Productivity and unemployment over different time frames

Marco Gallegati*, Mauro Gallegati, James B. Ramsey and Willi Semmler

*Department of Economics and Social Sciences
Polytechnic University of Marche
marco.gallegati@univpm.it

Frequency domain research in macroeconomics and finance,
Helsinki, 20-21 october 2011

Does productivity growth increase or reduce unemployment?

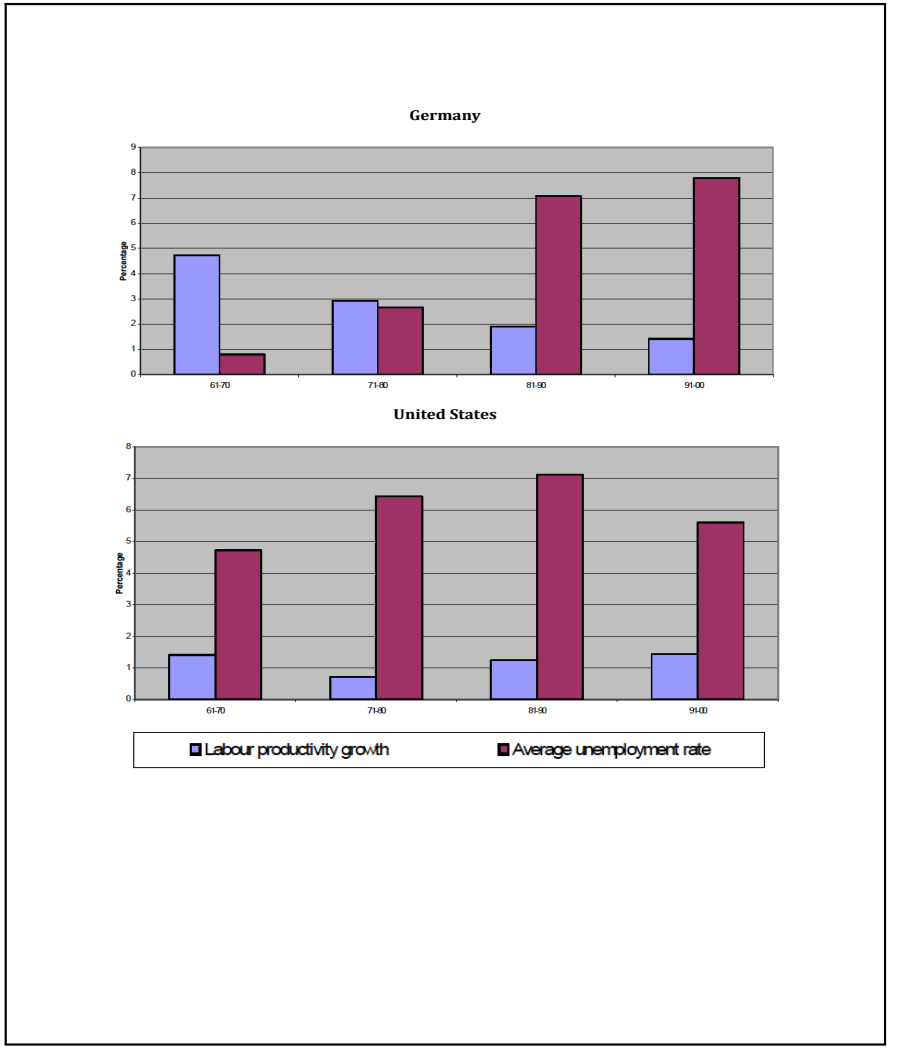
- Contradictory views about the relationship between productivity and (un)employment:
  - productivity growth is "bad" for employment (technology unemployment)
  - productivity growth is "good" for employment (rising living standards)
- For example, in the case of the process of job creation
  - in the short run new technology is likely to be labor reducing, and thus adding to unemployment, as was visible in Europe since the 1990s.
  - in the long run, however, new technology replacing labor increases productivity and makes firms and the economy more competitive and may increase employment, and thus reduce unemployment.

