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Money, Credit and House Prices from the Wavelet Perspective

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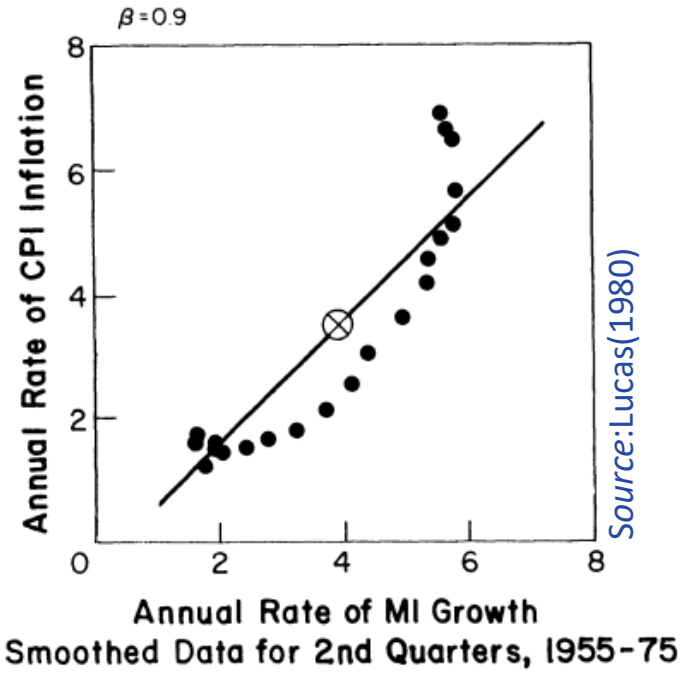
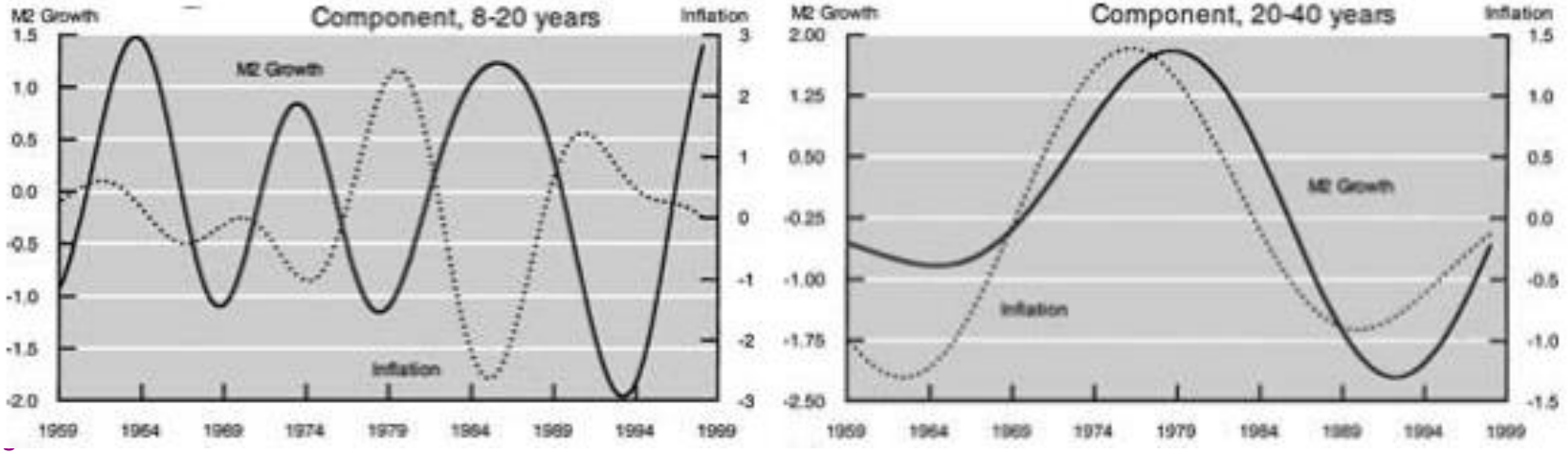


Source:Lucas(1980)

Lucas (1980) inaugurated the research on the frequency level while analyzing the link between money growth and inflation.

The idea that variables may be more closely tied in the long-run (i.e. at low frequencies) but possibly not in the short run (i.e. at high frequencies) set path to a growing literature assessing such relationships across frequency bands.



Source: Christiano and Fitzgerald (2003)

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Wavelet analysis accounts **for both time and frequency domains**.

The standard techniques for characterizing correlated behavior in time or frequency are **cross-correlation, the (Fourier) cross-spectrum, and coherence.**

Fourier transform provides no information on how the frequency content of the signal changes over time.

The problem with **the windowed Fourier transform** is that when a wide range of frequencies is involved, an underrepresentation of the low frequency components appears. T**he windowed Fourier transform does not allow an adequate resolution for all frequencies**.

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The phase of the wavelet cross-spectrum is used to identify the relative lag between the two time series.

The **bootstrap confidence intervals** for the bivariate quantities are generated according to **VAR(2) models**. To robustify the findings, other types of background spectra (besides the **AR(2)** background spectra in the basic scenario) were taken into account as well: ARMA(2,2) and AR(3) and different orders of vector autoregression.

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Most of the literature taking the frequency perspective condition the analysis on a somehow **arbitrary cut-off of the frequency bands**.

Papers that focus on the time-varying nature of the relationship resort to the analysis of sub-samples with **split dates more or less ad hoc**.

Wavelet analysis avoids such problems as it provides **a continuous assessment** of the relationship between the analyzed variables in the time-frequency space.

Wavelet analysis is particularly suitable to study the relationship between money/credit growth and house prices as it can **capture both frequency and time-varying features within a unified framework**.

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Problems with determining **casuality**.

Does not take into account other factors besides those for which the coherency is measured.

To analyze more complex interdependecies the continuos wavelet analysis **needs to be accompanied by econometric models**.

Areas of variable background spectra should be interpreted with caution. Significant power spectra indicate a structural change.

Limited interpretation due to the **cone of influence**. Areas of high coherence occurring outside or overlapping the cone of influence should be interpreted with caution.

