet transform (CWT) of the time series is as follows:

$$W_{pq}(k,f) = W_p(k,f)\overline{W_q(k,f)}, \tag{5}$$

where $W_p(k,f)$ and $W_q(k,f)$ indicate the CWT of two time series p(t) and q(t), respectively (Torrence and Compo 1998). As mentioned by Torrence and Compo (1998), the equation of the squared wavelet coherence can be constructed as shown below:

$$R^2(k,f) = \frac{\left|C\left(f^{-1}W_{pq}(k,f)\right)\right|^2}{C\left(f^{-1}\left|W_p(k,f)\right|^2\right)C\left(f^{-1}\left|W_q(k,f)\right|^2\right)} \tag{6}$$

C denotes time and the smoothing process over time, with $0 \leq R^2(k,f) \leq 1$. "Whenever $R^2(k,f)$ gets close to 1 it indicates that the time series variables are correlated at a particular scale,

surrounded by a black line and depicted by a red color. On the other hand, when the value of $R^2(k,f)$ approaches 0 it indicates that there is no correlation between the time series variables and is pictured by a blue color" (Kirikkaleli, 2019).

However, calculating the value of $R^2(k,f)$ does not provide any way to distinguish positive correlation from negative; thus "Torrence and Compo (1998) postulated a means by which to detect the wavelet coherence differences through indications of deferrals in the wavering of two time series" (Pal and Mitra, 2017). The equation of the wavelet coherence difference phase is constructed as follows:

$$\phi_{pq}(k,f) = \tan^{-1}\left(\frac{\mathrm{L}\left\{C\left(f^{-1}W_{pq}(k,f)\right)\right\}}{O\left\{C\left(f^{-1}W_{pq}(k,f)\right)\right\}}\right), \tag{7}$$

As a robust causality test, the TY causality test proposed by Toda and Yamamoto (1995) is employed. "Toda and Yamamoto (1995) developed a modified Wald test statistic (MWALD) to overcome bias and spurious models based on an augmented VAR approach" (Kirikkaleli and Gokmenoglu, 2019).

Empirical Findings

Based on the focus of this study and as a inital step, the WPS is implemented to explore the vulnerability periods and the behaviour of the NPL and ER variables, which are represented in Figure 1-2. In this study, a scale of 16 periods is selected since the dataset covers the period from 1995Q1 to 2017Q4. The white cone-shaped curve in Figures 1 and 2 represents "the cone of influence demonstrating an edge below where the wavelet power is affected because of discontinuity, while the thick black shape indicates a 5% significant level

determined by Monte Carlo simulations" (Kirikkaleli, 2019). As seen in Figure 1, the NPL as a ratio is significantly vulnerable in Turkey between 1999 and 2002 at different frequencies, ranging from 4 periods (high frequency) to 16 periods of scale (low frequency). However, during the period of 2006-2017, due to the stric supervision and regulation activities in the Turkish banking sector by BRSA and CBRT, the vulnerability in the NPL was minimized, despite the 2007-08 global economic crisis and the failed coup attempt in 2016. This situation is not significantly different from the case of ER in Turkey, as depicted in Figure 2, which shows that ER fluctuated significantly during the period between 2001 and 2002, the 2008 global crisis period, and the period between 2015 and 2017.

Figure 1. Power Spectrum for NPL

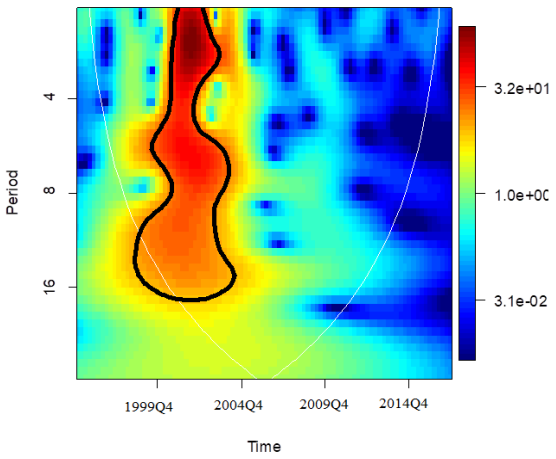
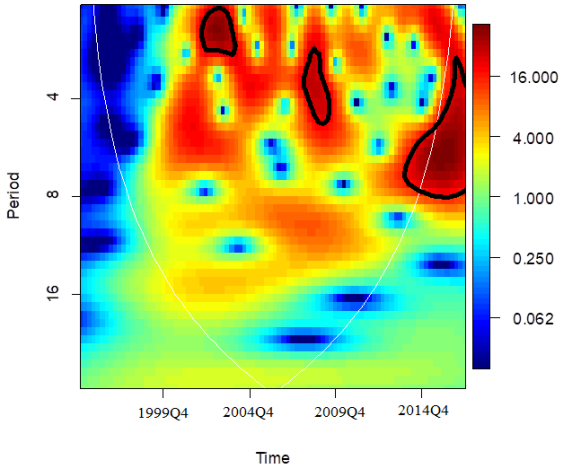


