



CO-MOVEMENT OF AGRICULTURAL RAW MATERIALS' IMPORTS AMONG ASIAN COUNTRIES: A NOVEL MATHEMATICAL APPROACH

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Abstract

Aim of the study is investigating the agricultural raw materials imports co-movements among selected Asian countries (Japan, Korea, Rep., and Malaysia). Overall Design of the study includes review of relevant literature, secondary data extraction and analysis. Data of the aforementioned variables of the refereed countries is extracted from World development indicators (WDI) for last approximately sixty years. The sample Countries have been selected on the basis of availability of the data. The method implied for analysis is "wavelet analysis". The results of the analysis show that the three countries initially have high agricultural imports and over the period of time the agricultural imports of all the countries reduced Japan and Korea, Rep. were able to reduce to zero. Whereas Malaysia after moderate reduction in imports again gained momentum. At the same time the power spectrums of all the countries show similar patterns from 1997 onward the concentration of agricultural raw material imports of Japan and Korea even at high frequency bands remained very low in density. Whereas in the shared power of Japan and Malaysia although Japan remained leading but the pattern of Japan remains different from Malaysia. Whereas the shared power of Japan and Korea, Rep. depicted low density from 1997 onward. This result also confirms to the real scenarios. The coherence of Japan and Malaysia at high frequencies remain very low but the coherence of Japan and Korea across all the frequencies localized against all the times remained high and hot.

Keywords: *Agricultural Raw Materials, Import, Asian Countries, Co-movement, Wavelet*

1. Introduction

Investigation the agricultural raw material imports is very vital phenomenon particularly in the context of Asian countries. In Asian countries agricultural production has significant contribution towards gross domestic products (GDP) of the countries. It is an ever-green area of research there are numerous research studies that cover wide variety of topics directly and indirectly related to agricultural production and imports. These research studies most of the times use classical statistical/econometric methodologies. There is depth of the studies that view the variables of agricultural sector or agricultural economic indicators as the signals. It is interesting to learn that all the economic indicators for the time series data is available can be viewed as signals. On every time series signal analysis can be performed. There are two popular techniques of signal analysis that are really useful to analyze the time series data or Fourier transform and wavelet transform. Fourier transform prevailed almost over a last century and wavelet transform is being viewed as transform of next century. In this way there is a research gap in the literature. Agricultural economic indicators, undoubtedly say, have been analyzed over the years but one can hardly

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find any study that uses wavelet transform. Wavelet transform is a technique of analysis that can offer more details of frequency- time resolution.

The research problem, therefore is to perform the wavelet analysis to fill the gap of detailed information on frequency-time resolution. The objective of the study is to analyze the co-movements of imports of agricultural raw materials of Japan, Malaysia, and Korea, Rep. In order to address the issue from the view point of aforementioned analysis the authors considered two basic techniques that is Fourier transform and wavelet transform. The Fourier transform is only the analysis of frequency resolution and to take the combination of frequency and time resolution a mathematical function of short spam window is create to capture the frequency-time resolution in the signal that has serious limitations. Therefore, this is never the preferred choice for frequency-time resolution on the continua. On the other hand, wavelet transform, inter alia the precision in frequency-time resolution have clear advantage over Fourier transform. Wavelet transform also have an array of mathematical and visual representations depending upon shapes of the waves. It includes, for example, Mexican head, Morlet, symlets, meyer, coiflets, haar etc.

This study uses morlet wavelet as methodological choice. In order to analyze aforementioned signals (time series data of the selected variables). The scheme of method includes plots, continues wavelet transform, cross wavelet transforms and cross wavelet coherence analysis. Reset of the paper is represented as review of the literature, methodology, wavelet analysis, discussion and conclusions.