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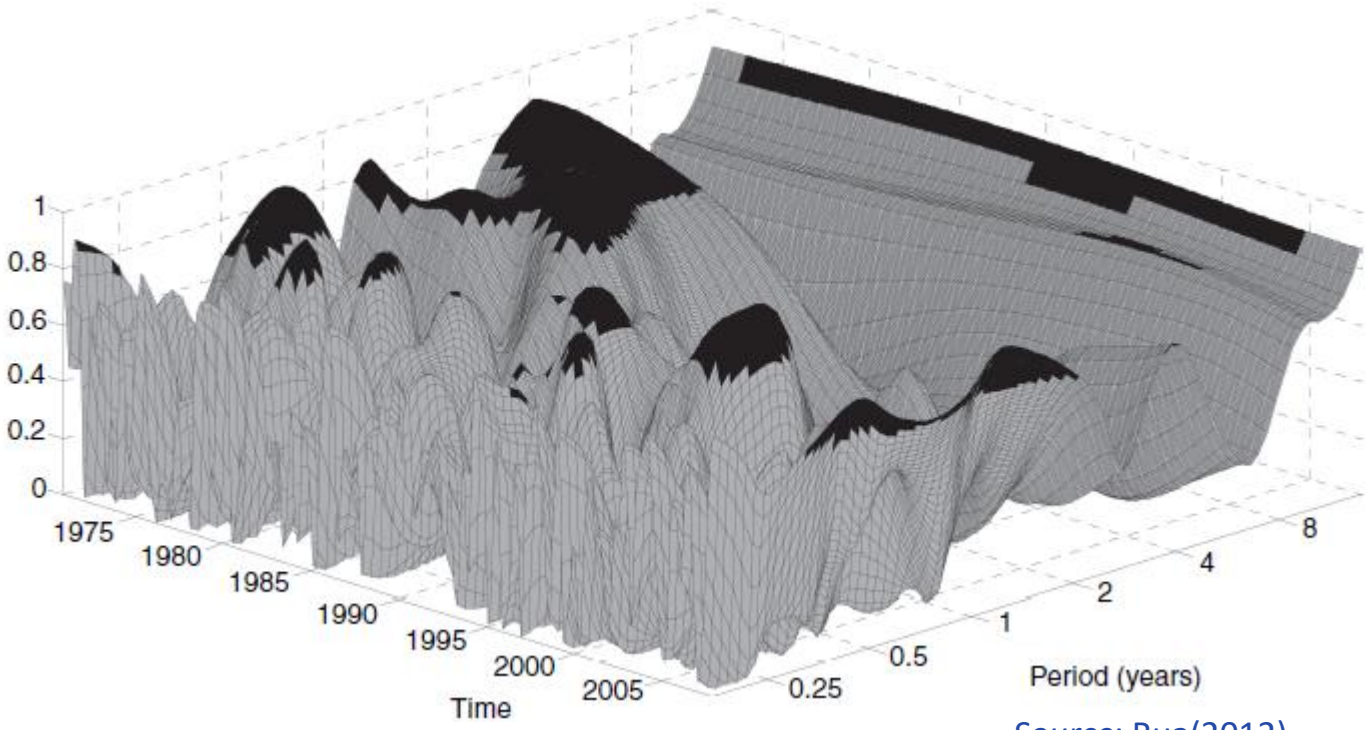

Source: Rua(2012)

In the euro area the findings of Rua (2012) **indicate a stronger link between inflation and money growth at low frequencies over the whole sample period**. At the typical business cycle frequency range the link is only present until the beginning of the 1980s.

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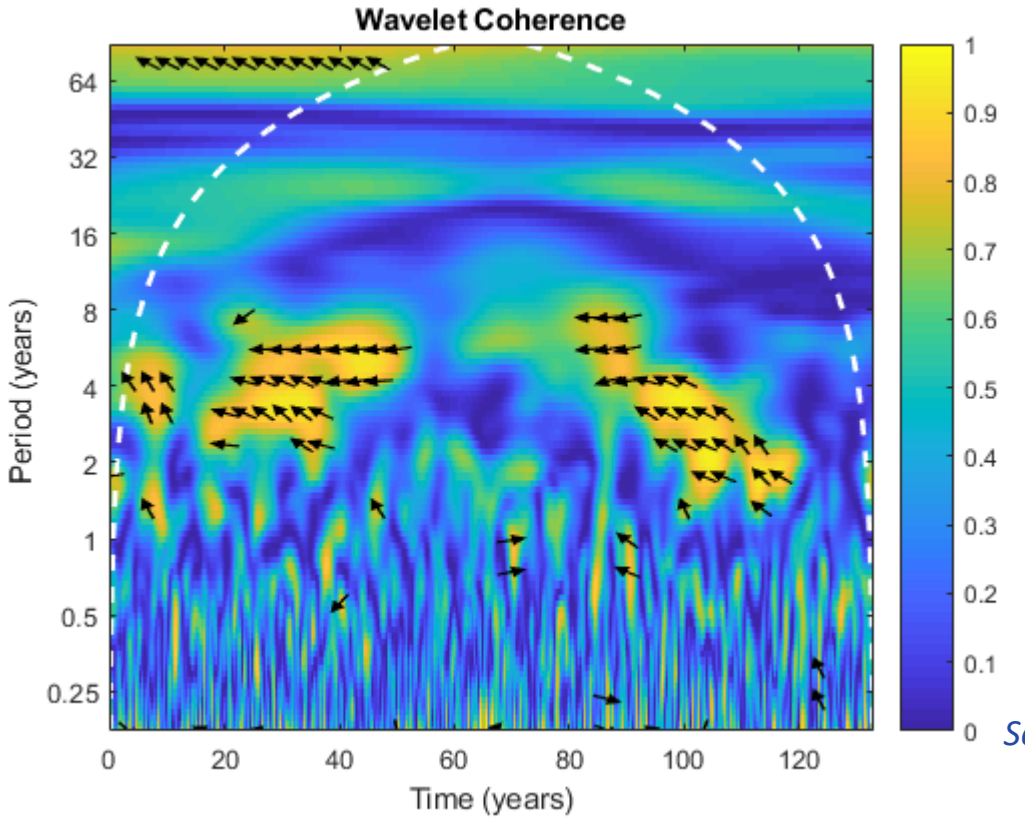

Source: www.mathworks.com

Sea surface temperature and deasonalized All Indian Rainfall Index from 1871 to late 2003

The plot shows time-localized areas of **strong coherence** occurring **in periods that correspond to the typical El Nino cycles of 2 to 7 years.** The plot also shows that there is **a delay between the two time series** at those periods. This indicates that periods of sea warming off the coast of South America are correlated with rainfall amounts in India approximately 17,000 km away, but that this effect is delayed by approximately 1/2 a cycle (1 to 3.5 years).