Figure 2. Power Spectrum for ER



The present study explores the two-way linkage between NPL and ER in Turkey using the wavelet coherence approach, which allows the bi-dimensional time-frequency causality to be observed. Therefore, the long-term and short-term causal relationships between NPL and ER in Turkey are investigated in the study. The wavelet coherence between NPL and ER is reported in Figure 3, which shows that ER has a strong power for explaining NPL from 2000 to 2007 at difference frequencies, since we a right-down arrow can be observed within the thick black shape. This clearly reveals how the exchange rate is important for predicting the non-performing loans in Turkey. In addition, NPL and ER are in phase in Turkey in 2008, but

only in the short term, indicating that during the global crisis period, there was a positive correlation between NPL and ER in Turkey. As can be seen in Table 2, the ER led-NPL hypothesis is empirically proved based on the outcomes of the TY causality technique.

Figure 3. Wavelet Coherence between NPL and ER

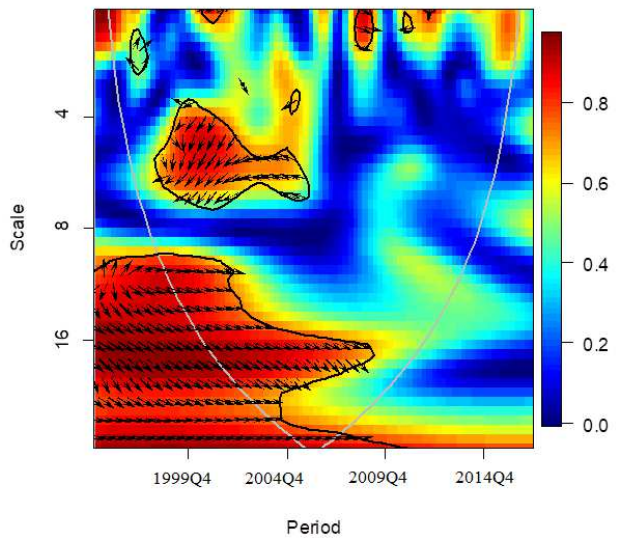


Table 2. TY Causality Test

Direction of Causality	Lag	MWALT	Prob.
ER →NPL	5	9.061	0.106
NPL→ER	5	13.065	0.022

Note: → presents the direction of causality.

Conclusion

Although the currency and banking crises in emerging markets have been heavily investigated, the time-frequency dependence of non-performing loans and exchange rate for an emerging market, Turkey, has not been explored thoroughly. Therefore, the present study proposes to fill this gap by investigating the linkage between non-performing loans and exchange rate in Turkey over the period of 1995Q1 to 2017Q4 using the wavelet coherence approach, which allows the investigation of the short-term, independently from the long-term. Additionally, the TY causality test is employed in this study as a robust test for finding the wavelet coherence. The outcome of WPS reveals that there was significant vulnerability in NPL between 1999 and 2004, whereas ER fluctuated significantly during the period of 2001-

02 and the 2008 global crisis period in the short-run. In addition, the wavelet coherence approach reveals that there is a uni-directional causality running from ER to NPL from 2000 to 2007 at difference frequencies, indicating that ER has strong power for explaining NPL in Turkey and this finding is supported by the outcome of the TY causality, since it supports the ER led-NPL hypothesis for the case of Turkey. Moreover, during the global crisis in 2008, we observe that NPL and ER were positively correlated in the short-run. Policymakers and bank managers in Turkey should be aware the effect of the movement in the US dollar-Turkish lira exchange rate over the non-performing loans, especially during the domestic and global crises periods. In other words, the present study suggests that governors in Turkey should control exchange rate volatility in order to control NPL volatility in the Turkish banking sector. Despite these results providing strong empirical evidence, further research should be conducted in other emerging markets.

