A LINKAGE BETWEEN PRODUCER AND CONSUMER PRICES IN EUROPEAN COUNTRIES

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Abstract: This paper examines a linkage between consumer and producer prices within European countries. The research sample in this paper includes 23 European countries and monthly data between February 2000 and March 2023 for the harmonized index of consumer prices (HICP) and producer prices index (PPI). Using a wavelet coherence approach country country-specific linkage was provided for each of the considered countries. Empirical findings suggested diverse relationships. However, the most frequently observed linkage is the one with producer prices as leading and consumer prices as lagging variables and a positive correlation between the two. Furthermore, the relation is more prominent at higher scales or lower frequencies. Conclusively, monetary policy needs to monitor producer prices while targeting inflation rates.
Keywords: producer prices; consumer prices; wavelet coherence; European countries.
JEL Classification: C54; E52; E64.

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Introduction

The mechanism of price transmission is one of the focal issues in macroeconomics. Understanding a linkage between consumer and producer prices bears important implications for monetary policy while framing measures towards inflation stability. Following Živkov et al. (2023) and references herein, existing research suggests diverse and conflicting conclusions regarding the linkage between consumer and producer prices. Therefore, there is a need for further analysis of the topic. This paper aims to contribute and provide empirical results from a sample of European countries.

Besides this introductory section, a reminder of the paper is organized as follows: section 2 summarizes literature development related to the issue under consideration. Section 3

illustrates the employed methodology and research data, Section 4 provides the results of empirical evaluation, and the final section provides an overview of the main findings from the research.

Brief overview of the related literature

Alemu (2012) used vector error correction model (VECM) and found causality from producer to consumer prices in in South Africa. Hakimipoor et al. (2016) found no interlingake between consumer and producer prices in Itran. Based on quarterly data from Australia between 1969q3 and 2010q Tiwari (2012) found Granger-causality from consumers' price to producers' price at intermediate frequencies suggesting medium-run cycles. Granger-causality from producers' price to consumers' price was not detected at any frequency level. Consequently, consumers' price identified as is a leading indicator for producers' price. Based on monthly data sample between January 2010 and August 2016, Anggraeni and Irawan, (2018)found unidirectional causality from producer to consumer prices in Indonesia. Topuz et a. (2018) used vector autoregression (VAR) approach and found bidirectional Granger causality between producer and consumer prices in Turkey and United Kingdom as well.Based on the monthly data sample between August 1995 and December 2007, Akcay (2011) found unidirectional causality from producer price to consumer price in the case of France and Finland, bidirectional causality in the case of Germany in the case of Sweden and Netherlands and no significant causality was found. Su et al. (2016) considered the case of Slovakia on a monthly data sample between 1998:01 and 2016:01 and pointed out that consumer prices play a focal role in the dynamics of consumer prices in the case of Slovakia. Khan et al. (2018) analysed a linkage between consumer and producer prices in Central and Eastern European countries. The finding suggested that producer prices affected consumer prices in terms of of Granger causality in Lithuania, Latvia, Slovakia Romania, and Slovenia while consumer prices has a significant effect on the producer prices only in case of Hungary. Ulke and Ergun (2014) analysed monthly data between January 2003 and December 2013 for Turkey and found a linkage between consumer to producer prices. Ozpolat (2020) studied a linkage between consumer and producer prices on a sample of annual panel data for Bulgaria, Croatia, Romania, Czech Republic, Poland, Slovenia, Slovak Republic and Latvia between 1992 and 2017. The empirical findings suggested the existence of long-run bidirectional causality between consumer and producer prices. Khan et al. (2018) employed wavelet coherence analysis and expenditure-switching mode on a sample of monthly observations between 1999 and 2016 and considered a linkage between consumer and producer prices in the Check Republic. The empirical findings suggested a time-dependent linkage between consumer and producer prices over the time and frequency domain. The results further suggested a non-negligible role of exchange rate in the relationship between consumer and producer prices. Živkov et al. (2023) used wavelet coherence analysis on a data sample between January 1998 and March 2022 and examined the relationship for Poland, Czech Republic, Slovakia, Lithuania, Hungary, Estonia, Latvia and Slovenia. The empirical results suggested a time-varying and scale-varying nature of the relationship. Tiwari et al. (2013) used a wavelet coherence approach and based on monthly data between 1991m1 and 2011m11 analysed a linkage between consumer and producer prices in Romania. The findings provided strong evidence to support the presence of cyclical effects or variables in phase while counter-cyclical effects were not found. Tiwari et al. (2014) used wavelet