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Jiang *et al.* (2015) found that **money growth and inflation** were positively related in a one-to-one fashion in the medium and long run in China.

In medicine, for example: Li and Lin (2018) applied wavelets for the fast detection of a **heart rate** and Abduljabbar *et al.* (2017) used Continuous Wavelet Transform-Based Frequency Dispersion to l**ocalize a lung cancer**.

Ftiti et al. (2017) analyze the **relationship between future energy intraday volatility and trading volume**.

Bruzda (2015) investigated amplitude and phase synchronization of **European business cycles**.

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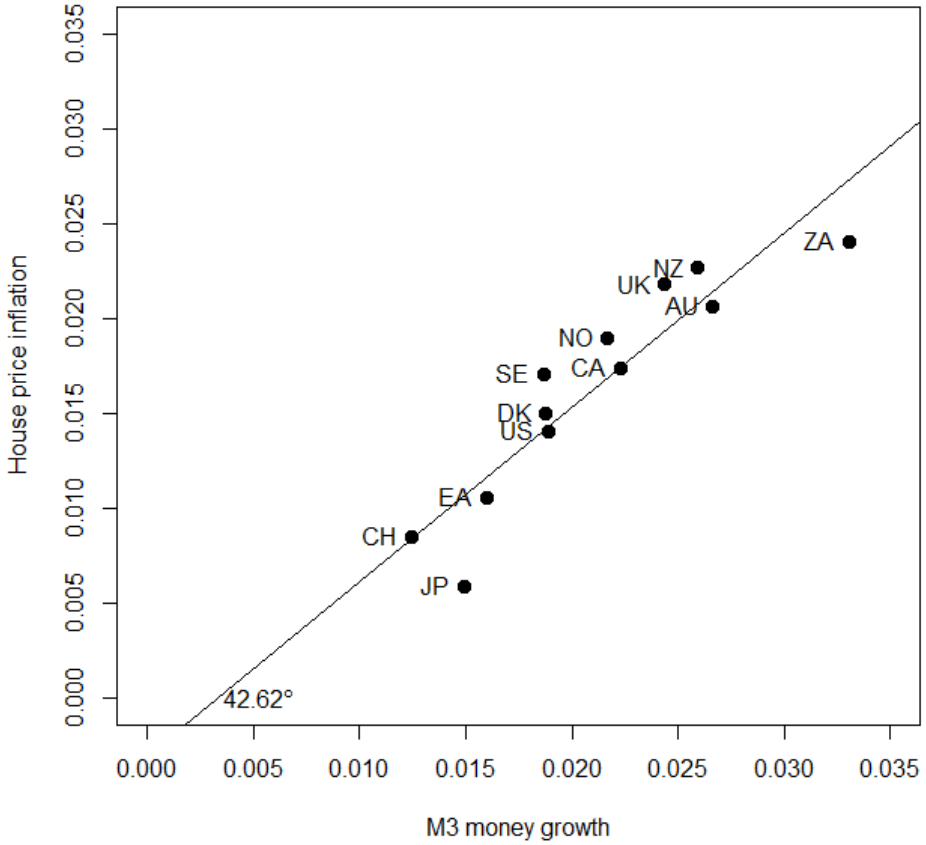

Average quarterly M3 money growth versus house price growth rate between 1Q 1970 and 4Q 2016

The considered countries are:

1. Australia,
2. Canada,
3. Denmark,
4. Euro area,
5. Iceland,
6. Japan,
7. New Zealand,
8. Norway,
9. South Africa,
10. Sweden,
11. Switzerland,
12. the United States,
13. Euro area.

Source: Ryczkowski (2019a)

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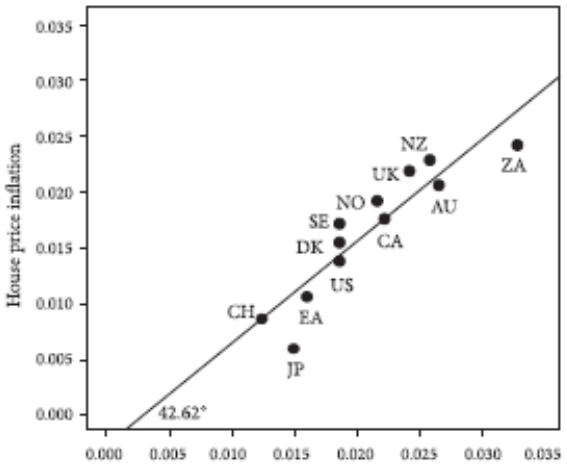
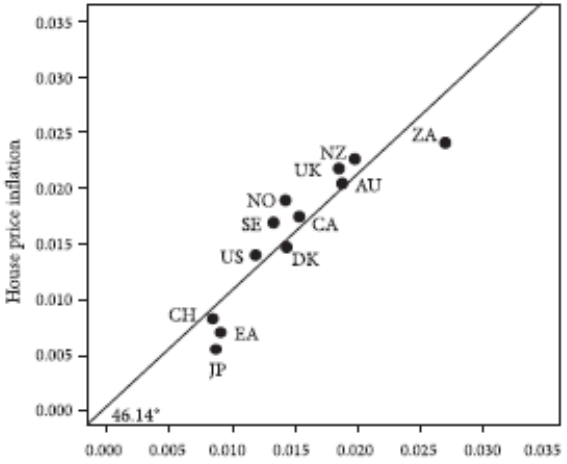
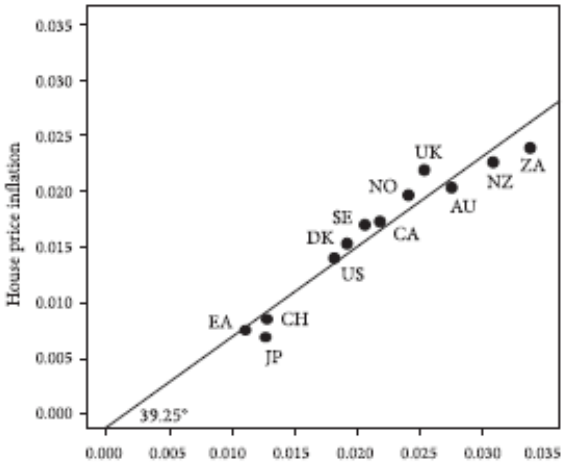