2. Literature Review

Recognizant of the fact that literature review is crucial as a part of the research study, the authors reviewed the contemporary literature. Review of literature establishes the context and the background of the study, helps to identify the research gaps, helps in identifying the research design or methodology and helps in avoiding duplication. It also helps to ensure originality of the research and building the arguments on existing knowledge. The authors, therefore explored all important research data basis viz; Scopus, Web od science, PubMed, JSTOR, Google Scholar, DOAJ, ERIC, IEEE, ScienceDirect, Sage, Tailor & Francis etc. Authors used advance search options with appropriate filters using google as search engine. The key words for search were used agriculture, agricultural, agricultural imports, agricultural raw materials, agricultural assets, agri-food, Agri- business etc. The searches resulted in a large number of research articles that have been critically reviewed keeping in view contextual scope of the study. Few of the highly relevant studies are being reported herein this section. However, a large number of studies is skipped from reporting for the sake of brevity. Muia and Thomas (1990) argued that there is no direct evidence to show that which compounds cause cancer in humans. Murthy, & Reddy, (1993) examined the feasibility of agricultural production of industrial feedstocks and energy. Oh, et al. (2005) investigated economic considerations, lactic acid fermentations from agricultural resources. Abdullah, & Nakagoshi, (2008) concluded that it is important to understanding the relationship quantitatively in order to describe the implications for land development of the agricultural crops. Alriols, et al. (2009) reached to conclusion that the organosolv pulping of an agricultural residue provided cellulose, hemicelluloses and lignin that are valuable products and can improve ecological drawbacks. Dao (2009) buttressed that magnitude of agricultural policy variables in an effort to use agriculture as an engine for economic development is crucial. Du, et al., (2009) argued that the service level is increased while the inventory variance is reduced. Ahamed, et al., (2011) asserted that energy & exergy efficiencies for agricultural in Malaysia and the devices used in this sector are accurately determined. Overall energy & exergy efficiencies of the agriculture sector is found to be 22% and 20.728%. Nilsson, Bernesson, & Hansson (2011) concluded that farm raw materials are of greatest interest for large-scale production of pellets. Investigated competitive raw material costs and acceptable fuel properties mixed with sawdust in existing large-scale pelleting factories. Zonin, Antunes & Leis (2014) bolstered that the problem of raw material production is a core component of economic viability of biodiesel production. Guijarro, et al. (2015) buttressed that there is dire need to for effective solution in the recognition of green plants (crops and weeds) in farm fields. Suwannasing, Imai, & Kaewkannetra (2015) affirmed that PHAs production medium containing pineapple is a sole carbon source can be used by Bacillus strain to produce a biopolymer. Wiedenmann, & Geldermann (2015) said that rising demand for industrial products from renewable resources calls interilic for