Theoretical and empirical results

- Theoretical results are mixed: for example, in matching models of unemployment the relation between growth and unemployment is either negative or positive according to the assumption of embodied or disembodied technical progress (Mortensen and Pissarides, 1998).
- Empirical results:
  - Productivity growth and unemployment are highly correlated contemporaneously at business cycle frequencies (Estrella, 2004);
  - Negative relationship between unemployment and productivity growth at low frequencies (Phelps, 1994, Blanchard *et al.*, 1995, Staiger, Stock, and Watson, 2001, and Pissarides and Vallanti, 2007)

Methodology

- The relationship between productivity growth and unemployment is generally analyzed in the empirical literature looking at average aggregate data, generally decades, because from a time series perspectives the rate of growth of labor productivity is a very volatile series whose implications in terms of the movements of the other supply-side variables are difficult to interpret, particularly in the short-run.



Time frames

- "it is useful to distinguish between an analysis of the forces shaping long-term equilibrium paths of output, employment and productivity on the one hand and the forces causing temporary deviations from these equilibrium paths on the other hand. However, ..., the need for this distinction is not universally accepted by macroeconomists. Even for those who accept its usefulness, it is sometimes difficult to separate long-term equilibrium trends from short-term disequilibrium phenomena." (Landmann, 2004, p.3)
- "the nature of the mechanism that link them [cfr.(un)employment and productivity growth] changes with the time frame adopted" (Landmann, 2004, p.35)

Methodology

- Some recent approaches have explored the contradictory views on this relationship using different time frames, *i.e.* short-run, business cycle frequencies and long-run
  - Tripier (2006)
  - Chen, Rezai and Semmler (2007)

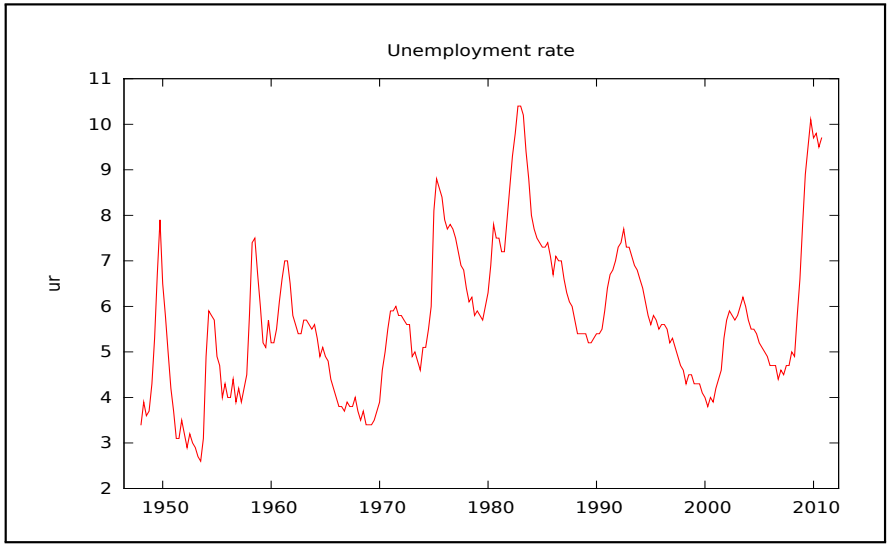
- The objective of this paper is to analyze the scale-by-scale relationship between labor productivity and unemployment using wavelet analysis (CWT and MODWT)