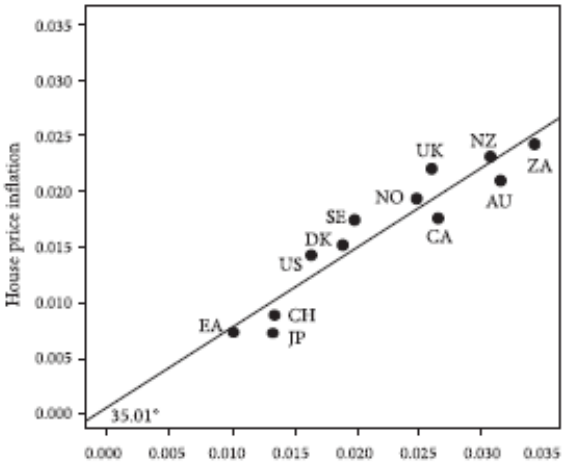
a) ΔM3



b) ΔM3-Δ real GDP



c) Δ bank credit



d) Δ credit from all sectors

Average quarterly money and credit rate of change versus house price rate of change between 1Q 1970 and 4Q 2016

Source: Ryczkowski (2019a)

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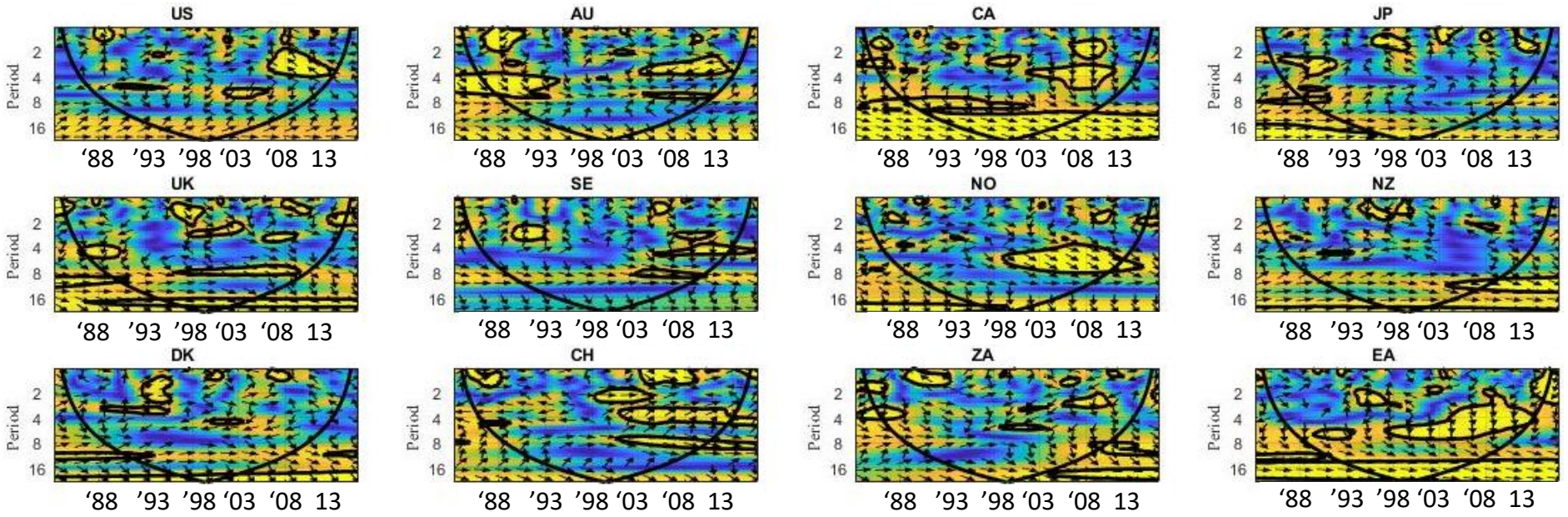
Findings 1: General international patterns:

The linkages and lead-lag effects between money/credit and house prices are time and frequency-varying .

The significant co-movements between money/credit and house price dynamics typically did not extend over the whole interpretable period.



Wavelet coherency between M3 and house price dynamics from 1Q 1984 to 4Q 2016
Source: Ryczkowski 2019a