coherence approaches and provided results for Mexico. Based on data samples between January 1981 and March 2009, empirical findings suggested a bidirectional linkage between consumer and producer prices. In the short run (up to 7 months), consumer prices were leading while for longer periods producer prices were the leading variable. Contemporary literature is ambiguous regarding a linkage between producer and consumer prices. Consequently, there is a need to bring further arguments and contribute to the debate.

Research methods

The recent empirical research in economics and finance has acknowledged the benefits of the wavelet-based methodology adopted in this study (Bošnjak, 2021, Rathinasamy et al., 2017; Rua, 2012; Vacha and Barunik, 2012; Xu, 2019). Wavelet coherence is a mathematical tool used in signal processing and time series analysis. Enables us to measure and visualize the degree of similarity or correlation between two time series in both the time and frequency domains. In this research paper, Morlet wavelet is utilized as described in the equation (1):

$$\psi^M(t) = \frac{1}{\pi^{\frac{1}{4}}} e^{i\omega_0 t} e^{\frac{-t^2}{2}} \quad (1)$$

where t denotes time, and ω_0 serves as the central frequency parameter, typically set to six as is common in similar economic research (Vacha and Barunik, 2012). The Morlet wavelet's intricate characteristics provide a valuable advantage by enabling the consideration of time-dependent amplitude and phase across various frequencies. Equation (2) illustrates the continuous wavelet transform:

$$W_x(\tau, s) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} x(t) \overline{\psi\left(\frac{t-\tau}{s}\right)} dt \quad (2)$$

where $x(t)$ represents the observed time series, while s denotes the scale, and τ represents the location determining the wavelet's position. Following the wavelet transform equation (2), the observed time series $x(t)$ is decomposed using wavelets. Subsequently, the study delves into assessing the magnitude and significance of the local correlation between consumer and producer prices, both considered as time series data. To analyse the size and significance of this local correlation, the paper introduces the concepts of cross-wavelet transform and cross-wavelet power. The cross wavelet transform for two time series $x(t)$ and $y(t)$ is defined in equation (3):

$$W_{xy}(\tau, s) = W_x(\tau, s)\overline{W_y(\tau, s)} \quad (3)$$

In this context, $W_x(\tau, s)$ stands for the continuous wavelet transform of the observed time series $x(t)$ and $\overline{W_y(\tau, s)}$ indicates the complex conjugate continuous wavelet transform of the observed time series $y(t)$. The cross-wavelet power is denoted as $\left|W_{xy}(\tau, s)\right|$. Finally, equation (4) introduces the squared wavelet coherence coefficient:

$$R^2(\tau, s) = \frac{\left|S\left(s^{-1} W_{xy}(\tau, s)\right)\right|^2}{S(s^{-1}|W_x(\tau, s)|^2) S\left(s^{-1}\left|W_y(\tau, s)\right|^2\right)} \quad (4)$$

where S denotes a smoothing operator. Similar to the Pearson squared correlation coefficient, the squared wavelet coherence coefficient falls within the range of zero to one. Additionally, the analysis of wavelet coherence offers insights into the phase differences

between the examined time series. The equation for wavelet coherence phase difference is presented as (5):