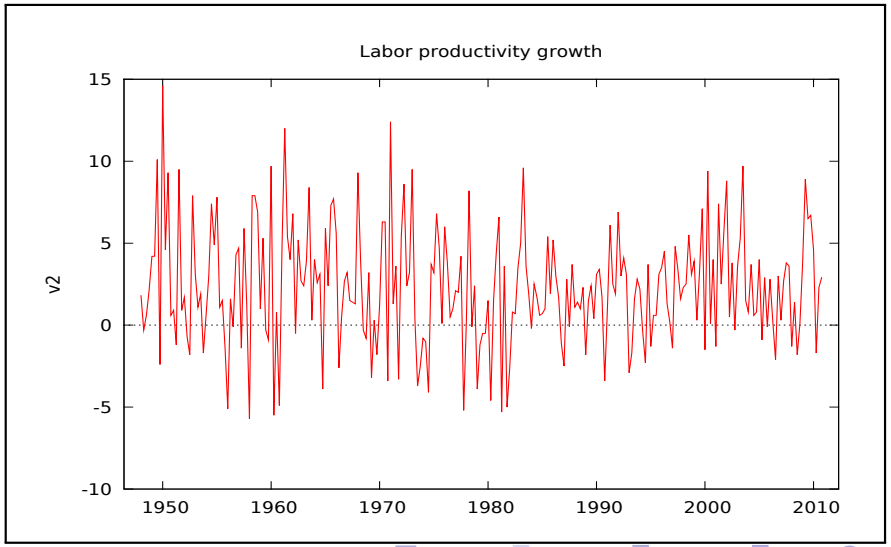
CWT tools

- Wavelet power spectrum: $W_x(s,\tau) = |W_x|^2$ depicts the local variance of x and can be interpreted as the energy density in the time-frequency plane.
- Cross-wavelet power: $|W_{xy}|=|W_x W_y|$ depicts the local covariance of the two time series at each scale and frequency
- Wavelet coherency: the modulus of the wavelet cross spectrum normalized to the single wavelet spectra and is especially useful in highlighting the time and frequency intervals where two phenomena have strong interactions.
- Wavelet phase difference: characterize the phase relationships between two time series as a function of frequency, *i.e.* phase synchronization of two time series.

Dataset

- - Labor productivity is defined as output per hour of all persons of the Nonfarm Business Sector (Index 2005 = 100) and measured as percentage change quarter ago at annual rate
- - Unemployment rate is defined as percent Civilian Unemployment Rate
- - quarterly data for the US between 1948:1 and 2010:4 from BLS