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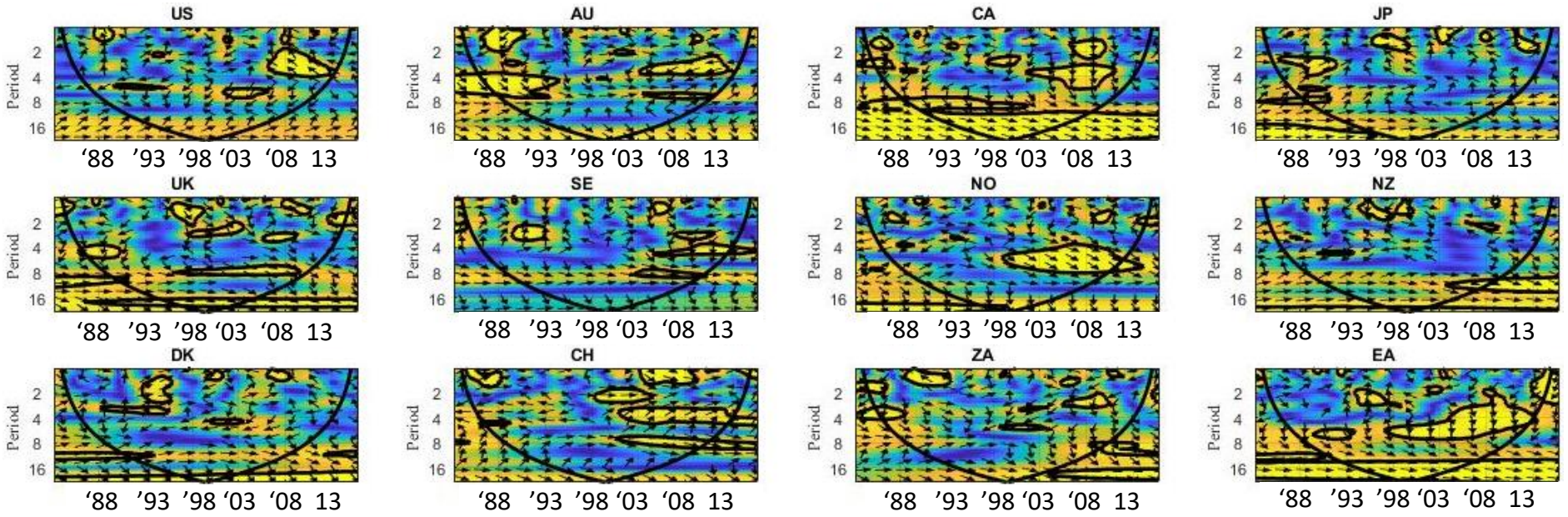
Findings 2: General international patterns:

The co-movements of money/credit and house prices are typically positive (arrows pointing to the right side).

The prevailing direction of the link has changed after 1984. House prices started to lead money and credit growth in most countries (arrows pointing down).



Wavelet coherency between M3 and house price dynamics from 1Q 1984 to 4Q 2016
Source: Ryczkowski 2019a

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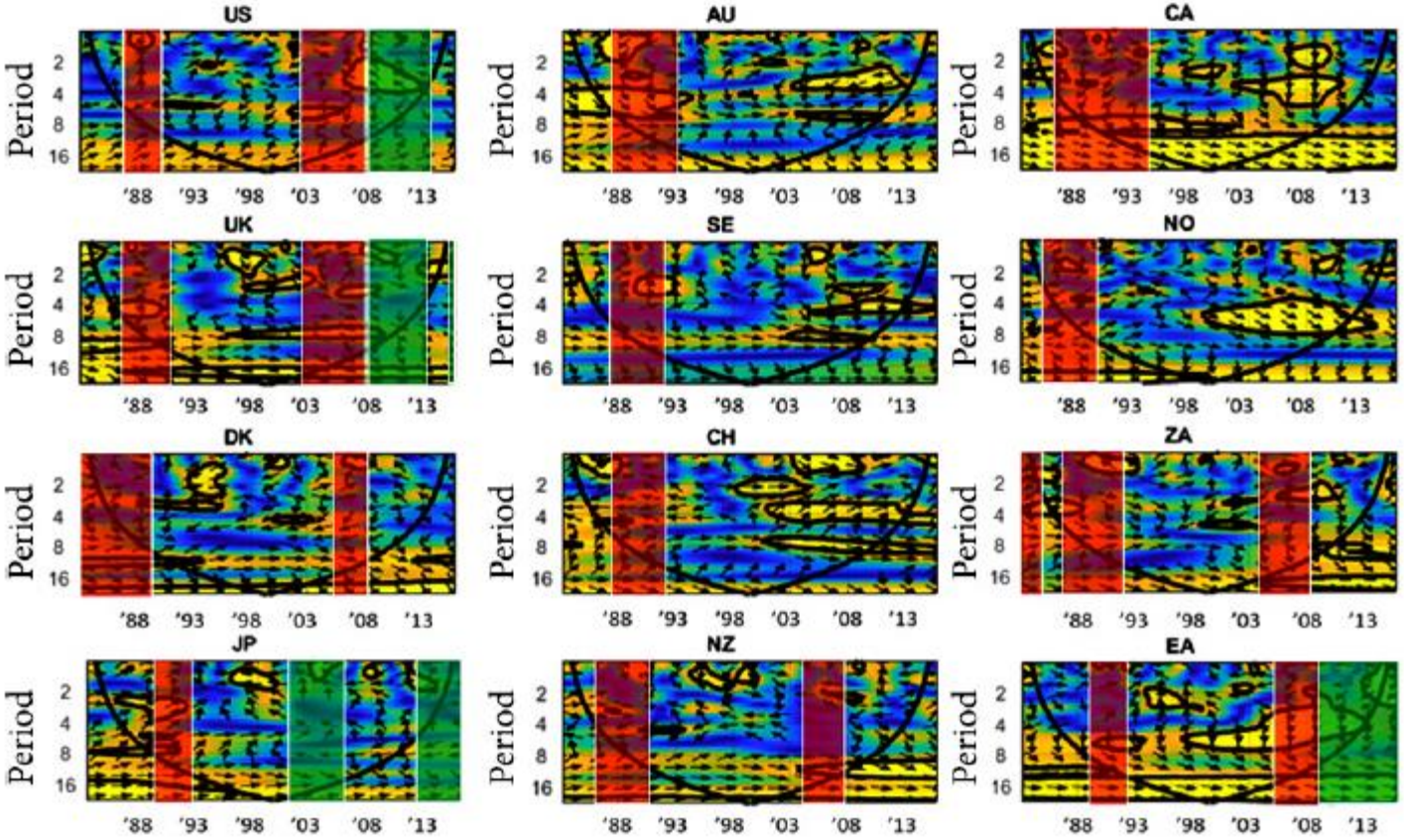
Finding 3: General international patterns:

The correlations between money/credit and house price dynamics rise during the episodes of booming house prices in all of the sample countries for the longer run developments (Depending on the choice of a financial variable for 80% to 96% of all of the detected episodes of house price booms).