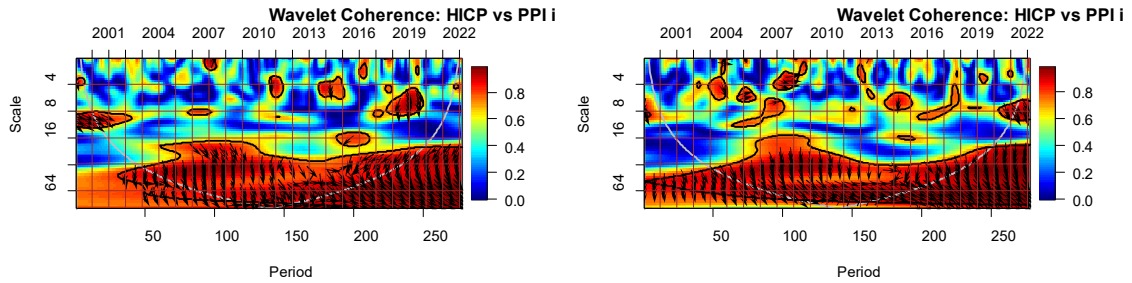
$$\varphi(\tau, s) = tan^{-1}\left(\frac{\Im\left(W_{xy}(\tau,s)\right)}{\Re\left(W_{xy}(\tau,s)\right)}\right) \quad (5)$$

where $\Re$ signifies the real part, and $\Im$ signify the imaginary part of the cross wavelet transform mentioned in equation (3). The phase difference is visually depicted using arrows. A zero-phase difference suggests that the analysed time series are positively correlated and move in sync. Arrows pointing to the right signify a positive correlation, while arrows pointing to the left represent a negative correlation. Upward-pointing arrows indicate that the first time series leads the second by a right angle, while downward-pointing arrows indicate that the second time series leads the first by a right angle. Consequently, the arrows can convey various combinations of relationships."

Empirical findings

Following procedure described in section entitled methods, Figure 1 illustrates interlinkage between consumer and producer prices in Austria.

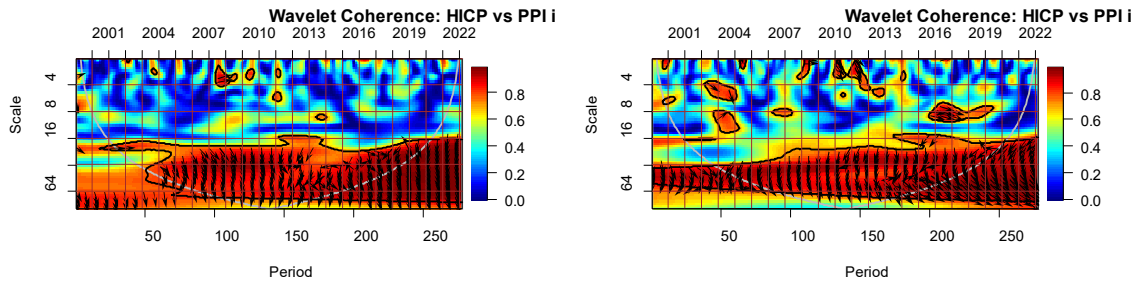
Figure 1-2 a linkage between consumer and producer prices in Austria/ Belgium



As illustrated in figure 1, the arrows pointed right and down suggesting that the producer prices index time series leads the harmonized index of consumer prices while correlations were positive. Furthermore, the linkage was identified at higher scales or lower frequencies. Figure 2 illustrates a linkage between consumer and producer prices in case of Belgium. Following Figure 2, a linkage between consumer and producer prices was found during the entire observation period. A linkage was present at lower frequencies with producer prices as leading variable.

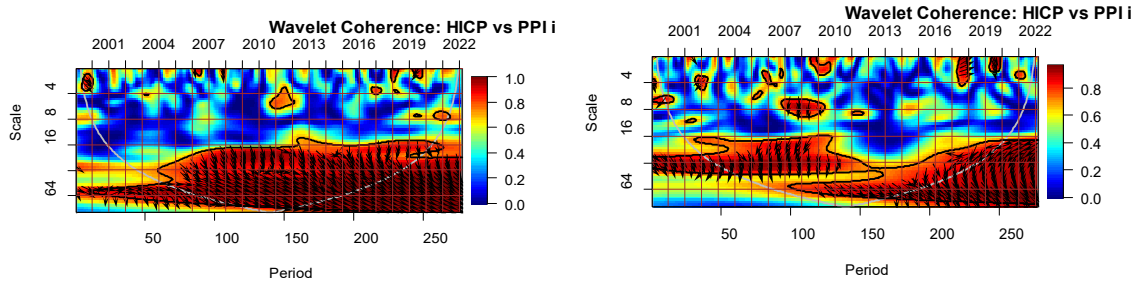
Figure 3 presents a linkage between consumer and producer prices in case of Bulgaria.