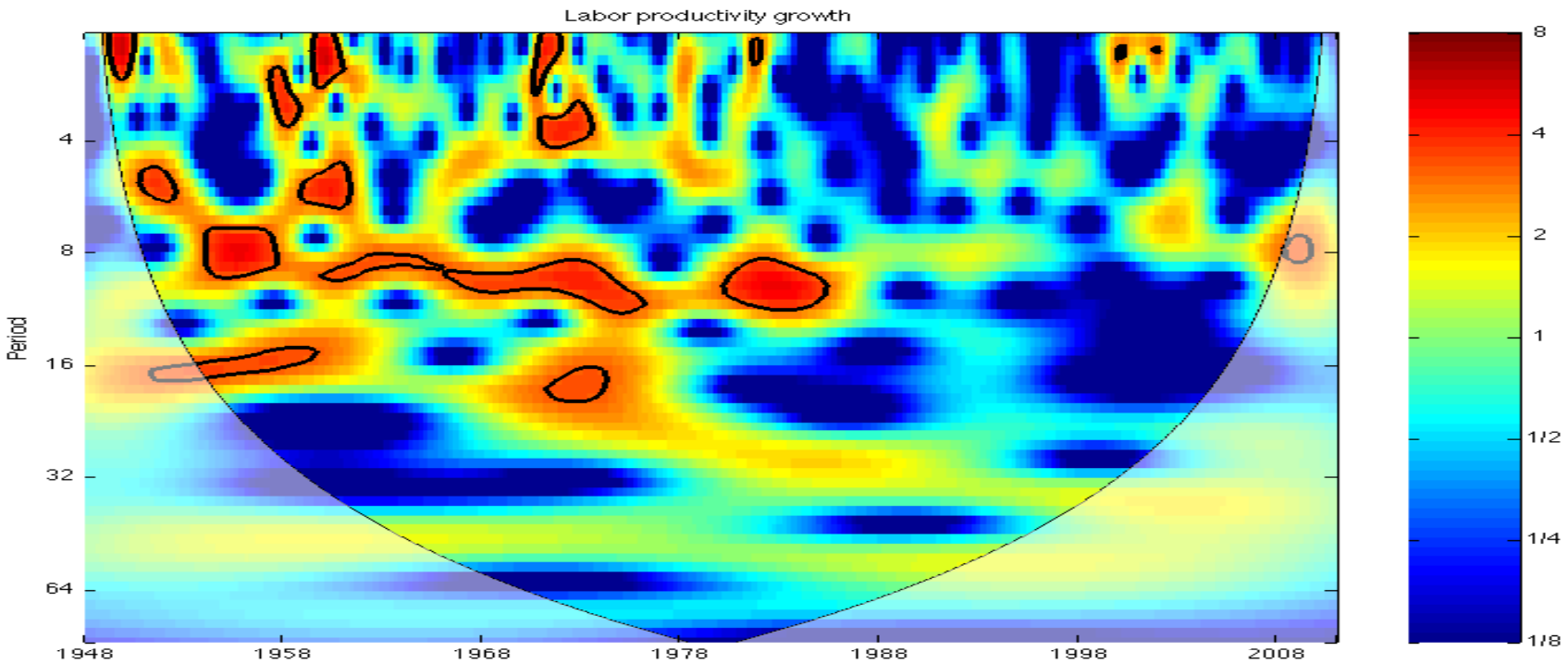


Wavelet power spectrum

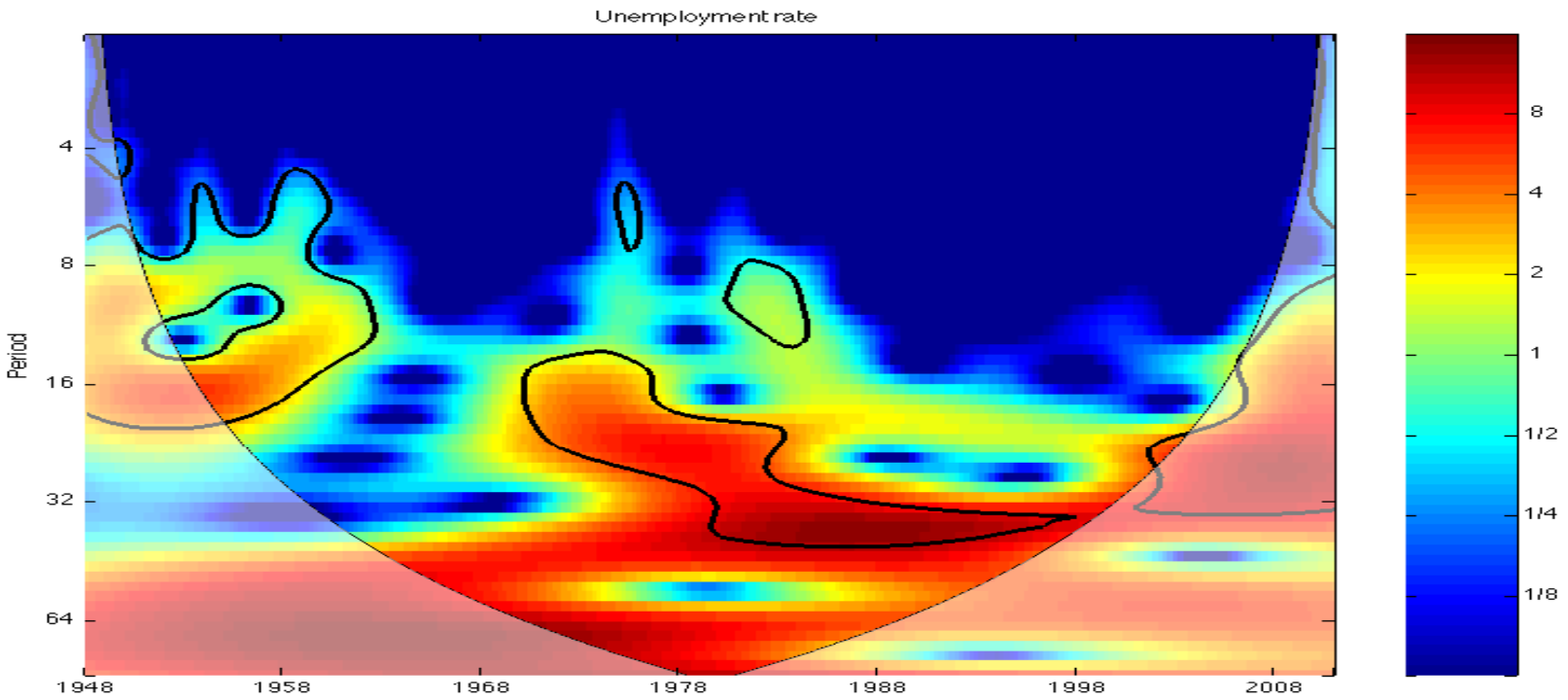
Wavelet power spectrum: legend

- the (local) wavelet power spectrum gives us a measure of the variance distribution of the time-series in the time-scale (frequency) plane; we can interpret the wavelet power spectrum as depicting the local variance of a time-series
- The color code for power ranges from white (low power) to red (high power) with significant regions associated with warmer colors (red, orange and bright green). This color coding can provide an objective method to show the presence of multiscale features and identify their temporal locations;
- A black contour line testing the wavelet power 5% significance level against a white noise null is displayed as is the cone of influence, represented by a shaded area corresponding to the region affected by edge effects.

