

INDUSTRIAL PRODUCTION AS A CREDIT DRIVER IN BANKING SECTOR: AN EMPIRICAL STUDY WITH WAVELETS

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Abstract

This paper examines the timescale effects of industrial production on credits volume at banks. By using industrial production in Turkey and credit volumes of Turkish banks from 3/1992-12/2006, this study employs wavelet filters to estimate multi-scale causality for scaled time series. The original data is transformed by the wavelet filter up to 5 time scales. The first wavelet coefficient captures oscillations with a period length 3 to 6 months. Equivalently, the consequent wavelets capture oscillations with a period of 7-12, 13-24, 25-48 and 49-96 months, respectively. The results of multi-scale granger causality test show that the industrial production is effective on credits volume upto 24 months, while the credits volume starts to affect industrial production after 2 years. This paper has originality in presenting multi-scale effects of industrial production as a credit driver by using wavelet analysis with Turkish data.

Key words: Bank credits, industrial production, wavelets, multi-scale causality, granger causality.
JEL classification: C45, E51, E23, C14.

1. Introduction

The relationship between banks as the intermediates and industrial sector as money demander is the milestone of the economic life. Banks as the credit providers have crucial role in the production facilities in the industrial sector. According to demand-following hypothesis, economic growth leads to financial developments, while the reverse relationship is suggested by supply-leading hypothesis.

[Robinson \(1952\)](#) as one of the initial supporters of the demand-following hypothesis argues that financial sector has minor effect on growth. Economic development creates demand for financial intermediates leading to growth in lending facilities of the credit institutions. On the other hand, [Schumpeter \(1911\)](#) already stresses the importance of financial intermediaries for economic development. [Gurley and Shaw \(1955\)](#) and [Davis \(1965\)](#), as the initial supporters of the supply-leading hypothesis underline the effects of financial system on macroeconomic growth. [Patrick \(1966\)](#) argues that financial sector contributes significantly to industrial growth in emerging markets, while the industrial growth increases demand for financial sector services in advanced economies. Though that argument might be accepted as valid in Latin America in 1990's, the financial crises in Mexico, Argentina and Brazil are extreme features of this relationship.

After that initial discussion in the theory of financial economics, numerous empirical researches that will be covered in the literature review part of this article have been conducted to show the relationship between growth and credit facilities of the banks. Research results mostly argue that there is a positive correlation between the financial development and economic growth in real terms. On the other hand, there is disagreement on the underlying causality. Studies often display varying results. The originality of this paper is that it uses a new methodology to display the time-scale of the relationship between the production and bank credits. By employing wavelets as a filtered model to determine the timescale effects among the variables, this paper measures both the strength of the relationship between production and credits volume and also the duration of the relationship. The methodology also enables us to see the dual way causality between the variables.

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For empirical analysis, the paper uses industrial production and volume of bank credits in Turkey from 3/1992 to 12/2006. The wavelet algorithm enables us to scale the causal effects between the variables. In that respect, as much as the authors know, it is the first empirical work to employ the wavelets analysis in measuring the causal interrelationship between credits volume and industrial production. Working with data from Turkish markets has also an importance for the research because of the volatile business cycle in Turkish economy. The wavelets are expected to filter the high volatility to display a robust causality between the variables under examination. The time period under examination includes three financial catastrophes in 1994, 1998 and 2001 in which interest rates on credits increased above 1000% and even in 2001 the credits facilities of the banks were frozen for a while. In that respect, the methodology is proper to capture the high volatility and shocks in the economy by filtering the time series data.

The paper is constructed as follows. In the next part, a theoretical framework and current literature are presented. In the third part, wavelets methodology is examined in detail. The fourth part includes the presentation and discussion of the empirical results both in terms of pragmatic and methodological perspectives. The final part is the conclusion where the research findings are summarized and suggestions for the future researches are given.

2. Theoretical Framework and Literature Review

Financial systems channel household savings into the industry and allocate economic resources among firms. They are the sources connecting financial development to economic growth. Patrick (1966) argues two alternative causal relationships between financial development and economic growth. The first one, namely demand-following hypothesis, states that the demand for financial intermediation depends on the economic growth measured by real output. The alternative perspective is supply-leading hypothesis. By transferring resources from the traditional sectors to the high-growth sectors, the financial system supports economic growth.