Figure 2-4 a linkage between consumer and producer prices in Bulgaria/ Croatia



In case of Bulgaria, as illustrated in Figure 3, producer prices were liding during the observation period. However, the correlation was not allways positive. Figure 4 illustrates ther linkage in case of Croatia. Similarly to the case in Bulgaria, in case of Croatia producer prices were leading variable and correlation was not positive during the observation period as one can see in Figure 4. The case of Cyprus is provided in Figure 5. As illustrated in Figure5, pruducer prices were leading variable and correlation were positive. Futhermore, the linkage was less prominent at the beginning of the observation period. Figure 6 illustrates the case of Denmark. Figure 6 illustrates a significant correlation between producer and consumer prices during the entire observation period. However, a linkage was established at lower frequencies after 2008.

Figure 3-6 a linkage between consumer and producer prices in Cyprus/ Denmark



The case of Finland is provided in Figure 7. Figure 7 illustrates a linkage between producer and consumer prices in case of Finland. Producer prices were leading variable during the entire obyervation period but correlation were not allways a positive at all frequencies. Figure 9 depicts a linkage in case of France. Figure 8 suggested a positive linkage between producer and consumer prices with producer prices as leading variable but correlation was detected at different frequancies in different time priods.

Figure 4-8 a linkage between consumer and producer prices in Finland/ France

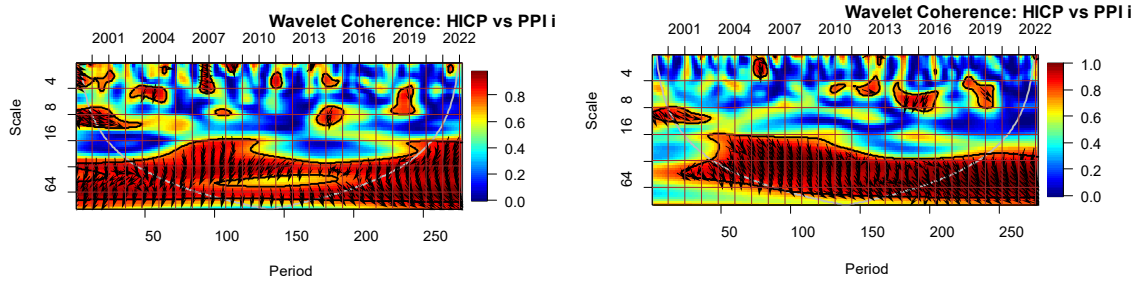
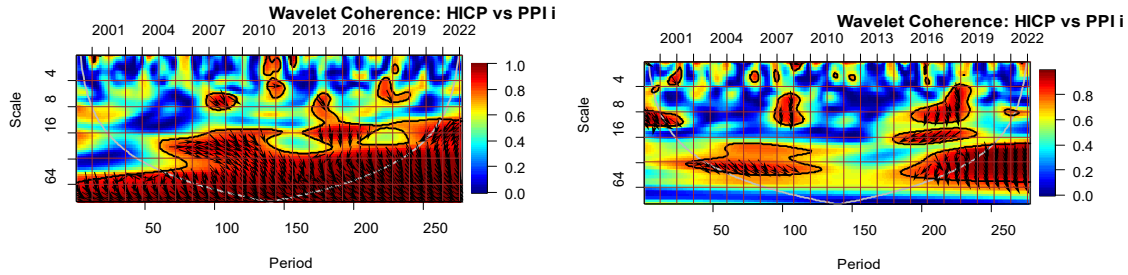


Figure 9 shows the linkage in case of Germany. Figure 9 brings the case in Germany. In case of Germany the linkage was positive and leading variable was the one representing consumer prices at lower frequencies.Slightly different relationship was observed with higher frequencies. Figure 10 provides the case in Greece.