15 Wavelet coherency between M3 and house price dynamics from 1Q 1984 to 4Q 2016
Source: Ryczkowski 2019a

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Findings 4: General international patterns:

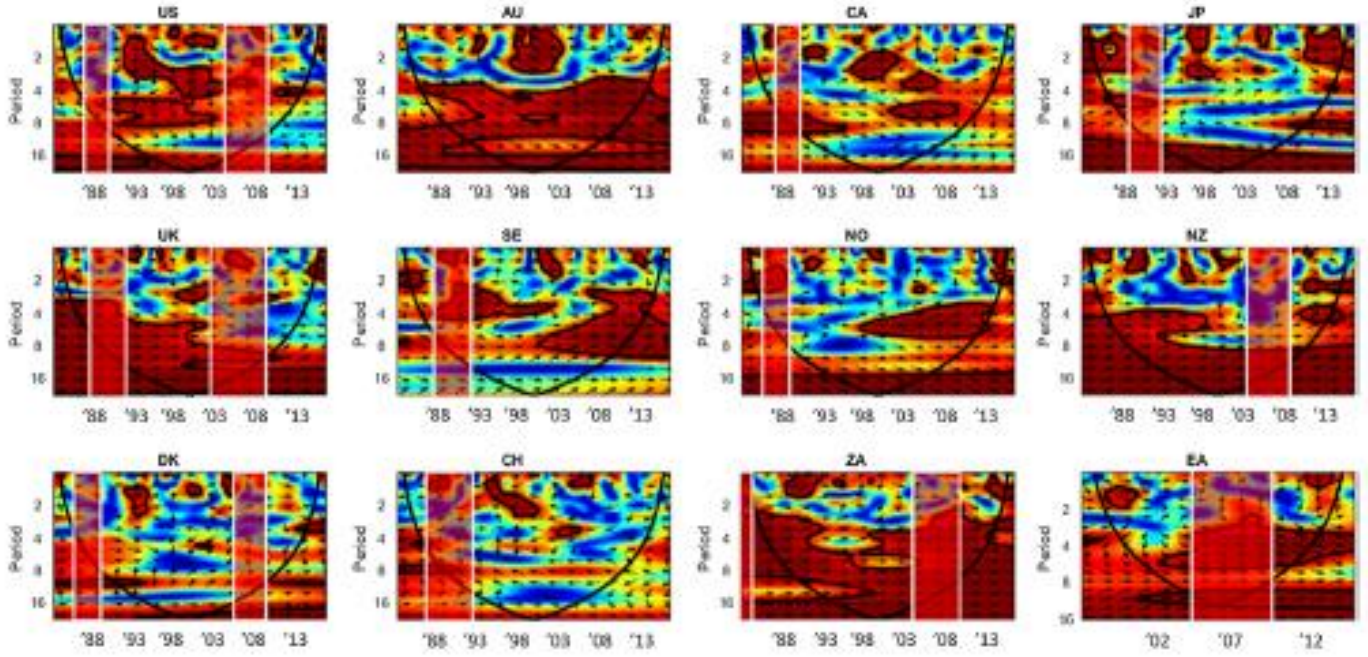
The euro area and Commonwealth Countries (Australia, Canada, New Zealand, South Africa, the United Kingdom) have rather strong co-movements between money and credit at longer frequencies.

Denmark and Switzerland show weak and episodic effects.

Scandinavian countries and the US are somewhere in between.

However, the correlations between money and credit rise during episodes of booming house prices, whereas they may be not significant over the normal times (Ryczkowski 2019b).

Similarly, the co-movements of money/credit and stock prices are significant in over 71 percent during build-ups and bursts of house price booms (Ryczkowski and Zinecker, N/A).



Wavelet coherency between M3 and bank credit from 1Q 1984 to 4Q 2016
Source: Ryczkowski 2019b

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Findings 4: Country specific results: [Quantitative easing]

The impact of money and credit developments on house prices was strikingly **diversified during QE** at the typical business cycle frequency (Ryczkowski, 2019a).

In the US and UK, growth of respectively broad money and bank credit was leading house prices after 2007. The uncommon for the post-1984 time period causality could mean that **Fed and the BoE** indeed assigned importance to property prices and **stimulated them through successful easing** of monetary and credit conditions after the outbreak of the Great Recession (Ryczkowski, 2019a).

As opposed to it, **the BoJ and the ECB either have not assigned separate roles to house prices in their reaction functions or were not capable to significantly influence them by extending money/credit through unconventional asset purchases** and other activities in the horizon of 2 to 8 years. QE has not managed to reverse the lead-lag pattern so that it would run from money/credit to house prices for the horizon of 2–8 years (Ryczkowski, 2019a).

The diversified patterns in the co-movements between money/credit and house price inflation during QE **coincided with macroeconomic performance** (Ryczkowski, 2019a)**.**