Schumpeter (1911) argues that the financial services are essential for technological progress and economic growth. If the financial sector is crucial for the economy, then there should be a relation between financial markets and economic growth. Gurley and Shaw (1955) are the first to examine the relationship between financial markets and industrial activity. Their study shows that financial markets extend financial power of borrowers and increase the efficiency of trade.

Since this is an empirical research paper, we do not discuss the theory in deep. Instead, the theory is expressed in reviewing literature. As parallel to two different theoretical perspectives, empirical results on the direction of the causality between two variables are also contradictory. The empirical results vary on the economy and time period under examination. Methodology also matters in facing different empirical results. For example Jung (1986) finds causality for both directions between financial development and economic growth by time series analysis. On the other hand, Xu (2000), by extending the research of Jung (1986) with VAR analysis shows that the financial sector does not affect growth. However, Christopoulos and Tsionas (2004) display that causality exists from finance to growth in the long-run by using panel unit tests and cointegration analysis.

King and Levine (1993) use liquid liabilities of banks and nonbank financial intermediaries over GDP, bank credit over the sum of bank credit and central bank domestic assets and credit to private enterprises over GDP to measure the effects of financial services on economic growth. They find that banking sector development can spur economic growth in the long-run.

According to Allen and Oura (2004), traditional neoclassical literature on growth suggests that financing is not important. In this perspective there are two main sources of economic growth. The first source is growth within the technological frontier as a result of factor accumulation. The second one is innovation that causes the technological frontier to move outwards. They state that innovation is crucial for an economy to experience sustained growth for long-run. On the other hand, factor accumulation can still be an important part of growth for emerging economies that are a long way from the technological frontier.

Empirical researches on the issue for the emerging markets have also different contradictory findings. We present recent empirical findings from different economies in this part of the paper before examining previous works with Turkish data. Dritsaki and Dritsaki-Bargiota (2006) examine the causal relationship among financial development, credit market and economic growth by using a trivariate autoregressive VAR model in Greece from 1988 to 2002. They show that there is a bilateral causal relationship between banking sector development and economic growth. Bulir (1998) shows that industrial production is cointegrated with various measures of bank credits between 1976 and 1990. Although the impact of credit supply shocks on production changes, growth follows credit loosening.

Asian economies have contradictory behaviours on the issue, as well. Tang (2005) examines the direction of causality relationship between bank lending and economic growth for the five ASEAN economies, namely, Malaysia, Singapore, Indonesia, Thailand and the Philippines. He uses Granger causality test to examine the demand-following hypothesis (economic growth causes bank lending), and supply-leading hypothesis (bank lending causes economic growth). The empirical results display that the supply-leading hypothesis is valid for Thailand while the demand-following hypothesis is approved by time series data of Singapore. In Malaysia, Indonesia and the Philippines, on the other hand, the variables are statistically independent.

Shan *et al.* (2006) estimate a vector autoregression (VAR) model to examine the relationship between financial development and economic growth for nine OECD countries and China. Test results have little support for the supply-leading hypothesis.

Empirical works on the relationship between bank credits and production or growth are restricted. Darrat (1999) examines the role of financial deepening in economic growth in Saudi Arabia, Turkey and the United Arab Emirates by multivariate Granger-causality tests within an error-correction model. Empirical results support the argument that financial deepening is a necessary causal factor of economic growth, but the strength of the evidence changes across countries. Kar and Pentecost (2006) investigate the causal relationship between financial development and economic growth in Turkey with five alternative proxies for financial development. By using Granger causality tests with cointegration and vector error correction methodology, they show that the direction of causality is sensitive to the proxy used for financial development. If financial development is measured by the money to income ratio the direction runs from financial development to economic growth. On the other hand, if the bank deposits, private credit and domestic credit ratios are used as proxy, growth leads financial development. Aslan and Kucukaksoy (2006) examine financial development and economic growth relationship for Turkey over the period of 1970-2004 by Granger causality test. The test results support the supply-leading hypothesis for Turkey.

As the results of empirical researches show, there exists contradictory evidence on the causality between growth and financial sector development even in the same economy. Our research presents a new perspective on the relationship by scaling the time to show the direction and strength of the interrelated effects between the variables.