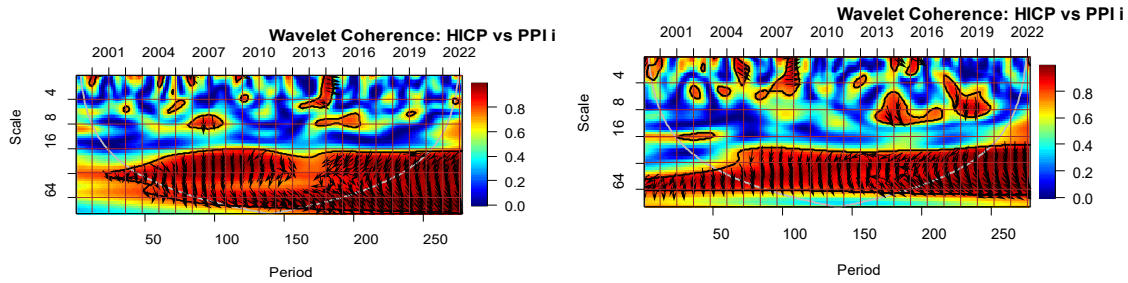
Figure 5-10 a linkage between consumer and producer prices in Germany/ Greece



As illustrated in Figure 10, the linkage in Greece is less prominent comparing to other considered countries. In some periods there was no linkage between producer and consumer prices in Greece.

Figure 11 illustrates the case in Italy. The linkage between producer and consumer prices in Italy was detected after 2002. As it is often the case the linkage is more prominent at higher scales or lower frequencies. The linkage in case of Lithuania was provided in Figure12.

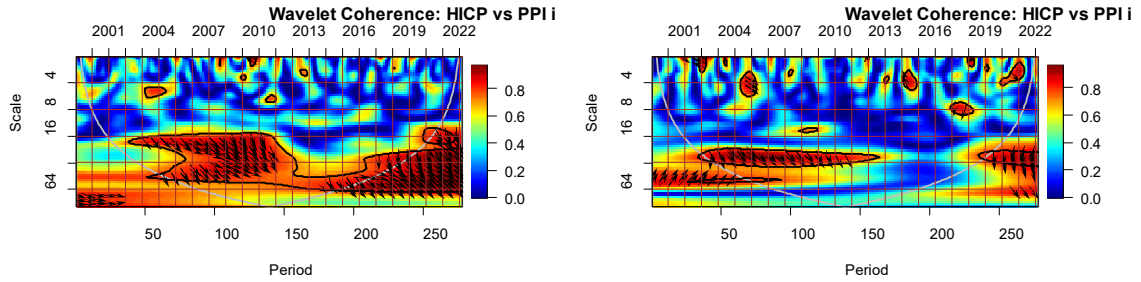
Figure 6-12 a linkage between consumer and producer prices in Italy/ Lithuania



The link between producer and consumer prices in Lithuania illustrates producer prices as leading variable and positive correlation at lowe frequencies. While at higher frequencies the linkage was not allways postive suggesting ambiguos and time dependent relationship between producer and consumer prices.

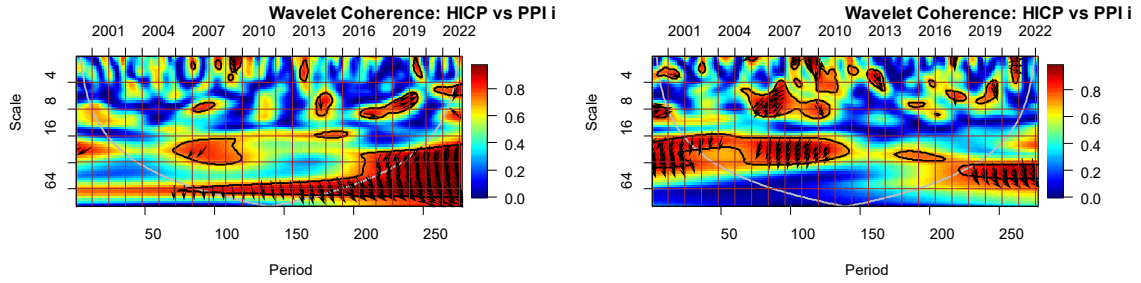
Figure 13 illustrates the linkage in case of Luxembourg.