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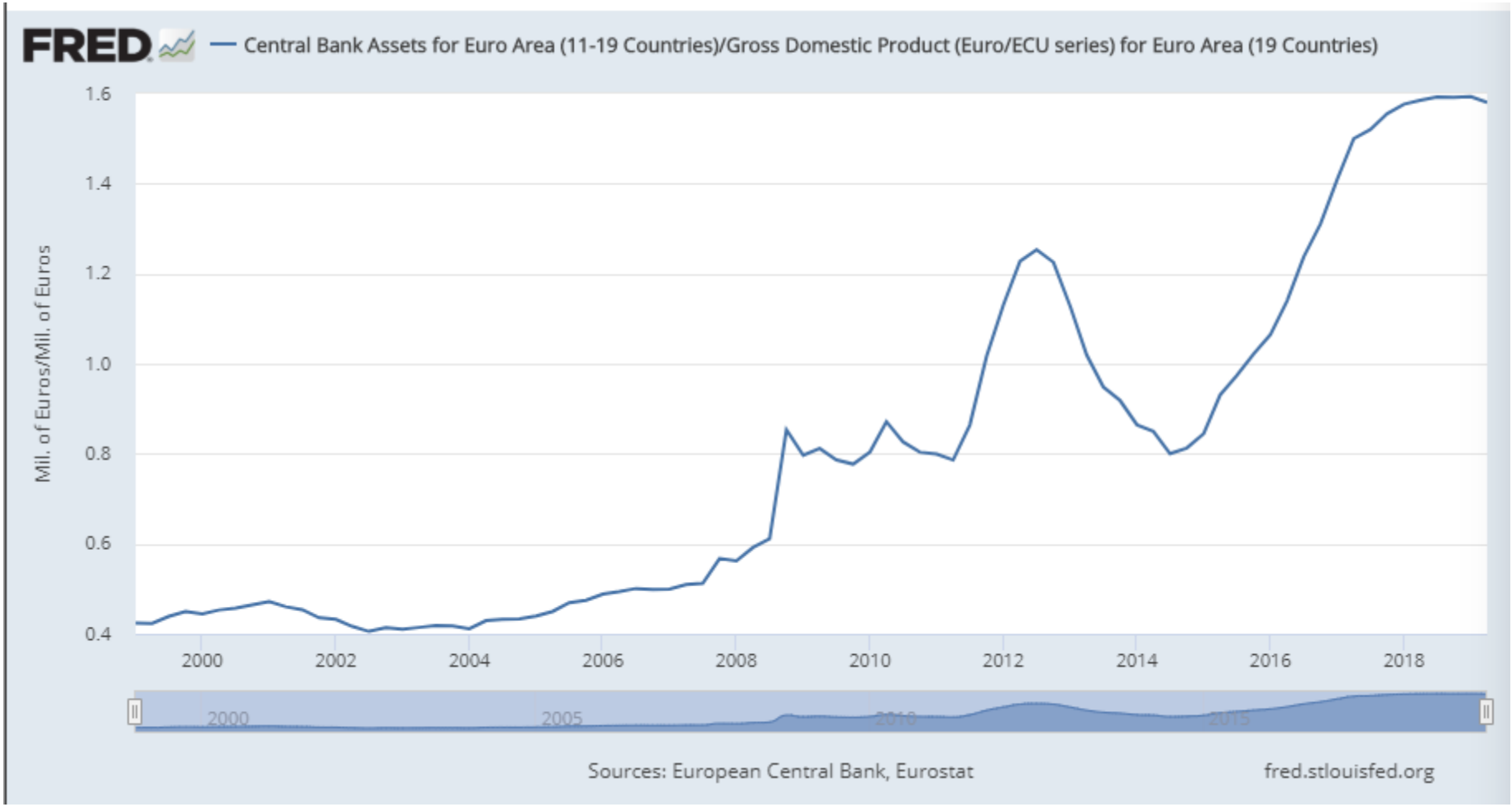

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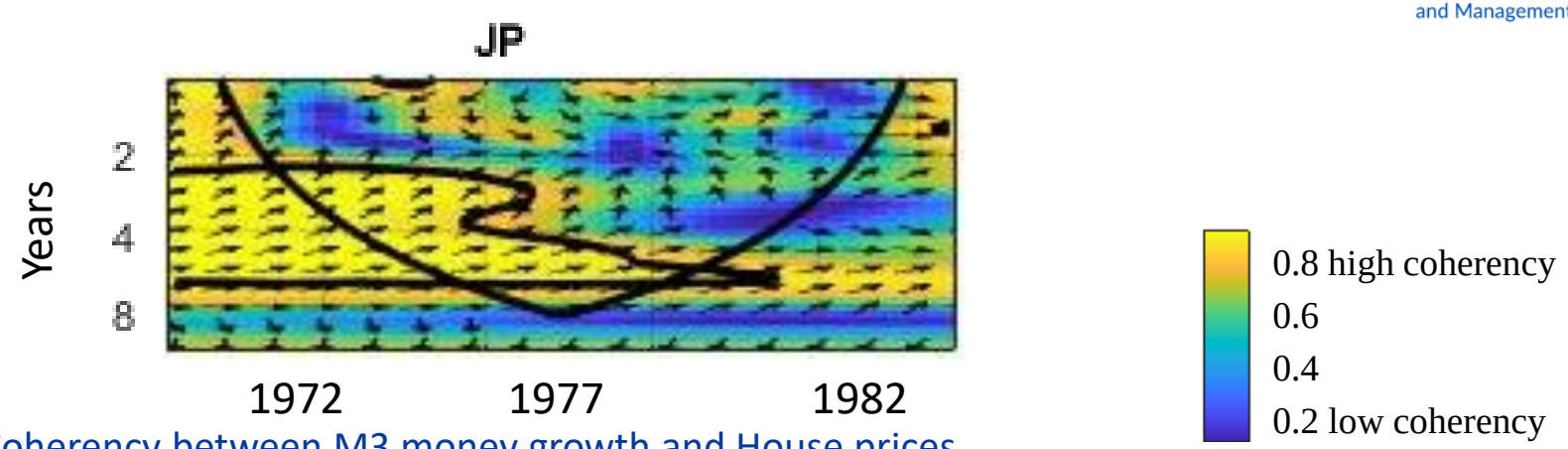
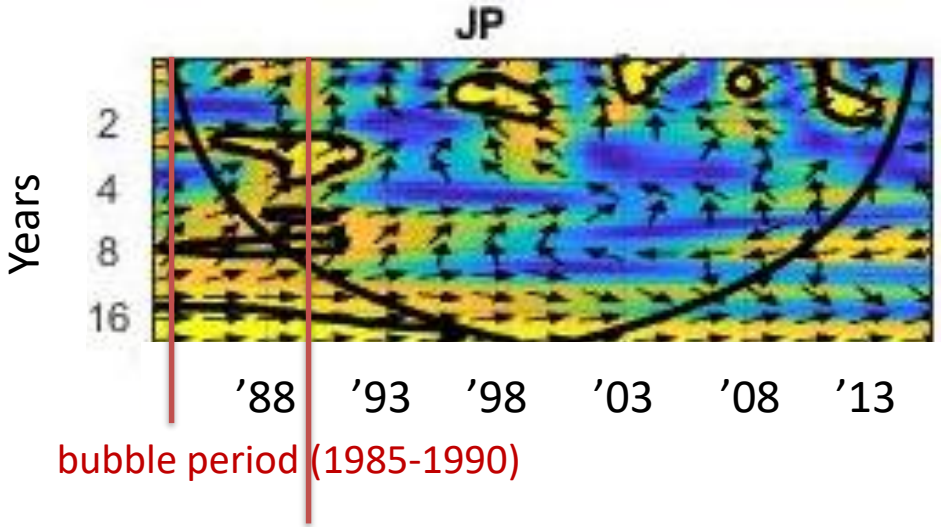


Coherency between M3 money growth and House prices at market value (1Q 1970 – 4Q 1983). Number of bootstrap samples: 500.