3. Methodology and Data

3.a. Methodology

The wavelets methodology derives its theoretical roots from Fourier analysis. Fourier analysis states that any function can be represented with the sum of sine and cosine functions. Fourier series are expressed in Equation (1).

$$f(x) = b_0 + \sum_{k=1}^{\infty} (b_k \cos 2\pi kx + a_k \sin 2\pi kx) \quad (1)$$

$$b_0 = \frac{1}{2\pi} \int_0^{2\pi} f(x) dx, \quad b_k = \frac{1}{\pi} \int_0^{2\pi} f(x) \cos(kx) dx,$$

$$a_k = \frac{1}{\pi} \int_0^{2\pi} f(x) \sin(kx) dx$$

a_0, a_k and b_k can be solved with OLS. Fourier to wavelet transition is in Equation (2).

$$f(x) = c_0 + \sum_{j=0}^{\infty} \sum_{k=0}^{2^j-1} c_{jk} \psi(2^j x - k) \quad (2)$$

$\psi(x)$ is the mother wavelet, mother to all dilations and translations of ψ in Equation (2). Tkacz (2001) gives a simple example for mother wavelet in Equation (3).

$$\Psi(x) = \begin{cases} 1 & : 0 \leq x < \frac{1}{2} \\ -1 & : \frac{1}{2} \leq x < 1 \\ 0 & : \text{other} \end{cases} \quad (3)$$

In finance, the maximal overlap discrete wavelet transform (MODWT) is used instead of discrete wavelet transform (DWT) since MODWT can work with any sample size N and wavelet variance estimator of MODWT is asymptotically more efficient than the estimator based on the DWT.

The MODWT is formulated with matrices (Percival and Walden, 2000) and yields J vectors of wavelet filter coefficients $\tilde{W}_{j,t}$, for $j=1, \dots, J$ and $t=1, \dots, N/2^j$, and one vector of wavelet filter coefficients $\tilde{V}_{j,t}$ through Equations (4) and (5) (Gallegati, 2005).

$$\tilde{W}_{j,t} = \sum_{t=L_j}^N \tilde{w}_{j,t}^X f(t-1), \quad (4)$$

$$\tilde{V}_{j,t} = \sum_{t=L_j}^N \tilde{v}_{j,t}^Y f(t-1), \quad (5)$$

where $w_{j,t}^X$ and $v_{j,t}^Y$ are the scaled wavelet and scaling filter coefficients. In and Kim (2006) define wavelet covariance between two series X_t and Y_t as in Equation (6).

$$\text{Cov}(\lambda_j) = \frac{1}{\tilde{N}} \sum_{t=L_j}^N \tilde{W}_{j,t}^X \tilde{V}_{j,t}^Y. \quad (6)$$

In the equation, λ_j represents scale. In and Kim (2006) also define MODWT estimator of the wavelet correlation as in Equation (7).

$$\tilde{\rho}(\lambda_j) = \frac{\text{Cov}(\lambda_j)}{\tilde{v}_X(\lambda_j) \tilde{v}_Y(\lambda_j)}, \quad (7)$$

where $\tilde{v}_X(\lambda_j)$ and $\tilde{v}_Y(\lambda_j)$ are wavelet variances estimated by the MODWT coefficients for scale λ_j described in Equation (8) and Equation (9).

$$\tilde{v}_X(\lambda_j) = \frac{1}{\tilde{N}} \sum_{t=L_j}^N [\tilde{W}_{j,t}^X]^2, \quad (8)$$

$$\tilde{v}_Y(\lambda_j)_Y = \frac{1}{\tilde{N}} \sum_{t=L_j}^N [\tilde{V}_{j,t}^Y]^2. \quad (9)$$

We employ Johansen unrestricted cointegration test without trend and with constant term to examine the cointegration between the variables (Johansen, 1988; and Johansen and Juselius 1990) as expressed in Equation (10).

$$H_1^*(r) : \Pi y_{t-1} + Bx_t = \alpha(\beta' y_{t-1}) + \rho_0. \quad (10)$$

Cointegration in stationary time series by Johansen procedure is set with trace and maximum eigenvalue statistics as shown in Equations (11) and (12).