Wavelet power spectrum: Productivity growth



Wavelet power spectrum: Unemployment rate



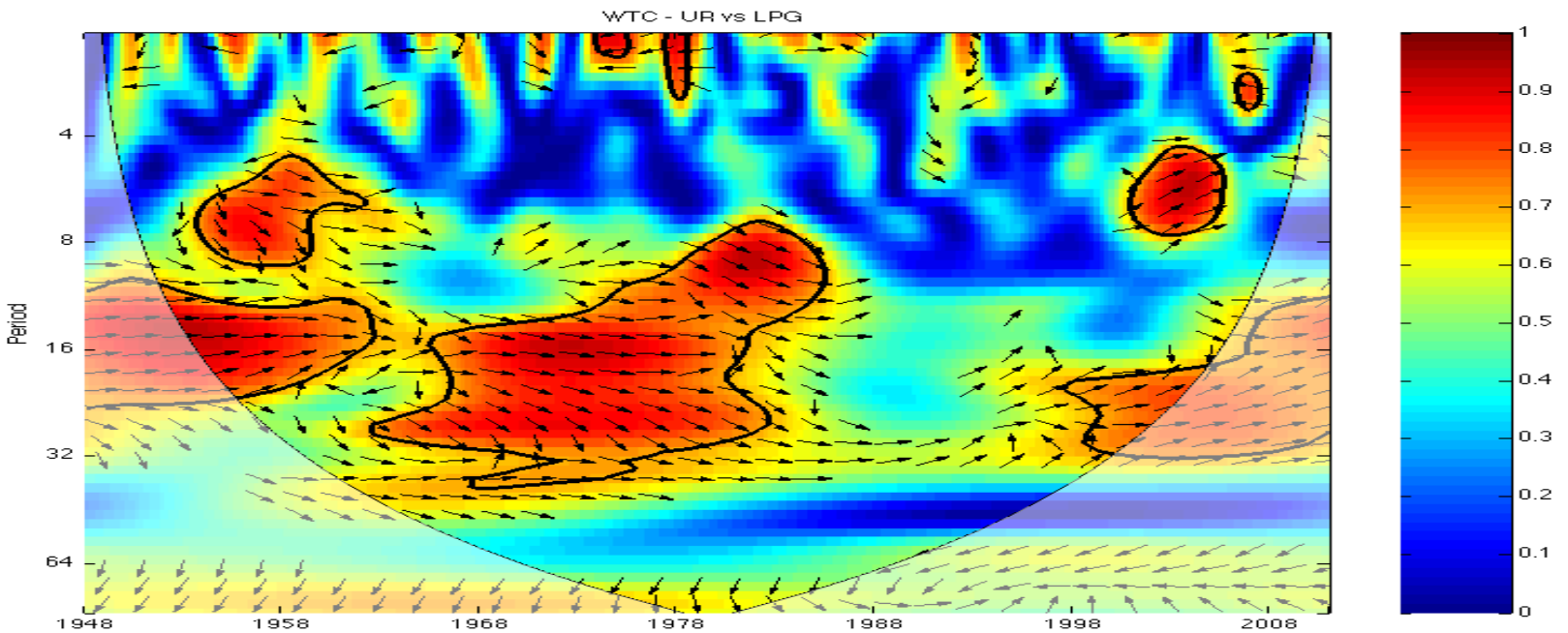
Summary results from CWT

- In the case of labor productivity growth there is evidence of highly localized patterns at certain scales, with high power regions concentrated in the first part of the sample (until late eighties) and at scales corresponding to periods up to 4 years.
- Otherwise, for the unemployment rate high power regions reveal the presence of dominant scales of variation at scales corresponding to the medium and long-run periods, since the coefficients of maximal energy are concentrated at the highest scales (lowest frequencies) and, starting from the seventies, also at intermediate scales, *i.e.* scales 3 and 4.

Wavelet coherence

- The color code for power ranges from white (low coherence) to red (high coherence). Regions of high coherency between two time series are synonym of strong local correlation;
- A pointwise significance test is performed against an almost process independent background spectrum. 95% confidence intervals for the null hypothesis that coherency is zero are plotted as contours in black in the figure;