decision support for industrial process. Jiang, et al. (2018) asserted that the extent and direction of the short-term linkage change over time but the long-term linkage will continue in several years. Shobri, Sakip, & Omar (2016) bolstered that due to the concern for the quality of life for present and future, sustainable agriculture guideline had been widely studied and improved by the international organizations. Gonzalo, et al. (2017) stated that six different agricultural residues (from pea, asparagus, broad bean, chili and bell pepper and okra plants) have been evaluated as potential raw materials for producing paper for cardboard and packaging paper using the soda semi chemical process. Wang, Lee, & Son, (2017) posited that The results revealed that the agriculture is the dominant economic mainstay providing: i) livelihood to over 70 per cent, ii) employing 60 per cent of the labor force, and iii) contributing about 22 per cent of the regional gross domestic product. Gillespie, et al. (2019) argued that to contribute to SDGs, significant changes are needed in agriculture and food systems. Ahmad, Mustafa, & Didams (2020) revealed that research on control practices to control soil erosion in agricultural land and focusing more on biological method instead of the mechanical method is call of the day. Alam, et al. (2020) investigated potential effects of agriculture insurance for disaster risk reduction (DRR) and identified the barriers by way of unplanned urbanization, persistent poverty, and ecosystem degradation. Alam, et al. (2020) observed that water-balance estimations in the water-limited Central Asian region under global warming scenarios. Kumara, Kandpal, & Pal (2020) reported that the economic and environmental benefits vary across the cropping system, soil texture and climate. Li, et al. (2020) argued that revealing of full agricultural drought propagation is vital for understanding agricultural drought hazards to develop a better early warning system. Liu, Ganesan, & Smith (2020) uncovered that there are issues in amalgamation of economic, diplomatic and nationalistic concerns, determined by political, socio-cultural nuances specific to each country. Nguema, (2020) asserted that market access standards for agricultural products need to be reformed because of their asymmetry therefore same should be rebalanced. Patil, Jadhav, & Maiti (2020) concluded in context of India that new agriculture export policy sets the foundation to make Indian agriculture globally competitive. Udomkun, et al., (2020) review contemporary literature that offered justifications for the use of solar drying as an affordable and cost-effective alternative method to overcome the restrictions of traditional sun drying, especially in low-income countries. Wang, et al., (2020) investigate three agricultural wastes to develop a new hybrid thermochemical process combining hydrothermal treatment and suggested subsequent pyrolysis to produce furfural and LG simultaneously. Bird, et al. (2019) identified in a systematic review studies that cover a wide variety of target groups, especially those considered to be the most nutritionally vulnerable including adolescents, women, children and landless households for LANSAs support. Boughton, et al. (2021) bolstered while studying Myanmar's agri-food system that there have been severe economic effects of COVID-19 in form of disruptions on farm and agricultural labor dependent households, agribusiness enterprises, and rural and urban consumers. Dizon, Josephson, & Raju (2021) examined the evidence on agri-food interventions in South Asia, including providing public food transfers. Epinat, et al. (2001) reached to the conclusion that a wavelet transforms of the four NDVI images proved to be a good method to quantify patterns at different resolution levels and directions. Leng, et al. (2021) posited that high spatial heterogeneity of salinity and major ion components along the longitudinal directions in both river catchments, pointing to an increasing influence of human activities toward downstream areas. Li, & Solaymani (2021) observed that there are the dynamic effects of economic growth, imports, technological innovation, and global crude oil prices on energy consumption in the whole Malaysian economy. Liu, et al., (2021) noticed that water and land for crop and animal products production and trade between the CANs and China were quantified to explore the environmental sustainability of their trade. Pande, et al. (2021) argued that spatial distributions of pH, EC and carbon content were observed using the Wavelet transforming method with ANN and polynomial models. Prabhakar (2021) revealed that in agricultural land-use changes and provided an understanding of various drivers behind these changes, achieving Sustainable Development Goals (SDGs) while safeguarding the health of agricultural land, in particular, presents a paradoxical problem for Asia. Pretty, & Hine (2000) showed that sustainable agriculture can deliver large increases in food production in Asia. But spreading these to much larger numbers of farm households will not be easy (Younas et al., 2025; Qaisrani et al., 2025; Shahi et al., 2025). Shrestha, Kawasaki, & Zin (2021) researched and concluded that The estimated results regarding the flood damage to the rice crops agree reasonably



with the reported data, indicating better estimations (mean absolute percentage error of 11 %). The developed FDFs can also be used in other areas in Asia where FDFs are unavailable. Van der Eng (2004) noticed that supply-side factors appear to be paramount in explaining why the countries of mainland South-East Asia dominated the prewar world rice market, because they help to define the comparative advantage of these countries in rice production. Wang, Mei, & Zhang (2021) argued that the highest tensile strength of forestry pine nutshell/PP composite is 25.44 MPa and the flexural strength is 47.84 MPa with the assistance of 5.0 wt% compatibilizer. Shankar, Poole, & Bird (2019) revealed that the literature on linkages between agricultural asset ownership and input use and nutrition outcomes amongst farm households in South Asia has shown that the literature has slowly but steadily grown.

3. Methodology

This study follows positivism as research philosophy, deduction as research approach, mono method (quantitative) as methodological choice, Archival research as strategy, cross sectional time horizon. The secondary data is extracted from website World Development Indicators (WDI) for the periods of last sixty years for the variable agricultural raw material imports of Japan, Korea, Rep., and Malaysia. Wavelet analysis is used as research methodology, the scheme of wavelet transform evolve as descriptive statistical analysis of the data, generating the frequency-time plot on Cartesian plane, continuous wavelet transform (CWD), cross wavelet transform (XWT) and cross wavelet coherence (WTC). The analysis has been performed through a wavelet analysis tool available in the tool box of MatLab software.