$$\lambda_{\text{trace}(r)} = -T \sum_{i=r+1}^k \ln(1 - \bar{\lambda}_i), r = 0, 1, 2, 3, \dots, n-1, \quad (11)$$

$$\lambda_{\text{max}(r,r+1)} = -T \ln(1 - \bar{\lambda}_{r+1}). \quad (12)$$

Granger causality test is used to see whether at least one directional causality exists between variables (Granger, 1969). Granger causality test is summarized in Equations (13) and (14).

$$C_t = B_0 + \sum_{n=1}^M B_n C_{t-n} + \sum_{n=1}^K \alpha_n IP_{t-n} + \varepsilon_t, \quad (13)$$

$$IP_t = B_0 + \sum_{n=1}^M B_n IP_{t-n} + \sum_{n=1}^K \alpha_n C_{t-n} + \varepsilon_t, \quad (14)$$

where C and IP represent change in bank credits and industrial production respectively. We apply Granger causality test with maximum 9 lags as our data are limited to 55 observations.

3.b. Data

By using industrial production in Turkey and credit volumes of Turkish banks from 3/1992-12/2006, the paper employs wavelet filters to estimate dynamic correlation for scaled time series. Level and log-differenced series are shown in Figure 1. Quartely data as industrial production index and credits volume that is used in this paper are from Turkish Central Bank database, www.tcmb.gov.tr. The original data is transformed by the wavelet filter up to 5 time scales. The first wavelet coefficient captures oscillations with a period length 3 to 6 months. Equivalently, the consequent wavelets capture oscillations with a period of 7-12, 13-24, 25-48 and 49-96 months, respectively.