Declarations

Availability of data and material

The non-performing loans and US dollar-Turkish lira exchange rate data that support the findings of this study are available from the Central Bank of the Republic of Turkey and The Banks Association of Turkey, respectively.

Competing interests

I have no conflicts of interest to disclose.

Funding

The present study lacks financial resources and competitive resources.

Authors' contributions

Both authors - Dervis Kirikkaleli and Melike Torun - contributed to the design of the study, data collection, data analysis and development of the manuscript. Both authors read and approved the final manuscript.

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Authors' information (optional)

'Not applicable'

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Figures

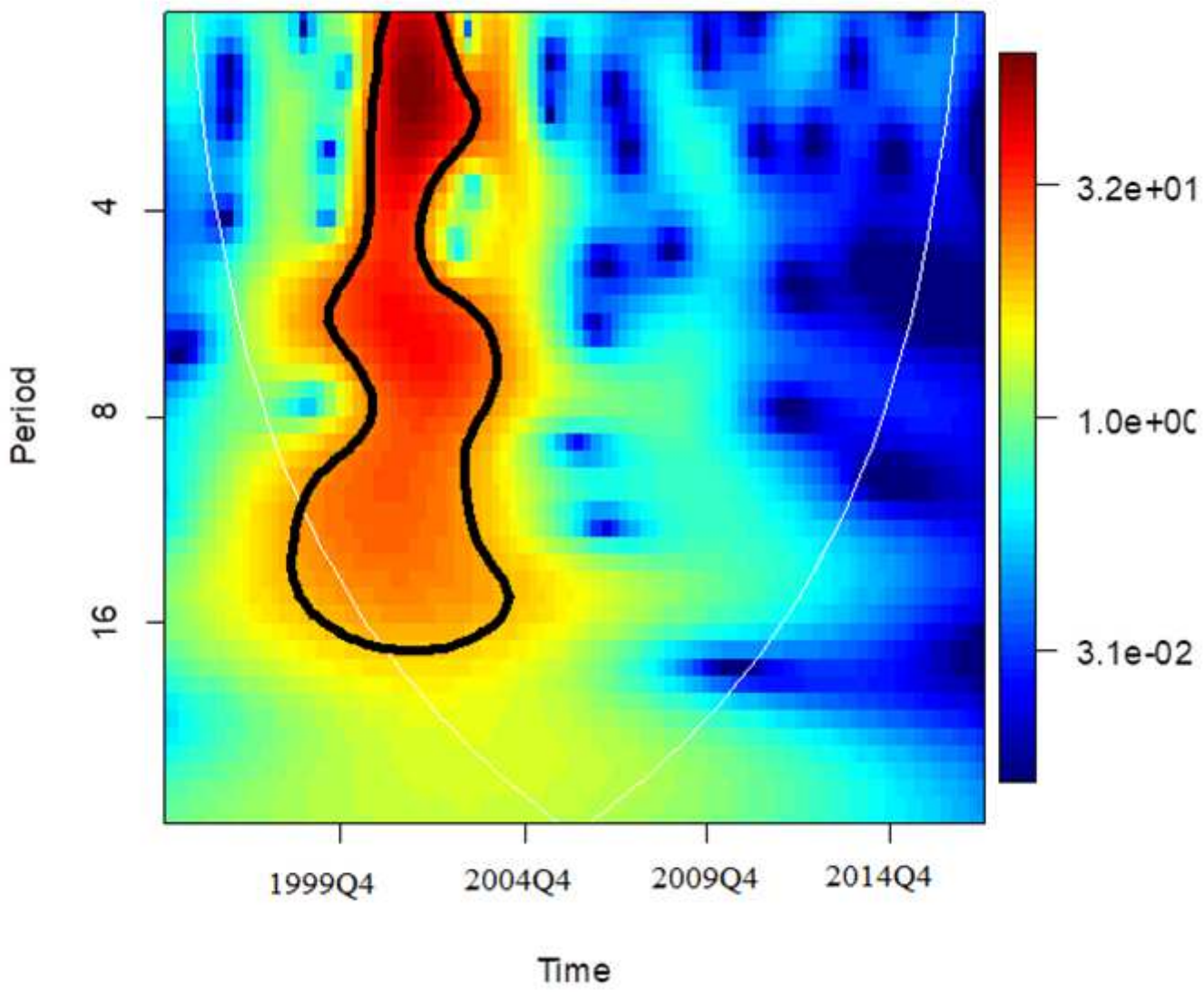

Figure 1

Power Spectrum for NPL

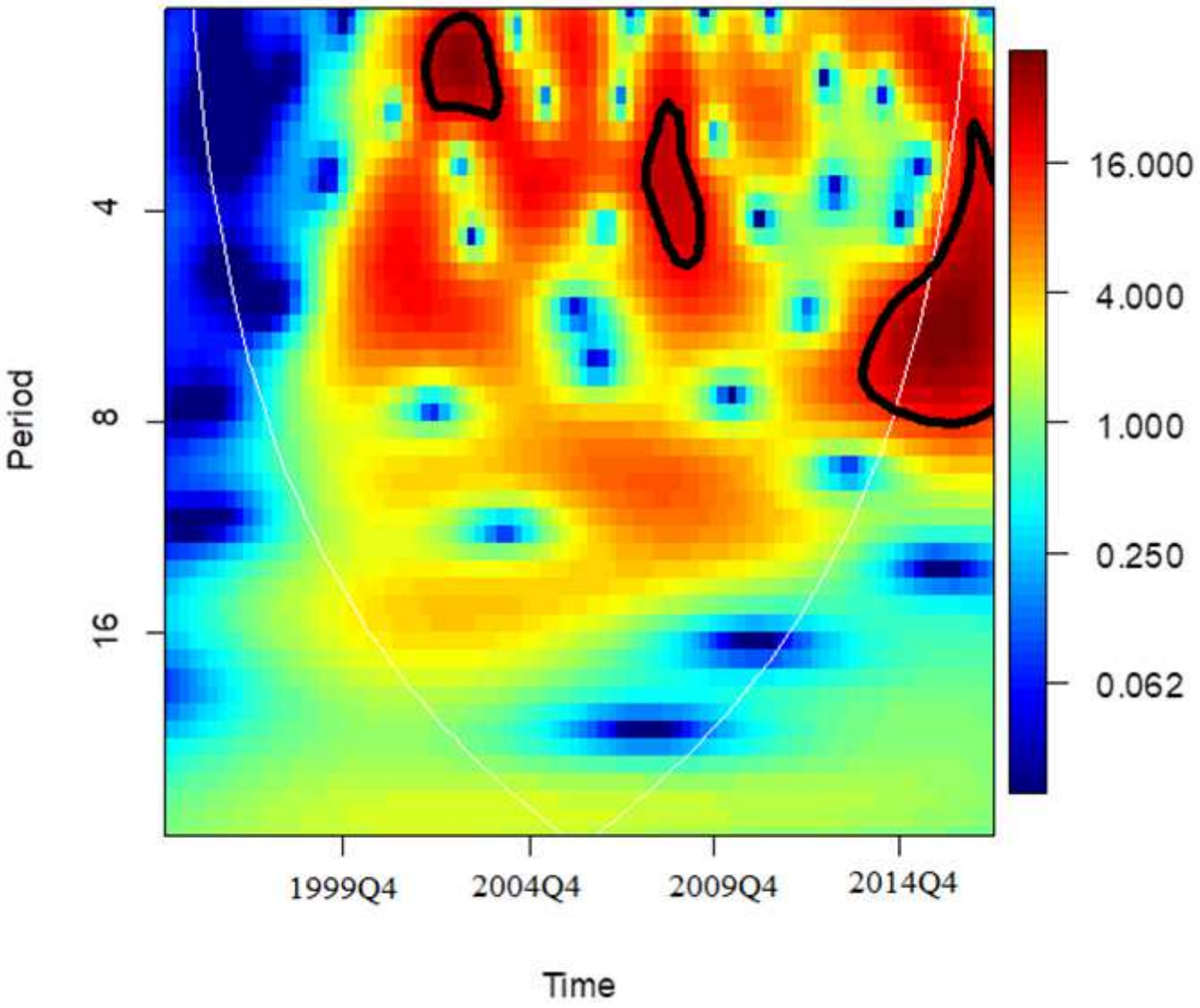

Figure 2

Power Spectrum for ER

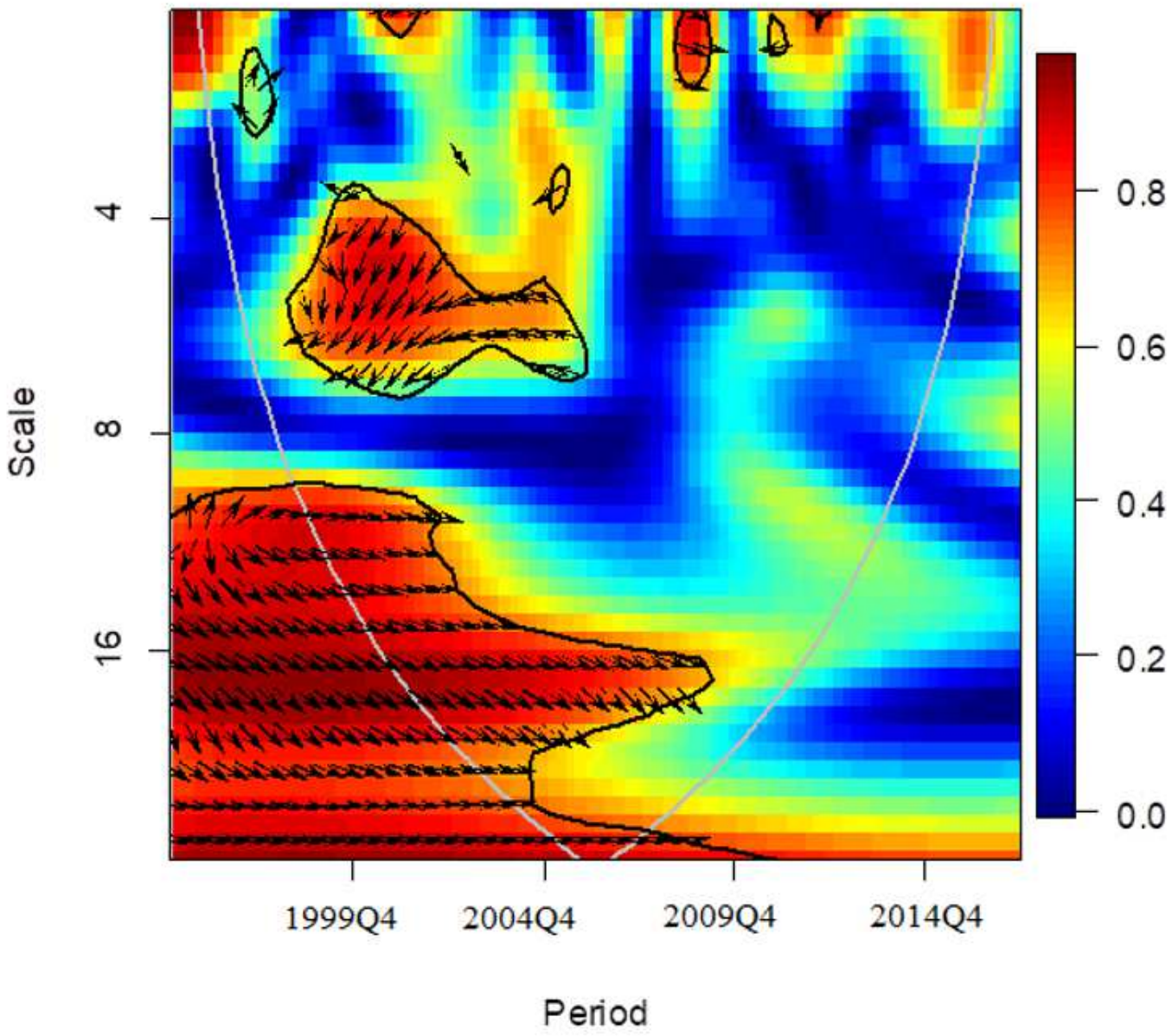

Figure 3

Wavelet Coherence between NPL and ER