3.1. Data, Descriptive analysis and wavelet Analysis

In this part of the paper the original data set, descriptive statistical analysis and wavelet analysis are represented. **Dataset:** As mentioned above, for the purposes of the study the data is obtained from website of the world bank mainly World development Indicators popularly known as WDI (WDI, 2021) for the years from 1964-2019 for the countries namely Malaysia, Korea, Rep., Japan, for the agricultural raw material imports in percentage merchandise imports. The complete dataset is available in supplementary file that can be made available on request and for the sake of brevity the data set is presented below in Table 1 in skipped format.

Table 1: Agricultural raw materials imports in % of merchandise imports

| Year | Malaysia | Korea, Rep. | Japan |
|------|----------|-------------|---------|
| 1964 | 2.5661 | 21.6681 | 20.7413 |
| 1965 | 2.7405 | 22.1925 | 20.3662 |
| 1966 | 2.4382 | 18.2225 | 21.2930 |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| 1991 | 1.0419 | 6.7410 | 6.6872 |
| 1992 | 1.0778 | 6.4242 | 6.7729 |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| 2017 | 1.9951 | 1.4101 | 1.7182 |
| 2018 | 1.7605 | 1.3666 | 1.6298 |
| 2019 | 1.8829 | 1.2479 | 1.6387 |

Source: (WDI, 2021)

For the purpose of this study the definition of agricultural raw materials imports (in % of merchandise imports) is also adopted from WDI. The data of selected three countries for the purpose of analysis and the year range from 1964 to 2019 is made subject to analysis because of availability of complete dataset. If the data would have been available for more countries in a greater number of years that would have also been included.

The data analysis have been performed into two parts (descriptive analysis i.e. Table-2 and inferential analysis i.e. Figure 1-4). As a part of descriptive statistical analysis mean, median, mode, standard deviation, standard error, variance, kurtosis, skewness, range, minimum, maximum, sum and count have been calculated for the variable of every country. Whereas for the other type of analysis that is wavelet analysis Figure 1-4 have been performed to

provide inferential information about time localization, frequency localization, bio stretching, skewing and shifting. Wavelet analysis is performed step wise as first step, the frequency-time plots of time series data of all three countries are generated (Figure 1A-1C). As a second step, continuous wavelet transform (wavelet power spectra) have been generated. Cross wavelet transform that is Japan vs Malaysia and Japan vs Korea, Rep. have also been generated and similarly the cross-wavelet coherence that is Japan vs Malaysia and Japan vs Korea, Rep. are also generated.

Wavelets provides information about time, location, and frequency by stretching, squeezing, and shifting. It is used for identifying and analyzing the discontinuities, patterns, sharp spikes, de-noising, and statistical estimation/prediction from economic time-series. Stepwise mathematical procedure is applied to the data i.e. choosing mother wavelet, multi-resolution analysis, decomposition, down-sampling, up-sampling, filtering, and summation. The frequency is broken into frequency-bands i.e. high-pass filter bands (coarser or approximate coefficients) and low-pass filters (detailed or precise coefficients). Wavelet by nature is visual representation of the analysis of time series. This mathematical process of integration and differentiation is performed on MatLab software that resulted into following set of plots and wavelet periodograms (scalograms). The times series' plots of all variables mentioned in Table 1, individual wavelet power spectra (continuous wavelet transform) of all variables, cross wavelet transform spectra of variables namely agricultural raw material imports of Malaysia and Korea, Rep. with that of Japan in Table 1, and wavelet coherence spectra of variables namely agricultural raw material imports Malaysia and Korea, Rep. with that of Japan in Table 1 are generated and represented below as Figure 1-4 respectively. All plots and spectra have been inspected carefully by the authors for detection of horizontal or vertical patterns, sharp peaks, defuse areas, and other significant or non-significant events (if any) evident from the plots and spectra. The findings of the inspection are given after each set of periodogram (i.e. under Figure 1-4 respectively).