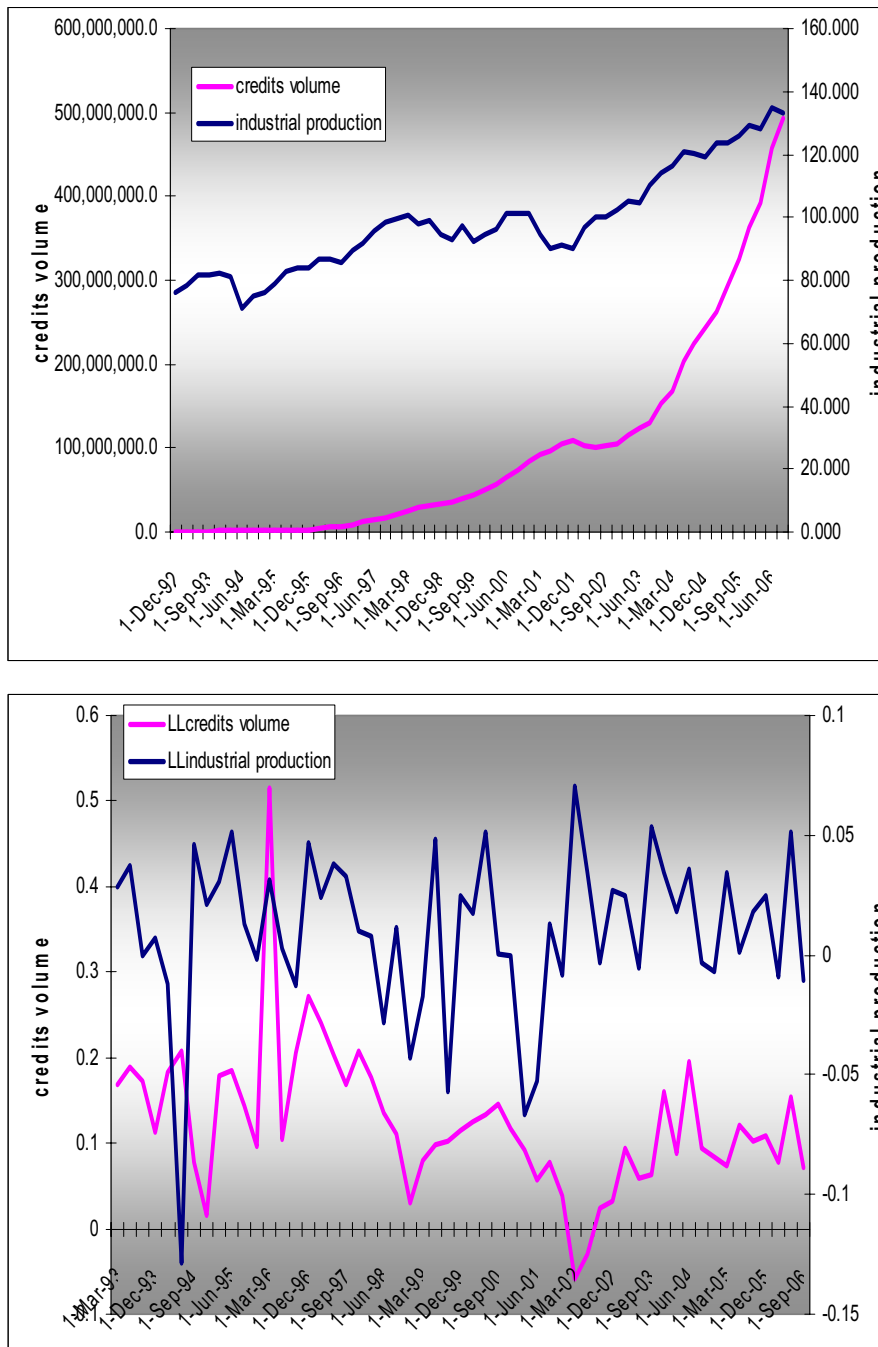


Fig. 1. Credits volume and industrial production (level and log-differenced series)¹

¹ Bright line represents change in credits and dark line represents change in industrial production.

4. Empirical Results

Table 1 reports Phillips-Peron (Phillips and Peron, 1988) and Augmented Dickey Fuller tests (Dickey and Fuller, 1981) of industrial production (IP) and credits volume (C) based on level, log-differenced and time-scaled decomposition up to 5 scale. Lag lengths are determined with Schwartz Information Criteria. Series are not stationary at $I(0)$ where stationary at $I(1)$ based on both Phillips-Peron (Phillips and Peron, 1988) and Augmented Dickey Fuller test (Dickey and Fuller, 1981) unit root tests at the 1% significance level. WJ_1 , WJ_2 , WJ_3 , WJ_4 and WJ_5 represent time-scale decomposition of C and IP log-differenced series.

Table 1

Unit Root test results

	Phillips- Peron test $I(1)$	Augmented D-F test $I(1)$
C	4.19608	0.769523
C (Log-differenced)	-5.14417***	-3.13032**
WJ_1 for C	-24.6553***	-8.13458***
CWJ_2 for C	-6.68074***	-7.14287***
WJ_3 for C	-2.78277*	-6.49884***
WJ_4 for C	-2.02804	-1.51253
WJ_5 for C	-1.31928	-2.05974
IP	-0.00553034	0.168694
IP (Log-differenced)	-7.26752***	-7.19877***
WJ_1 for IP	-30.7972***	-7.41872***
WJ_2 for IP	-4.66449***	-7.68116***
WJ_3 for IP	-3.46919***	-6.3224***
WJ_4 for IP	-1.7842	-4.57092***
WJ_5 for IP	-1.20227	-2.44645

Notes. The table reports results of the Phillips-Perron and augmented Dickey-Fuller tests for all the time series. The number of lags has been selected using the Schwarz information criterion with a maximum of twelve lags. *, **, *** Indicate the rejection of the unit root null at the 10%, 5% and 1% significance level respectively.

Johansen cointegration test (Johansen, 1988; and Johansen and Juselius, 1990) results in Table 2 show that original data (C and IP) are cointegrated where time-scaled data are cointegrated up to 3rd scale at 5% significance level and cointegrated up to 4th scale at 10% significance level. This indicates that credits volume and industrial production are not only cointegrated at log-differenced level but also cointegrated based on time-scale decomposition or multi-scale cointegration. Since we employ multi-scale granger causality we will also add 5th time-scale in multi-scale causality analysis although 5th scale is not cointegrated¹.

¹ Granger causality test can be applied both cointegrated and noncointegrated variables in multi-scale analysis.

