Journal of Business Models and Applications
Vol. 1, No. 1 (2020), pp.19-26
http//dx.doi.org/10.33832/jbma.2020.1.1.04

STATUS OF MANUFACTURING BUSINESSES AND WAVELET MODEL

Seong-hoon Jeong[1] and In-ho Choi[2*]

[1]*Associate Professor, Dept. of Economics & International Trade, Daegu Catholic University, Daegu, South Korea*
[2]*Professor, Dept. of Real Estate, Namseoul University, Cheonan, South Korea*
[1]James1101@cu.ac.kr, [2]landchoi@nsu.ac.kr

***Abstract*— The purpose of this study is to reveal how the Equilibrium relationship between the production and exchange rate of the manufacturing industry, Korea's main industry, exists on an annual and periodic basis. because production changes due to changes in technology structure, economic crisis, and globalization of industry. This relationship is based on the shock response function and the wavelet model, and the results are as follows. First, the exchange rate and production differed by industry on whether long-term balanced relationships existed or not The primary metal manufacturing industry (C24) and the electronic parts manufacturing (C26) were analyzed to have a long-term equilibrium relationship between exchange rates and production, and the automobile manufacturing (C30) was found to exist in part.**

***Keywords*— Exchange Rate, Shock Response Function, Wavelet Model , Financial Crisis, Interest Rates**

1. INTRODUCTION

Looking at Lucas (1982)'s theory of exchange rate equilibrium, which presented a model for a balanced relationship, it suggests that the exchange rate has a balanced relationship with the amount of money and industrialization.[1] Then, it is necessary to examine whether the nation's manufacturing industries are following Lucas (1982)'s theory of exchange rate equilibrium. Korea is a country of trade and manufacturing-oriented growth and is sensitive to changes in exchange rates.

In general, academia suggested that before the 1997 financial crisis, exchange rates and industrial production in Korea existed in a balanced relationship (Seobyeongseon; 2001), and there has been no such research since the financial crisis.

There are also a number of studies that have generally analyzed the relationship between production and foreign exchange rates in early 2000 (Harris; 2001, MacDonald and Taylor; 1994, Chinn and Meze; 1995).

Among them, there is a study of claims that production and exchange rates are in a long-term equilibrium with each other (MacDonald and Taylor; 1994, Chinn and MEE; 1995). However, because production changes due to changes in technology structure, economic crisis, and globalization of industry, this study examines whether there exists a balanced relationship between production and foreign exchange rates around 2000 after the 1997 financial crisis, including 2008 when the economic crisis existed.

In order to achieve the purpose of the research, the following research topics were established and verified.

Received: April 10, 2020
Reviewed: June 28, 2020
Accepted: July 9, 2020
* Corresponding Author

ISSN: 2652-7421 JBMA

The balance between production and exchange rates is analyzed by year and cycle using a sofa model.

Perform an annual and periodic analysis that was not seen in the impact response function. That is, how the relationship between production and foreign exchange rates appears over time, and how the relationship between the economy and the exchange rate is viewed using one of the characteristics of the changes in the economy, the movement. Economic fluctuations refer to the repetition of the rise and fall of economic activities, and this study analyzes them around the small cycle of two to four years.

The reason why we look at the cycle is because the study focuses on changes in exchange rates, so economic fluctuations in the cycle of Kitchen Cycle are mainly attributable to changes in inventory, interest rates and prices.

2. PRECEDENT RESEARCH FOR MODEL

1) PRE-RESEARCH ON EXCHANGE RATES

I would like to look at prior studies on exchange rates and production, which are the central variables of this study.

First of all, prior research related to exchange rates is being conducted to identify the cause of exchange rate fluctuations and to determine the impact of exchange rate fluctuations. If you look at the preceding studies on the causes of fluctuations in exchange rates and look at the ripple effects and effects of exchange rate fluctuations, you will be able to understand the flow of exchange rate fluctuations.