- The cone of influence is marked by black lines. Values outside the cone of influence should be interpreted very carefully, as they result from a significant contribution of zero padding at the beginning and the end of the time series.

Wavelet sample coherence: productivity growth and unemployment rate



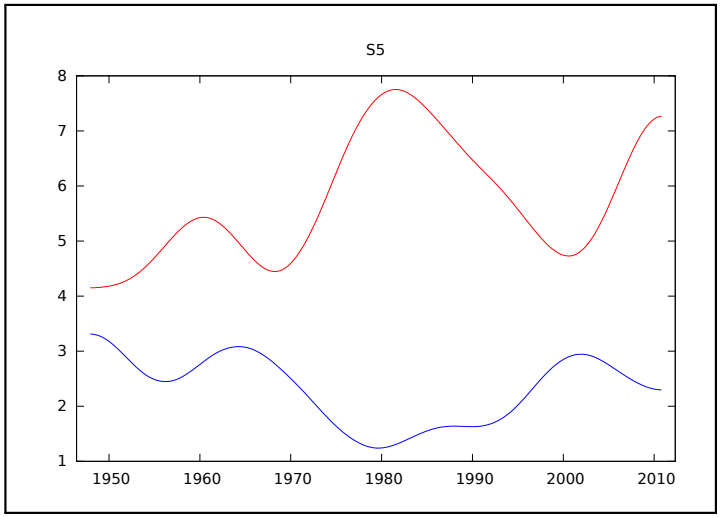
Summary results for wavelet coherence

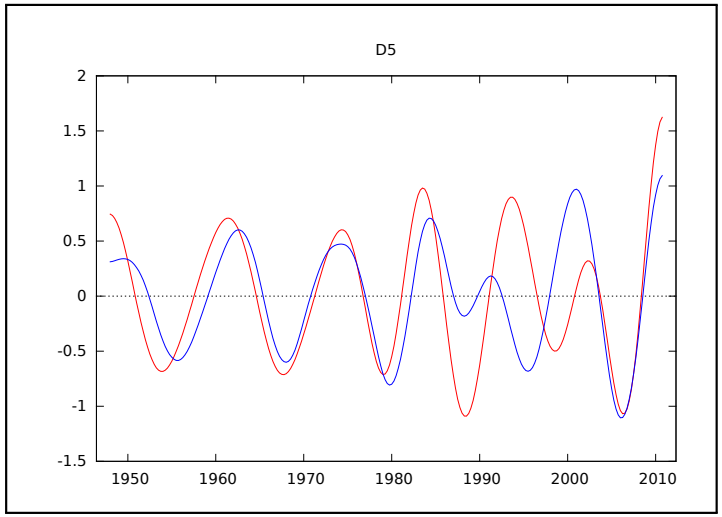
- Regions of strong coherency are evident at business cycles scales, *i.e.* at scales corresponding to periods between 2 and 8-years, except for the mid80s-mid90s period.
- The phase difference reveals that around the 4-year frequency the two series are generally in phase, while at frequencies approximating 2- and 8-years we can see that the unemployment rate was leading in the mid60s-mid80s period.
- In the last decade of the sample productivity growth is, respectively, leading and slightly leading the unemployment rate at scales corresponding to periods between 4 and 8 years.
- That both series are highly correlated at the longest scale (corresponding to periods greater than 16 years) with a stable antiphase relationship until mid 80s is also revealed by the high coherency (about 0.6) emerging throughout the sample