Table 2

Cointegration test results

	Unrestricted Cointegration Rank Test		
		Trace Stat.	Max-Eigen Stat.
Original data (C&IP)	r=0 r ≤ 1	20.6245*** 3.75923	20.6245*** 24.3837**
WJ ₁ (6 months)	r=0 r ≤ 1	89.6598*** 31.2678***	58.392*** 31.2678***
WJ ₂ (1 year)	r=0 r ≤ 1	41.7976*** 15.872***	25.9256*** 15.872***
WJ ₃ (2 years)	r=0 r ≤ 1	24.8944*** 9.68213**	15.2122* 9.68213**
WJ ₄ (4 years)	r=0 r ≤ 1	23.3752** 2.09998	21.2752*** 2.09998
WJ ₅ (8 years)	r=0 r ≤ 1	15.6297 0.541378	15.0883* 0.541378

Notes. *, **, *** indicates significance of cointegration at the 10%, 5%, and 1% level respectively. The number of lags is selected as 4 using the Schwarz information criterion with a maximum of nine lags.

Figure 2 shows original data and scaled data with wavelet analysis. LA (8) MODWT multi-scale decomposition is applied in wavelet analysis (five different wavelet details, WJ₁ to WJ₅). There is a high correlation between C and IP at 5th scale or 8 years decomposition.

Figure 2 shows dynamic correlation (between C and IP) for scaled time series as WJ₁ to WJ₅. Rolling window size is 18 data points or 4,5 years. 2001 is crises year for Turkish economy and in 2001 all scaled time series correlation became negative but not WJ₂ or one year decomposition. Since the negative correlation between C and IP is not significant in the theory of credit-growth explanation this indicates that C and IP cointegrate in one year lag in crises period. After 2006 or presently WJ₃ or 2 years correlation increases where other time-scale decomposition becomes non-significance. This evidence shows that C and IP cointegrate around 2 years lag presently.

Figure 4 shows wavelet correlations between C and IP. Correlation is maximum at 5th time scale as 53% and wavelet correlation increases with time scales from WJ₂ to WJ₅. This indicates that C and IP are not fundamentally different starting from 6 months until 8 years or in the long-run (Lee, 1999; and In and Kim, 2006).