Figure 7-14 a linkage between consumer and producer prices in Luxembourg Malta



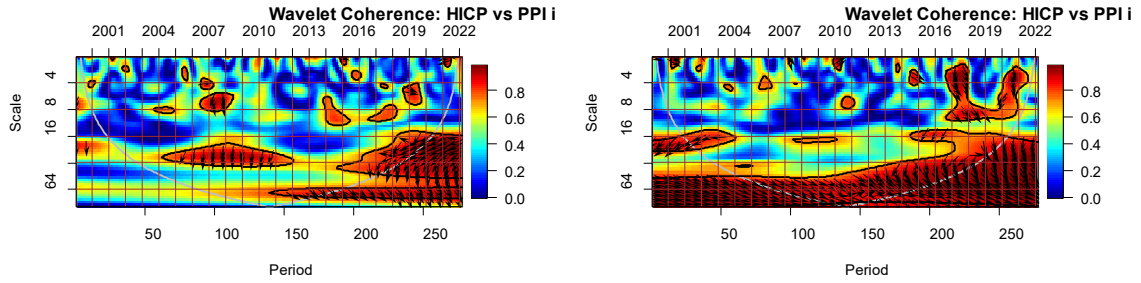
Following Figure 13, in case of Luxembourg the linkage was potitive and producer prices were leading variable but the linkage was not detected during the whole observation period. Figure 14 depicts the case in Malta. As illustrated in figure 14, there was no linkage between consumer and producer prices from 2012 up to 2020. In the rests of the observation period the linkage was positive. However, at the beginning of the observatio period and at lower frequencies the leading variable was the one presenting consumer prices.
The case of Netherlands was illustrated in Figure 15.

Figure 8-16 a linkage between consumer and producer prices in Netherlands/ Norway



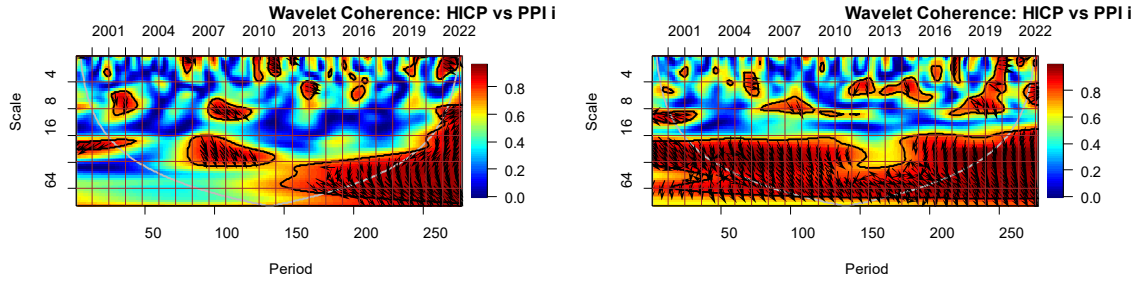
Based on findings in Figure 15, the linkage in Netherlands was bacame more prominent by the time. Producer prices was found as the leding variable and correlation was positive. Figure 16 illustrates the case of Norway. Figure 9 a linkage between consumer and producer prices in Norway. Following Figure 16, the correlation between produvcer and consumer prices in Norway was positive when detected. The variable representing producer prices was the leading variable. However, the linkage was not present during the entire observation period.
The case of Portugal was illustrated in Figure 17.