Coherency between M3 money growth and House prices at market value since the Great Moderation (1Q 1983 – 4Q 2016). Number of bootstrap samples: 500.

Source: Own work on Matlab v.2017a

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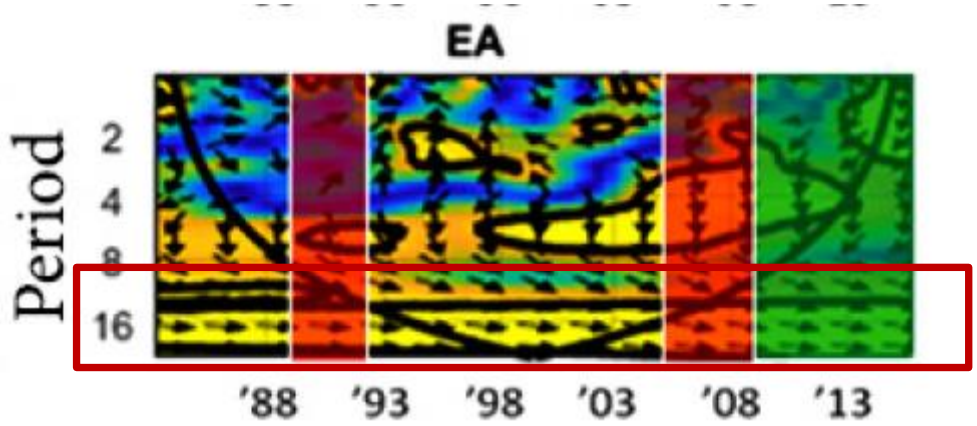
Findings 5: Country specific results: [The euro area]

CWT shows that the dynamics of M3 exhibit longer run significant co-movements with house price dynamics both during normal times and booming house prices (Ryczkowski, 2019a).

The CWT results deliver a new wavelet argument for a separate monetary pillar as M3 in the euro area may convey useful information about future inflation dynamics in the housing sector (Ryczkowski, 2019a,b).



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Major conclusions related to house price dynamics:

a) The co-movements of financial variables and house prices around booming episodes suggest that a bubble can be stopped by increasing restrictions on lending;

b) The difficulty with "leaning against the wind" is associated with the evidenced diversity of the impact of money/credit on house prices between countries and for different time horizons;

c) Expansionary monetary policy during the Great Recession brings beneficial macroeconomic results (including house price dynamics). On the other hand, the discovered significant longer run interdependencies between money/credit and house prices during housing booms and during aggressive QE call for the right timing of the exit strategies;

d) In case the policy would lead to a large money (credit) growth around the booming episode, it may eventually translate into credit (money) growth of a similar size with a lag of between 2 and 16 years;

e) The wavelet analysis largely supports the need to consider different operational horizons when assessing the linkage between money and credit, which may have relevant implications for macroprudential policy;

f) The CWT results deliver a new wavelet argument for a separate monetary pillar as M3 in the euro area may convey useful information about future inflation dynamics in the housing sector.

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References:

Abduljabbar, A. M., Yavuz, M. E., Costen, F., Himeno, R., & Yokota, H. (2017). Continuous Wavelet Transform-Based Frequency Dispersion Compensation Method for Electromagnetic Time-Reversal Imaging. *IEEE Transactions On Antennas & Propagation*, 65(3), 1321-1329. doi:10.1109/TAP.2016.2647594.

Bruzda, J. (2015). Amplitude and Phase Synchronization of European Business Cycles: A Wavelet Approach. *Studies in Nonlinear Dynamics & Econometrics*, 19(5). doi:10.1515/snde-2014-0081.

Christiano, L., & Fitzgerald, T. (2003). The Band Pass Filter. *International Economic Review*, 44(2), 435-465. doi:10.1111/1468-2354.t01-1-00076.

Ftiti, Z., Jawadi, F., & Louhichi, W. (2017). Modelling the relationship between future energy intraday volatility and trading volume with wavelet. *Applied Economics*, 49(20), 1981-1993. doi:10.1080/00036846.2016.1229453.

Jiang, C., Chang, T., & Li, X. (2015). Money Growth and Inflation in China: New Evidence from a Wavelet Analysis. *International Review Of Economics & Finance*, 35, 249-261. doi:10.1016/j.iref.2014.10.005.

Li, M., & Lin, J. (2018). Wavelet-Transform-Based Data-Length-Variation Technique for Fast Heart Rate Detection Using 5.8-GHz CW Doppler Radar. *IEEE Transactions On Microwave Theory & Techniques*, 66(1), 568-576. doi:10.1109/TMTT.2017.2730182.

Lucas, R. (1980). 'Two illustrations of the quantity theory of money', *American Economic Review*, Vol. 70, pp. 1005–1014.

Ryczkowski, M. (2019a). Money, credit, house prices and quantitative easing – the wavelet perspective from 1970 to 2016. *Journal of Business Economics and Management*, 20(3), 546–572. doi:10.3846/jbem.2019.9859. Available at: https://journals.vgtu.lt/index.php/JBEM/article/view/9859.

Ryczkowski, M. (2019b). Money and credit during normal times and house price booms: evidence from time-frequency analysis. Empirica. doi:10.1007/s10663-019-09457-2. Available at: https://link.springer.com/article/10.1007%2Fs10663-019-09457-2.

Ryczkowski, M. Zinecker, M. (N/A). The interconnectedness of stock prices, money and credit across time and frequency from 1970 to 2016 (unpublished, forthcoming).

Thank You

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