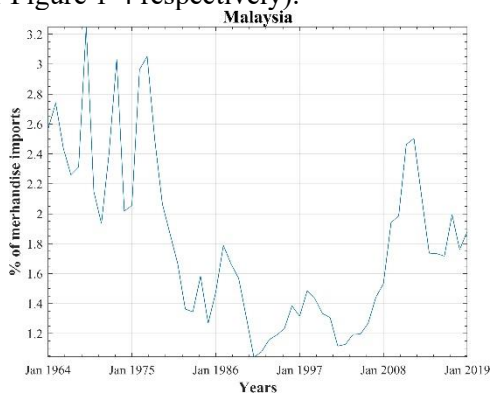


Figure 1(a)

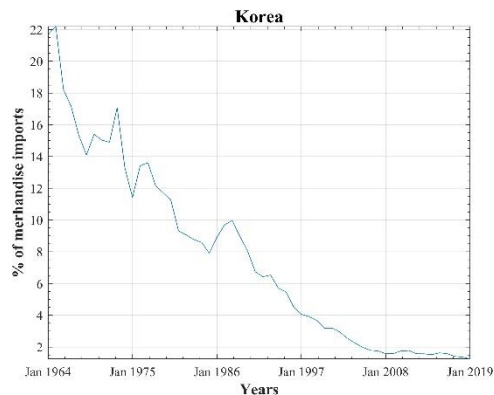


Figure 1(b)

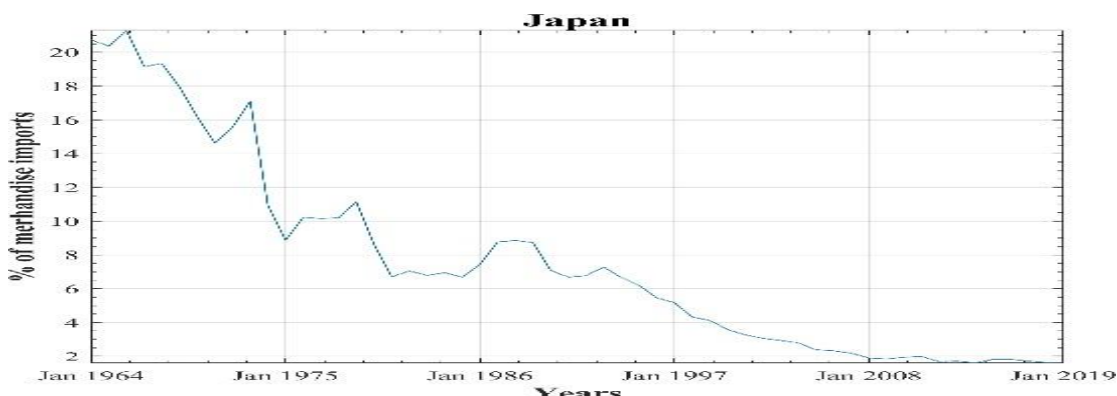


Figure 1(c)

Figure 1: Plots: The plots of agricultural raw material imports of all the three countries (Malaysia, Korea, Rep., Japan) are presented in *Figure 1*. That of Malaysia is given as *Figure 1(a)* Korea, Rep. as *Figure 1(b)* and Japan as *Figure 1(c)*. If we observe *Figure 1(a)* the time is taken on x-axis whereas the percentage of imports is taken as y-axis the close observation of the line chart reveals that there were high agricultural raw material imports from 1964 to almost 1979, thereafter the agricultural raw material imports sharply decreases and came at relatively low values that started increasing in 2008 and it touch moderate high levels in 2015-2016 but again it declined to moderate low levels. Similarly, if we observe *Figure 1(b)* there were high imports in 1964 to 1968 approximately by Korea, Rep. and gradually decreasing trend can clearly be observed that result to almost zero agricultural raw material imports in 2019. Accordingly, if we observe *Figure 1(c)* we find high agricultural raw material imports by Japan in 1964 till 1965-1966 and there remained a decreasing trend over the period of time which almost became zero in 2012 onward. The pattern of imports by Japan and Korea, Rep. remained almost similar over the period of time.