A study that analyzes the determinants of exchange rate fluctuations is representative of the study by Park Yong-jung. [2] The determinants of the change in foreign exchange rates were analyzed in terms of currency volume, short-term interest rate difference, capital balance and financial account relative to GDP, and industrial production growth rate.

There are many studies on the ripple effect of exchange rate fluctuations.

Lee Sang-ho (2005) used the vector error correction model to analyze how uncertainty in exchange rates affects the economy.[3] As a result, it was analyzed that the higher the uncertainty of the exchange rate, the higher the export and import prices, resulting in a decrease in the volume of goods.

Choi Bong-ho and Lee Jae-deuk (2006) adopted exchange rates, currency volatility, domestic economic world income, and trade conditions as variables, and demonstrated that currency volatility had an adverse effect on Korea's trade balance using Johanssen's test and vector error correction model as an empirical analysis method.[5]

Based on these prior studies, empirical analysis is conducted around the component price path in this study. In other words, we would like to look at the inverse relationship between rising component costs, decreasing component inputs, decreasing total supply and decreasing production due to the increase in exchange rates.

2) PRE-STUDY ON WAVELET MODEL

Wavelet analysis is a method that has expanded rapidly since it was first introduced in the field of mathematics in the mid-1980s by Goupillaoud *et al.*, [6] (1984) and Grossmann *et al.*, (1984) and is used very frequently in fields such as physics, mechanics and signal processing today.

In particular, recent research focuses on the study of economic coordination among countries and the study of coordination among economic variables within countries.

Ranta, M. (2013) looked at the phenomenon of assimilation of major national stock markets over the 25-year period. As a result, it was argued that the stock market was strongly sympathetic in the event of a financial crisis. YANG, Lu, et al. (2016) conducted empirical analysis using a wavelet model of the foreign exchange market's interdependence on the British pound, the U.S. dollar, the Japanese yen and the European euro. [7] As a

result, strong interdependence, or sympathy, occurs during the global financial crisis and the debt crisis from Europe.

3. WAVELET MODEL

1) WAVELET MODEL BACKGROUND

Wavelet analysis began in earnest in the early 1980s and has recently expanded its application to social science, including the analysis of economic time series and financial indicators. Wavelet refers to a small wave itself limited to a specific time, allowing simultaneous use of information about the vibrating water area as well as the time domain of a time series.

Wavelet is a function transformation in the same context as Fourier transformation, and Fourier analysis uses the sine function and cosine function as a base function to express time series motion as a linear combination of various periodic components and assess the importance of each periodic component in the overall variation of the time series.

2) FUNDAMENTAL THEORY

Wavelets are divided according to the standardization method by father wavelet (Father wavelet, $\phi(t)$) and mother wavelet (mother wavelet, $\psi(t)$). These two wavelets can be expressed in the following ways.

$$\int \phi(t)dt = 1, \int \psi(t)dt = 0 \tag{1}$$

As shown in the above expression, if you integrate Father wavelet, you have a value of 1; if you integrate the mother wavelet, you have a value of 0. This Father wavelet and mother wavelet are paired in the wavelet function, which can be determined by Father wavelet for the line-up data and the long-term period description, and the mother wavelet is used to identify the factors and short-term cycles of these trends.

Because this study identifies the factors of variation in trends, it focuses on the mother wavelet. The basic size function of the mother wavelet is as follows.

$$\psi_{j,k}(t) = 2^{-j/2}\psi(2^{-j/2}t - k) = 2^{-j/2}\psi(\frac{t-2^j k}{2^j}) \tag{2}$$

Where $2^{-j/2}$represents the scale factor, and the $2^{-j/2}$is intended to make the basic function $\psi(t)$scale one. The $2^j k$determines the position of the wavelet. Here, the basic scale function changes with the change of j and k, the larger the j, the larger the scale factor, the shorter the function $\psi_{i,k}(t)$, and the wider spread.

In the mother wavelet, a large value of j can extract the part of the change at a high cycle level, and a small value of j can extract the part of the change at a low cycle.