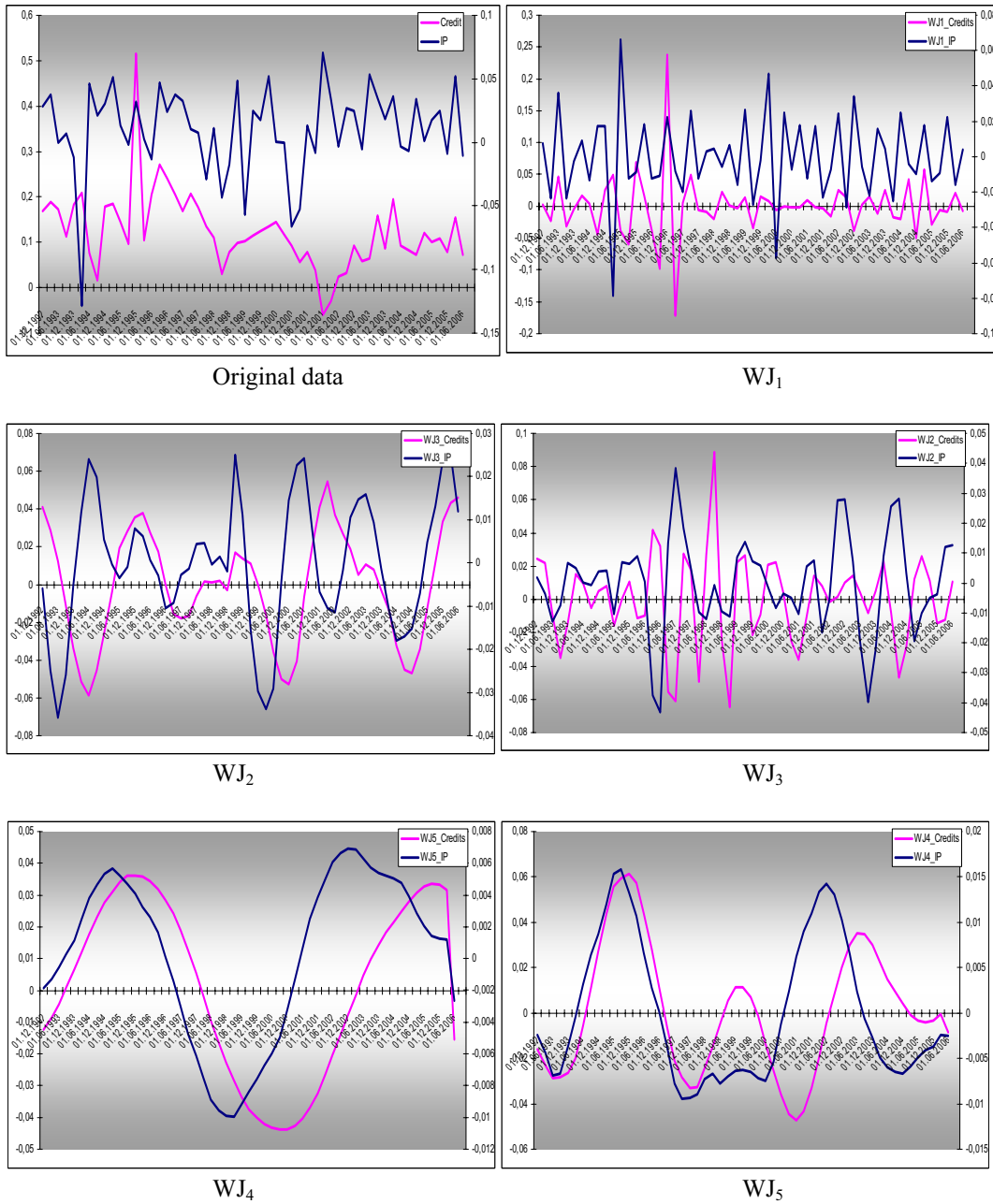


Fig. 2. Original data and scaled data with wavelet analysis¹

¹ Bright line represents change in credits and dark line represents change in industrial production.