Figure 10-18 a linkage between consumer and producer prices in Portugal- Turkiye



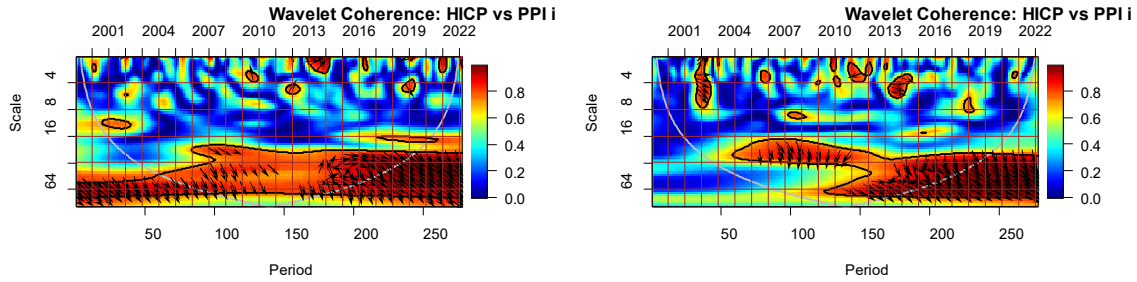
Following Figure 17, there were different linkages between producer and consumer prices in Portugal. However, whenever the linkage was detected producer prices appeared as leading variable. Figure 18 provides the case in Turkiye. Unlike the findings from Ulke and Ergun (2014) empirical results in Figure 18 suggested producer prices as a leading variable and positive correlation between producer and consumer prices.
Figure 19 illustrates the case of Sweden.

Figure 11-20 a linkage between consumer and producer prices in Sweden/ Spain



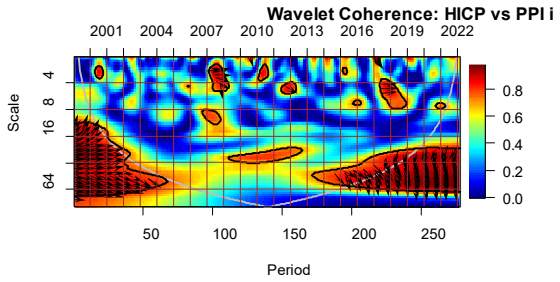
Following presented in Figure 19, the linkage in Sweden was not present during the whole oservation period. Variable presenting producer prices was the leading one whenever the lingake was found. Figure 20 illustrates the case of Spain. Following findings in Figure 20, the linkage in Spain was prominent. The variable representing producer prices was the leading one and correlation was mostly positive.
Figure 21 provides the linkage in case of Slovenia.

Figure 12-22 a linkage between consumer and producer prices in Slovenia/Slovakia



As well as in case of Spain, Figure 21 illustrates a prominent linkage between producer and consumer prices in Slovenia. The variable representing producer prices was the leading one and correlation was mostly positive. Figure 22 provides the case from Slovakia. As illustrated in Figure 22, the findings for Slovakia are in line with points from Su et al. (2016). The linkage is less prominent comparing the case from Slovenia and Sopain, for example.
Figure 23 brings the case from Romania.

Figure 13 a linkage between consumer and producer prices in Romania



As illustrated in Figure 23, the linkage in the case of Romania was prominent at the beginning as well as at the end of the observation period. Producer prices were leading during both identified periods. However, consumer and producer prices in Romania were more in phase during the beginning of the observation period. McKnight (2011) suggested that central banks in open economies should be oriented towards targeting consumer prices rather than producer prices. Findings from this paper suggested producer prices to govern consumer prices. Therefore, for the considered sample countries targeting producer prices might be more effective.

Conclusions

Several conclusions can be pointed out based on the research provided in this paper. Firstly, existing literature suggests various linkages between producer and consumer prices from various parts of the globe. Empirical approaches employed to establish the link include cointegration and Granger causality on samples of panel data or on a sample of a single country. Recent empirical literature recognized the wavelet coherence approach as a well-suited approach to establish a linkage between producer and consumer prices in the time domain as well as in the frequency domain. Following wavelet coherence analysis, various linkages were established in European countries. The most prominent nature of the linkage is the one with producer prices as the leading and consumer prices as the lagging variable. The correlation was mostly positive and established at higher scales or lower frequencies. Empirical findings suggested producer prices as a focal variable while controlling price stability. As is always the case, there are some limitations of the research. This paper observes consumer and producer prices while not taking into account potential effects from other variables. Consequently, further research might be directed towards including other variables like exchange rates into the linkage between producer and consumer prices.

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