3) WAVELET CORRELATION COEFFICIENT

Similar to Fourier analysis, wavelet analysis uses a power spectrum to assess how the periodic components account for the movement of the time series at a point in time. The formula for the wavelet's power spectrum is as shown below.

$$WPS_x(r,s) = |W_x(r,s)|^2 \tag{3}$$

After assessing the importance of the components and timing through the above formula, the covariance for the two time series is measured by the following formula, Cross Wavelet Spectrum.

$$W_{xy}(r,s) = W_x(r,s)W^*(r,s) \quad (4)$$

After the covariance for the two time series is obtained, the covariance value is calculated by substituting the formula below for the wavelet correlation coefficient.

$$\rho_{xy}(r,s) = \frac{WPS(W_{xy}(r,s))}{\sqrt{WPS_x(r,s) \times \wp S_y(r,s)}} \quad (5)$$

4) WAVELET CONSISTENCY MODEL

The wavelet consistency model measures the correlation between two signals, and the formula for wavelet consistency of two time series x and y is as follows.

$$\frac{\left|S(C^*(a,b)C_y(a,b)\right|^2}{S(|C_x(a,b)|^2 S(|C_y(a,b)|^2} \quad (6)$$

$C_x(a,b)$ and $C_y(a,b)$ represent continuous wavelet transformations of x and y at scales a and b. S serves to refine time and scale. In order to look at the relationship between the exchange rate and the production index of specialized manufacturing industries by region, it is necessary to use a wavelet model that can be analyzed both short-term and long-term beyond the existing correlation analysis.

We would like to examine whether there is a reverse relationship between exchange rate and production through the component price route of the exchange rate ripple.

A number of studies, including Chowdhury (1993), Cushman (1988), and Keneland Rodrik (1986), Kang Sam-mo, Lee Chang-soo (2005), Choi Bong-ho and Lee Jae-deuk (2006), claim that changes in exchange rates adversely affect corporate earnings.

This suggests that if the exchange rate rises, it will lead to an increase in component costs, thereby lowering the total supply and thus adversely affecting imports due to worsening production and productivity. However, in the case of the light industry sector, the hypothesis was established by referring to a study by Lee Gyun-hee [8] (1999), which showed different results from other industries.

Therefore, in this study, the correlation analysis among wavelet models is used to determine whether the following hypotheses are consistent with existing theories.

Existing theories failed to discuss the relevance from an annual and periodic perspective. This study looks at the long-term balanced relationship and correlation from the long-term and short-term perspectives of the impact response function used in the past, which is different from the existing research and is believed to have academic significance.

5) GRANGER CAUSAL RELATIONSHIP

Table I is the result of verification of Granger-related between the exchange rate and the production index of each manufacturing sector in South Korea. First of all, it was analyzed that food manufacturing (C10), beverage manufacturing (C11), printing and record media cloning (C18), medical materials and medicines manufacturing (C21), medical, precision, optical equipment and watch manufacturing (C27), and other product manufacturing (C33) had no causal relationship with each other. Changes in the production index of the manufacture of chemicals and chemicals (C20) were analyzed to affect the exchange rate.

Table I. Results of Granger's Causal Relationship

Period	January 2000 to December 2018			
Sortation	EX C00		C00 EX	
	F-statistics	p-value	F-statistics	p-value
C10	0.39096	0.6769	0.61188	0.5432