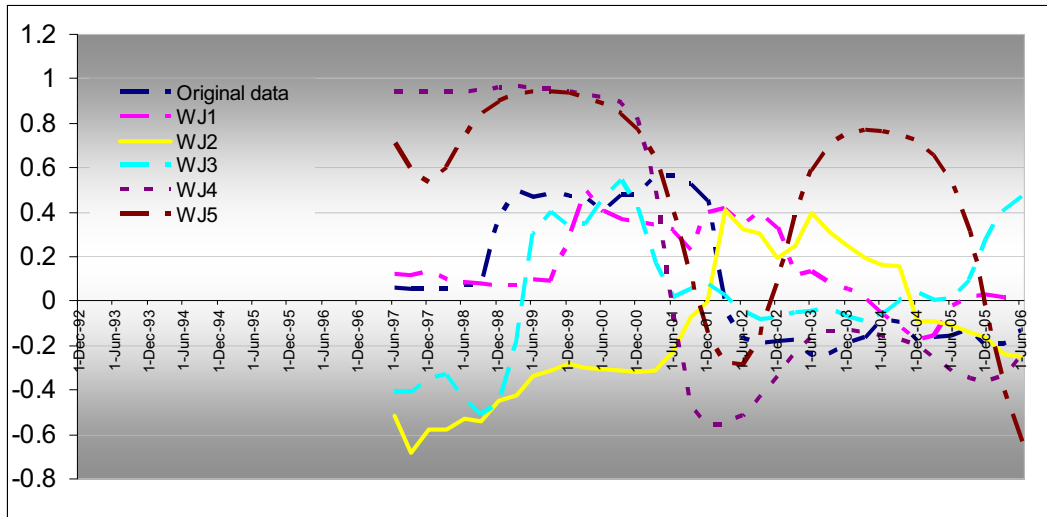


Fig. 3. Estimated dynamic correlation for scaled time series

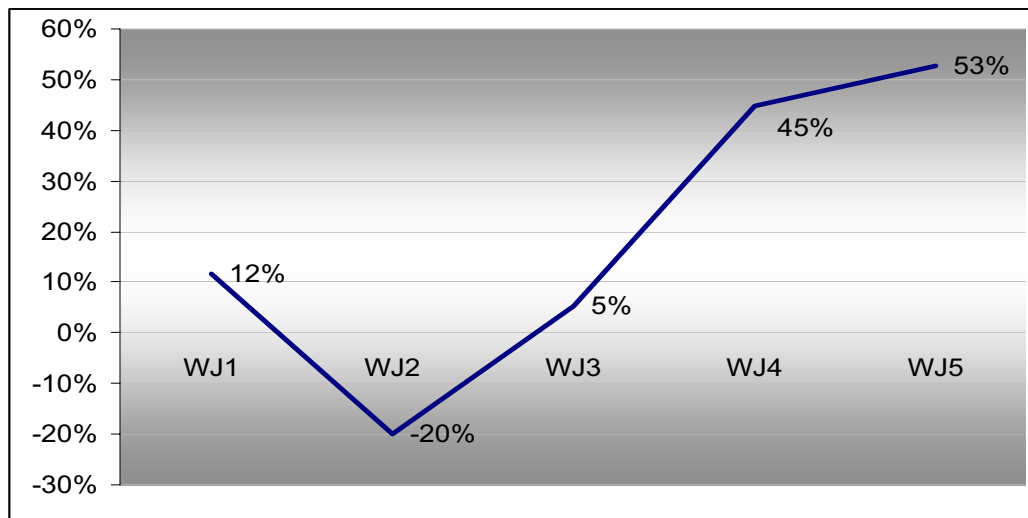


Fig. 4. Estimated wavelet correlations between Credits and Industrial Production

Multi-scale granger causality test results for original and time-scaled data are shown in Table 3. C and IP are not caused each other where causality exists for time-scaled data or wavelet based decomposition analysis. IP causes C at WJ₁, WJ₂, and WJ₃ while C causes IP at WJ₄ and WJ₅. In other words, IP causes C in 6 months to 2 years while C causes IP in 4 years to 8 years in the long-run. As a result IP affects C in the short-run and C affects IP in the long-run.

Table 3

Granger causality test

	Granger causality test for original data	Granger causality test for wavelet analysis				
	C&IP	WJ ₁	WJ ₂	WJ ₃	WJ ₄	WJ ₅
C→IP	0.45800 (0.76603)	0.35349 (0.8401)	1.41311 (0.2462)	1.76452 (0.1540)	2.58648 (0.0505)*	2.42800 (0.0626)*
IP→C	1.44553 (0.36199)	5.03170 (0.0021)*	2.40185 (0.0649)*	3.45960 (0.0156)*	0.99249 (0.4222)	1.68293 (0.1719)

Notes. The original data has been transformed by the wavelet filter (LA(8)) up to time scale 5. The significance levels are in parentheses. * indicates significance at 5% level. The first detail (wavelet coefficient) WJ₁ captures oscillations with a period length 3 to 6 months. Equivalently, WJ₂, WJ₃, WJ₄, and WJ₅ capture oscillations with a period of 7-12, 13-24, 25-48 and 49-96 months, respectively.

5. Concluding Remarks

In many researches conducted with data from different economies and time periods, relationship between industrial production and credit volume has been empirically figure out. However, the evidence on the direction of that relationship varies on the methodology used, economics and time periods examined.

In this research paper, we use a new methodology, namely wavelets analysis, to empirically examine the time-scale relationship between industrial production and credit volume. By using data from Turkish economics for the time-period between 3/1992 and 12/2006, we try to figure out the industrial production is a credit driver for the Turkish banks.

We transform the original data upto 5 time scales with wavelet filter, which captures oscillations with a period length 3 to 6 months. The consequent wavelets capture oscillations with a period of 7-12, 13-24, 25-48 and 49-96 months, respectively. The results of multi-scale granger causality test display the fact that the industrial production has significant effects on credits volume upto 24 months. However, after that period, the credits volume starts to cause industrial production to increase. We think that the paper represents interesting empirical findings with a new methodology from an emerging economy.

The researches in the future might focus on alternative new methodologies that are able to show dynamic relationship between the two variables. We think that a combination of wavelets and neural networks, namely wavelet networks, might be used to see the relationship. On the other hand, it should be noted that empirical results might be biased in methodology employed. Therefore, future researches with new methodologies might present comparative analysis for different methodologies.

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