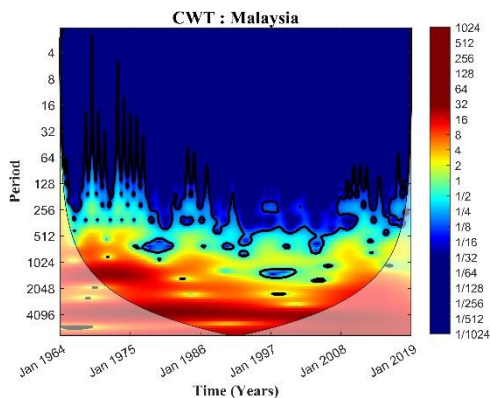


Figure 2(a)

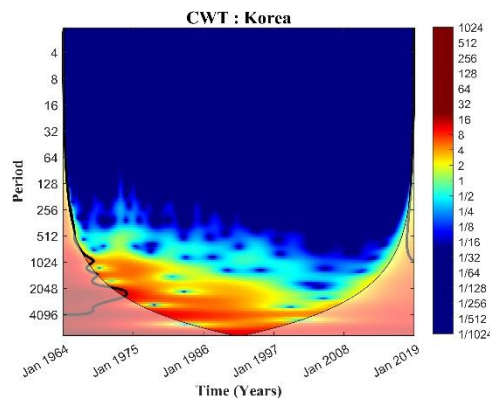


Figure 2(b)

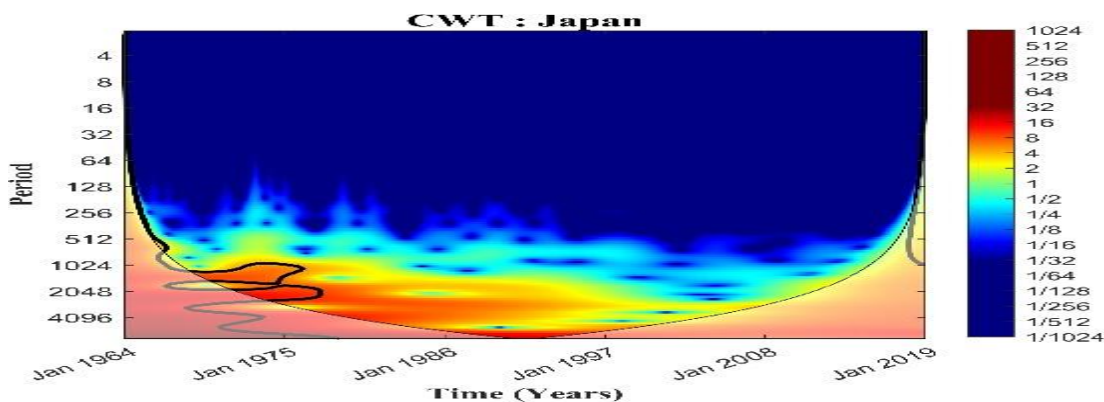


Figure 2(c)

Figure 2: Periodograms of Continuous Wavelet Transform: The continuous wavelet transform periodograms are presented as *Figure 2(a)* CWT-Malaysia, *Figure 2(b)* CWT-Korea, Rep, and *Figure 2(c)* CWT-Japan. If we observe *Figure 2(a)* we find time in years on x-axis and frequency-scale at y-axis and magnitude or intensity of activity at color scale that is blue for low activity to red for high activity. At low frequency bands that is 4-64, we find low power of the signal across all time bands. Whereas at frequency band 64-512, it can be found that there is moderate power of the signal across all time lines whereas at frequency band 512-4096, it can be found high activity of the signal across all time bands since the color scale is red. However, from within the cone of influence we are 95% confident that the wavelet coefficients are accurate whereas out of the cone of influence in the shaded region the values of the coefficients might dilute the level of confidence because of edge effects. At the same time, if we look at the *Figure 2(b)* CWT of Korea, Rep. we find similar type of patterns with a bit exception at the time periods from the 1997 to 2008. In this period at frequency band 512 to 2048 there were moderate level activity. Similarly, if we observe *Figure 2(c)* that is CWT of Japan the results in general that high degree of resembles with that of *Figure 2(a)* and *Figure 2(b)*. With a little bit exception at the time period 1986 to 2008 at frequency band 512-4096. In this period, at this frequency band the power of the signal remained moderate in magnitude.