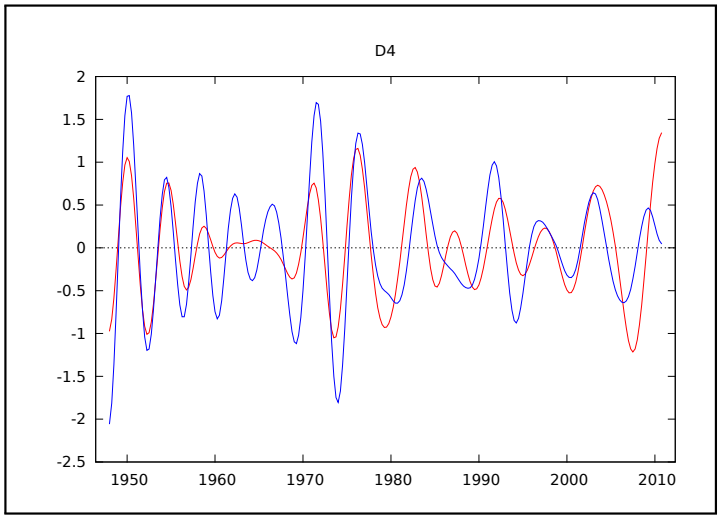
From CWT to (MO)DWT

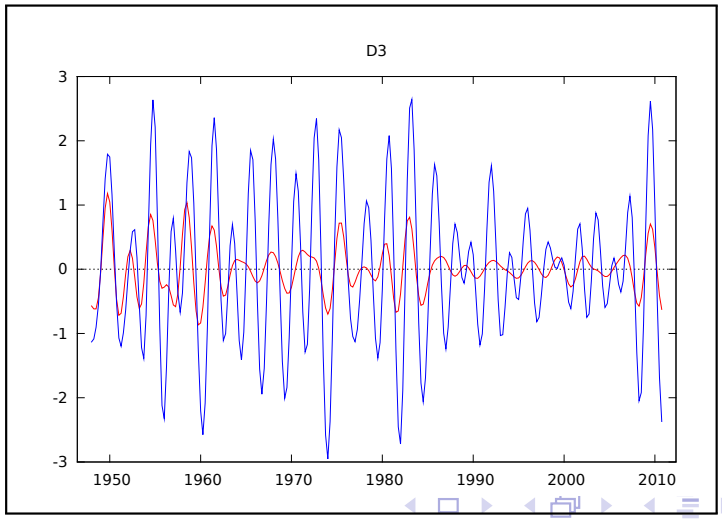
- The CWT provides a useful tool for analyzing how the different periodic components of a time series evolve over time, both individually and jointly, but is a highly information redundant transform
- A discretized version of it, the DWT, which uses only a limited number of translated and dilated versions of the mother wavelet to decompose the original signal is largely predominant in economic applications
- As a matter of fact, the preference for DWT in economic applications can be explained by its ability to facilitate a more direct comparison with standard econometric tools than is permitted by the CWT (e.g. time scales regression analysis, homogeneity test for variance, nonparametric analysis,)

Multiresolution decomposition for unemployment (red lines) and productivity (blue lines)









Time scale regression analysis

After decomposing each variables into a set of different time scale components by applying the *maximal overlap discrete wavelet transform* (MODWT) using the Daubechies least asymmetric (LA) wavelet filter of length $L = 8$ we estimate a sequence of least squares regressions

$$ur[S_J]_t = \alpha_J + \beta_J lp[S_J]_t + \epsilon_t \quad (1)$$

and

$$ur[D_j]_t = \alpha_j + \beta_j lp[D_j]_t + \epsilon_t \quad (2)$$

where $ur[S_J]_t$, and $lp[S_J]_t$ represent the smooth components, and $ur[D_j]_t$, and $lp[D_j]_t$ represent the detail components at each j scale, with j=1,2,....,J.