C11	0.42565		0.6539	0.09143	0.9127
C12	5.33523	***	0.0055	0.49431	0.6107
C13	4.68667	**	0.0102	0.31480	0.7303
C14	3.82278	**	0.0233	0.13790	0.8713
C15	3.83208	**	0.0231	0.14853	0.8621
C16	2.86584	*	0.0591	0.12451	0.8830
C17	11.91770	***	0.0000	0.82059	0.4415
C18	1.07533		0.3430	0.24119	0.7859
C19	0.78175		0.4589	0.00397	0.9960
C20	2.16100		0.1176	4.12249 **	0.0175
C21	1.31380		0.2709	0.34293	0.7101
C22	8.92554	***	0.0002	2.78235	0.0641
C23	4.92331	***	0.0081	1.08588	0.3394
C24	23.40520	***	0.0000	2.50926 *	0.0836
C25	4.78196	***	0.0093	1.45242	0.2362
C26	7.32279	***	0.0008	10.85620 ***	0.0000
C27	1.41070		0.2462	0.27515	0.7597
C28	2.66658	*	0.0717	1.44802	0.2373
C29	9.17053	***	0.0001	0.20363	0.8159
C30	4.86221	***	0.0086	2.71554 *	0.0684
C31	4.57860	**	0.0113	0.11106	0.8949
C32	8.76365	***	0.0002	3.69887 **	0.0263
C33	1.92962		0.1476	0.21619	0.8058

Note: *** is 1% significant; ** is 5% significant; * is 10% significant

A total of 16 industries are affected by changes in production indices due to changes in exchange rates, including tobacco manufacturing (C12), textile manufacturing (C13), clothing, clothing accessories and fur products (C14), leather, bags and shoes manufacturing (C15), wood and wood products manufacturing (C16), rubber and plastic products manufacturing (C23), non-metallic mineral products (C24C), metal processing (C25, metal processing).

Among them, the primary metal manufacturing (C24) was affected by the exchange rate (F value: 23.4052, P-value: 0.0000, a significant level within 1%), whereas the exchange rate was affected by the production index of the primary metal manufacturing industry (F value: 2.50926, P-value 0.836, a significant level within 10%), and the causal relationship with each other was analyzed. In addition, manufacturing of electronic components, computers, video, sound and telecommunications equipment (C26) was also found to have a stronger causal relationship than other industries as the exchange rate was strongly affected by the production index (F value: 10.85620, P-value 0.0000, and a significant level within 1%). It was analyzed that the automobile and trailer manufacturing (C30) has a causal relationship between exchange rates and production at a level similar to that of primary metal manufacturing. Finally, the household manufacturing (C32) production index was also analyzed to affect the exchange rate (F value: 3.69887, P-value 0.0263, a significant level within 5%).

Compared with the previous share of manufacturing imports, it was analyzed that the manufacturing of electronic components, computers, video, sound and telecommunications equipment (C26) had the highest share of 52.3% of imports and had the highest impact on the exchange rate. The primary metal manufacturing (C24) was analyzed to have a higher relationship with the exchange rate at 26.5 percent, higher than the average import share of

the manufacturing industry. Finally, the automobile and trailer manufacturing (C30), which is highly related to the exchange rate, is 13.0% lower than the average import share of the manufacturing industry, but when looking at the Korea International Trade Association's exports and imports, it is analyzed that the export amount is higher than other items (third in HSK units) at 61,171,472,000 dollars in 2018. Furniture manufacturing (C32) is lower than the manufacturing average when compared with the import share, but the export amount is $1,785,035,000, which is within the top 30%, indicating that there is a causal relationship with the exchange rate due to its high export influence.

4. WAVELET COHERENCE ANALYSIS RESULTS

1) DISASSEMBLING THE WAVELET

To find out the relationship between production and exchange rates using the wavelet model, the wavelet decomposition is performed on the time series data, the exchange rate and the production index of each manufacturing type. First of all, the exchange rate time series data from January 2000 to December 2018 were decomposed into six stages, as shown in the following picture. If you look at the final six-stage decomposed graph, you can distinguish it into three stages from 2000 to 2018. First of all, it has been on the decline from 2000 to 2004, increasing and decreasing significantly from 2005 to 2010, and increasing since 2010.