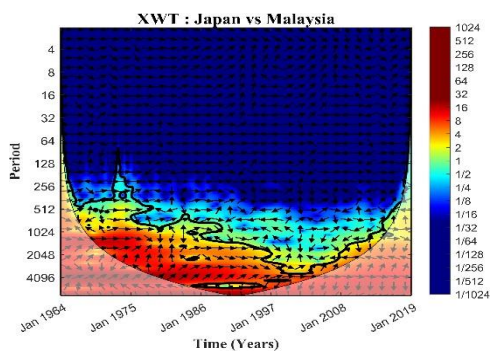


Figure 3(a)

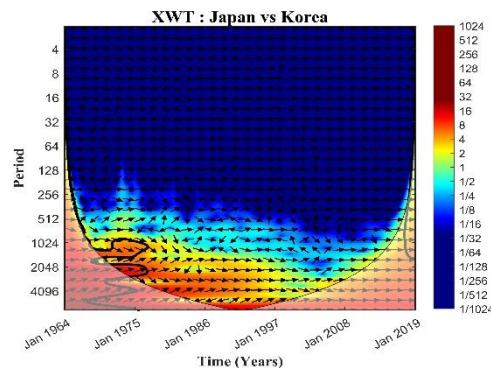


Figure 3(b)

Figure 3: Periodograms of Cross Wavelet Transform: The periodograms namely *Figure 3(a)* and *Figure 3(b)* are the presentations of the shared power spectrum of two times series i.e. agricultural raw material imports of Japan and that of Malaysia (*Figure 3(a)*) and the time series of agricultural raw material imports of Japan and Korea. Rep *Figure 3(b)*. The scheme of the plot is traditional and classically that is taking time on X-axis frequency and scale on Y-axis and intensity of activity on color scale that is blue for low activity and red for high activity. The arrows are superimposed to indicate that has to whether the oscillations of two time series are in phase or out of phase. If we closely observe the *Figure 3(a)* (XWT Japan vs Malaysia) at valid at low frequency bands that is 4-256 the two-time series are in phase and seems to be low powerful whereas at the frequency band 256-512 there is moderate shared power of the two-time series. Whereas at frequency band 512-4096 up to the time period of 1997 the time series have high shared power and are in phase and in most of the time points the Japan is leading and the Malaysia is lagging. For 1997- 2019 at the frequency band of 1024-4096 the time series have moderate shared power. Out of the Cone of Influence the shaded areas show high shared power of the time series but the authors are unable to emphasize on these coefficients because of edge effects. On a similar token if we observe *Figure 3(b)* at a frequency band 4-512 there is low shared power between the time series of agricultural raw material imports of Japan and Korea. Rep whereas at the frequency band 512-1024 there is moderate shared power of time series against all the time periods. At the frequency band 1024-4096

till 1997 both the time series have high shared powers after 1997 against this frequency band the time series have moderate shared power. Across all the frequencies and times Japan is leading and the Korea, Rep. is lagging (approximately). The shaded area out of the cone of influence though seem red in color that naturally means presence of high shared powered activity but cannot be emphasized because of edge effects.