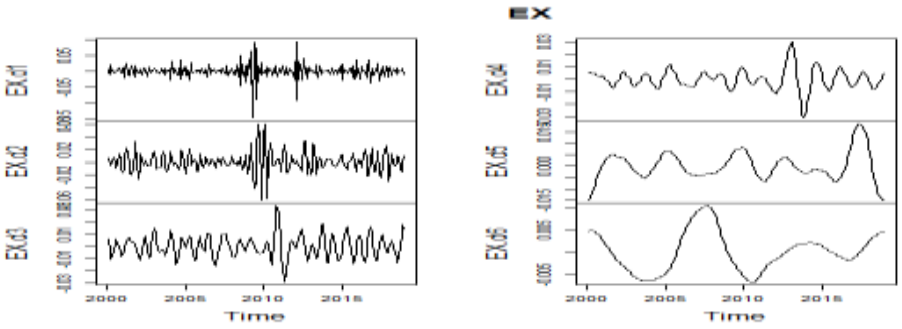


Fig. 1 Analysis of Wavelet on Exchange Rate

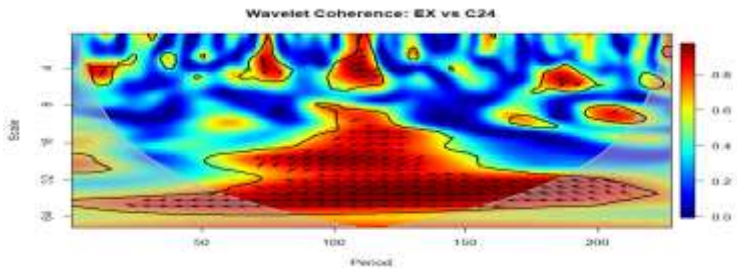
2) WAVELET COHERENCE ANALYSIS RESULTS

Economically, the long- and short-term divisions are generally divided based on the time when fixed costs become zero, but in this study, the long-term and short-term were divided by referring to the previous prior research due to difficulties in analyzing fixed costs. According to Aguiar-Conracia, et.al (2008), more than four years (48 months) are considered long-term, so this study conducted a wavelet consistency analysis based on four years (48) months.

Granger looks at the primary metal manufacturing (C24) first among the industries that have a causal relationship.

The analysis of the airworthiness of the exchange rate and the primary metal manufacturing (C24) production index showed that basically long-term equilibrium exists.

According to the annual survey, the long-term balanced relationship between 2008 and 2012 appears from eight months, not four years, during the period that affects the global financial crisis. It is understood that external shocks are strong, making it highly resonant.

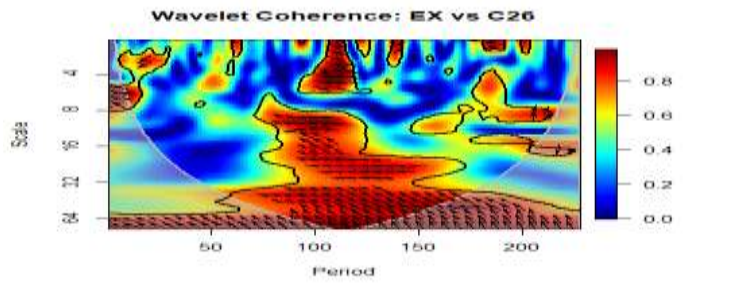


Period	Year
0~ 50	2000~ 2004
51~ 100	2005~ 2008
101~ 150	2009~ 2012
151~ 200	2013~ 2016
201~	2017~

Fig. 2 Analysis Result of Wavelet Coherence on Exchange Rate and Production Index of Primary Metal Manufacturing Industry

We look at the manufacturing of electronic components, computers, images, sound and communication equipment (C26). As a result of the analysis of the airworthiness of the exchange rate and the production index, it was analyzed that long-term equilibrium exists basically.

On an annual basis, it was analyzed that the long-term equilibrium generally appeared from about five years from 2000 to 2004, but the long-term equilibrium appeared from eight months, not four years, between 2008 and 2012, a period that affects the global financial crisis. It is understood that external shocks are strong, making it highly resonant. Since the global financial crisis, the period of long-term balanced relations has been gradually extended, and it tends to recover to five years, the period of long-term balanced relations between 2000 and 2004.



period	Year
0~ 50	2000~ 2004
51~ 100	2005~ 2008
101~ 150	2009~ 2012
151~ 200	2013~ 2016
201~	2017~

Fig. 3 Analysis Result of Wavelet Coherence of Exchange Rate and Production Index for Manufacturing of Electronic Components

The annual analysis of the performance of the exchange rate and the production index for the automobile and trailer manufacturing (C26) showed that the long-term equilibrium generally appeared after about five years in 2000, but the long-term equilibrium appeared from eight months, rather than four years, between 2008 and 2012, a period that gradually decreased and affected the global financial crisis.

5. CONCLUSION

Existing theories failed to discuss their relevance from a perspective by year and period. However, this study examined the long-term equilibrium relationship and correlation from the long-term and short-term perspectives of the shock response function and year, which

were used in the previous study. In this regard, it is considered that this study is different from existing studies and is academically significant.

This relationship is based on the shock response function and the wavelet model, and the results are as follows.

First, the exchange rate and production differed by industry on whether long-term balanced relationships existed or not The primary metal manufacturing industry (C24) and the electronic parts manufacturing (C26) were analyzed to have a long-term equilibrium relationship between exchange rates and production, and the automobile manufacturing (C30) was found to exist in part. Food and beverage manufacturing (C10) and beverage manufacturing (C11) were analyzed to have no long-term equilibrium between exchange rates and production. The reason for this difference in existence can be identified as related to the structure of the industry. Food and beverage manufacturing supported Lee Choong-yeol's claim that "light industry has a weak response to most shocks" due to light industry, and especially in beverage manufacturing production, the import share was relatively low, which is not significantly related to the macroeconomic variable foreign exchange rate. In general, the short-term balance adjustment process appeared mainly, and it was analyzed that the short-term adjustment was made due to the change in the exchange rate, not the change in production facilities but the change in prices through the adjustment of production. Other primary metals manufacturing (C24) and electronic components manufacturing (C26) were found to control the balance of production and exchange rates through adjustment of production facilities. The long-term balance of automobile manufacturing (C30) has been gradually disappearing due to external factors, but in general, automobile manufacturing has been found to follow the long-term balance in the past.

REFERENCES

[1] Lucas Jr, R. E., “Interest rates and currency prices in a two-country world”, Journal of Monetary Economics, vol. 10, no. 3, (1982), pp. 335-359.
[2] Park, Y. J., “Analysis and Implications of Decision Factors in Exchange Rate Changes”, Weekly economic review, Seoul: Hyundai Economic Research Institute, vol. 774, no. 17-49, (2017), pp. 1-13.
[3] Lee, S. H., “Economic Impact Analysis of exchange-rate uncertainty, Financial Research”, Seoul: Korea Financial Research Institute, vol. 19, no. 2, (2005) December, pp. 1-38.
[4] Kang, S.-M. and Lee, C.-S., “The effect of volatility on the exchange rate of the United States in the currencies of the exporting and importing countries on imports”, Economics Research, Seoul: The Korean Economic Association, vol. 53, no. 4, (2005) December, pp. 67-89.
[5] Choi, B.-H. and Lee, J.-D., “The Effect of Exchange Rate Volatility on the Trade Balance”, International Trade Research, Seoul: Korea International Trade Association, vol. 11, no. 3, (2006) December, pp. 67-86.
[6] Goupillaud, P., Grossmann, A. and Morlet, J., “Cycle-octave and related transforms in seismic signal analysis”, Geoexploration, vol. 23, no. 1, (1984), pp. 85-102.
[7] Yang, L., Cai, X. J., Zhang, H., and Hamori, S., “Interdependence of foreign exchange markets: A wavelet coherence analysis”, Economic Modelling, vol. 55, (2016), pp. 6-14.
[8] Lee, G. H., “Korea's Price Model”, Economic Analysis, Bank of Korea Research Department, vol. 5, no. 1, pp. 53-114.