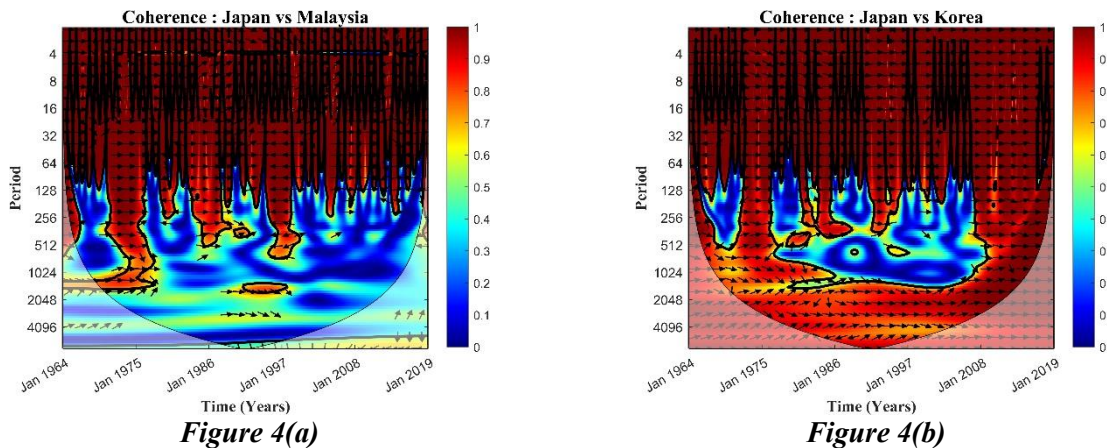


Figure 4: Periodograms of Wavelet Coherence Transform: The cross-wavelength coherence periodograms of Japan vs Malaysia (Figure4(a)) and Japan vs Korea, Rep. Figure4(b) also follow the classical scheme of representation of wavelet transform. The time span is taken on X-axis frequency bands and scale on Y-axis and presence for activity is taken at color scale that is blue for low density and red for high density. The arrows are superimposed to capture the phase relationships that is right pointing arrows show that two time series are in phase at that time and frequency whereas the left pointing arrows show that two time series are anti phase at that point of time and frequency. If we closely observe Figure 4(a) at frequency band 4-128 we find both the time series highly correlated wavelet. Whereas at frequency band 128- 104 except for vertical patterns at different points of time there is moderate correlation among the time series whereas at frequency band 2048-4096 across all the time the series seems to be low correlated. Exceptions can also be observed like a vertical pattern present at 1973-1976 against the frequency band 32-1024 and similarly a horizontal pattern from 87-97 at frequency band around 2000. If we look at the arrows the series are in phase and Japan is leading whereas the Malaysia is lagging. By the same token cross wavelet coherence transform can be observed and it can be found that almost all frequency bands that us 4-4096 and across all the time 1964-2019 both the time series have high degree of correlation with some exceptions that are captured by the blue regions present in vertical against certain time periods and horizontal against certain time periods and certain frequency bands for example there us a blue colored pattern at almost against the years 68-70 against the frequency band 128-512 that necessarily mean that the time series have low correlation coefficients localized at this frequency and time and similarly some other patterns of blue color can be located. we observe the arrows in most of the time we find the time series in phase that Japan is leading whereas the Korea, Rep. is lagging.

4. Conclusion

The research paper is aim to investigate the agricultural raw material imports co moments of selected Asian countries (Malaysia, Korea, Rep. and Japan) using the WDI time series data of last 60 years. The analysis is performed using annoval mathematical approach that is wavelet analysis. The results if the study show that it is interesting to analyze the time series data of agricultural raw material imports as a percentage of merchandizing imports for three selected countries that is Malaysia, Korea, Rep. and Japan. From the results of the study and the



observed co moment of the time series lot of lessons can be learned particularly when we relate the results of the study with practical and real time scenarios. It is interesting to observe that all the three countries initially have high agricultural imports and over the period of time the agricultural imports of all the countries reduced Japan and Korea, Rep. were able to reduce to zero. Whereas Malaysia after moderate reduction in imports again gained momentum. If these results of the plots be related to real time scenario the Korea, Rep. and Japan altogether switched from agriculture to industrial economies. And at the same time the power spectrums of all the countries show similar patterns from 1997 onward the concentration of agricultural raw material imports of Japan and Korea even at high frequency bands remained very low in density. Whereas in the shared power of Japan and Malaysia although Japan remained leading but the pattern of Japan remains different from Malaysia. Whereas the shared power of Japan and Korea, Rep. depicted low density from 97 onward. This result also confirms to the real scenarios. The coherence of Japan and Malaysia at high frequencies remain very low but the coherence of Japan and Korea across all the frequencies localized against all the times remained high and hot. The study contributes lot of new information by way of visualization of time series on control diagrams that provides visual insights to stakeholders of the phenomenon. The study has also certain limitations that include statistically the lack of statistical significance of testing etc. Therefore, it is advised to corroborate the results of this study through other statistical models.

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