Time scale regression results

Dependent variable: $ur[D_j]$			
Details	$\Delta lp[D_j]$	Adj.R^2	*s.e.*
D_2	0.0419 (4.50)	0.0713	0.1961
D_3	0.2462 (12.03)	0.3641	0.3854
D_4	0.5052 (12.53)	0.3833	0.4203
D_5	0.3677 (5.62)	0.1085	0.5717
Dependent variable: $ur[S_J]$			
Scaling	$\Delta lp[S_J]$	Adj.R^2	*s.e.*
S_5	-1.4208 (-26.37)	0.7345	0.5023

Results

Summary results from time scale regression analysis are:

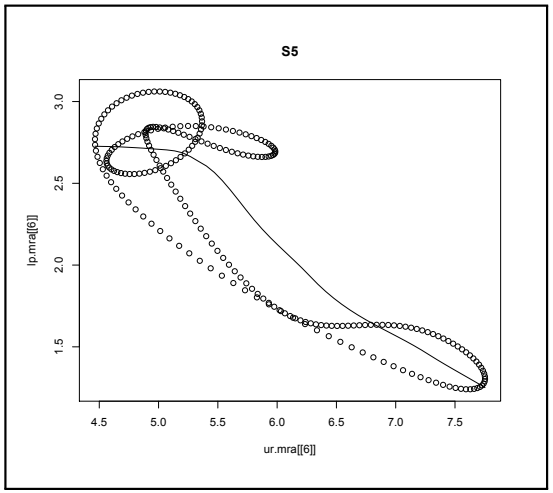
- the effects of productivity on unemployment rate differ across scales in terms of sign, significance, and estimated size.
- the effect of productivity on unemployment rate is positive at the detail scale levels, with the relationship being mostly significant at the D_3 and D_4 scale levels, but negative at the smooth scale level
- labor productivity growth is associated with an increase in the unemployment rate in the short and medium term, and to a decrease in the long run
- similar qualitative results in terms of co-movements are obtained in Tripier (2006) using spectral analysis.

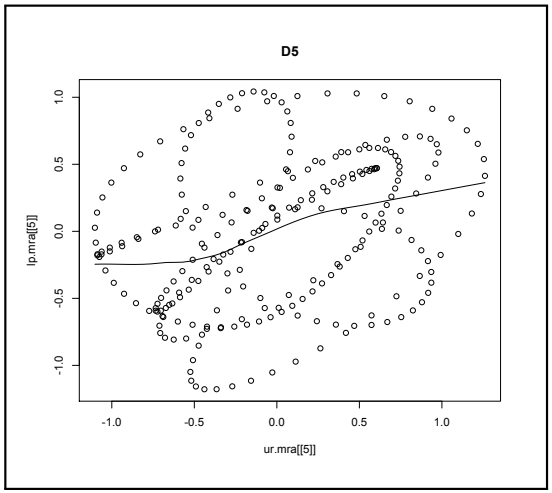
Nonparametric analysis

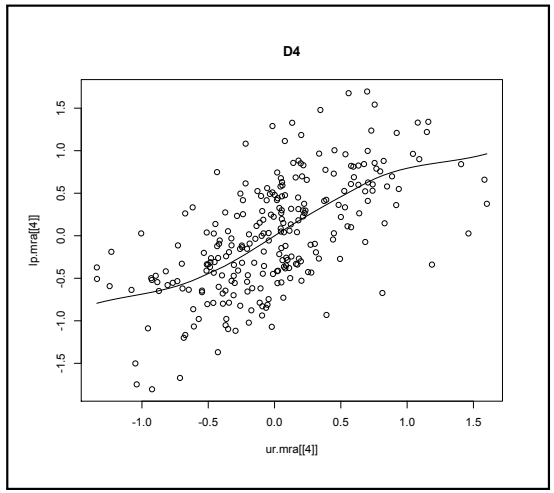
Nonparametric regressions can capture the shape of a relationship between variables without making any *a priori* explicit or implicit assumption about the form of the relationship in the model $y = f(x_1, ..., x_k) + \epsilon$

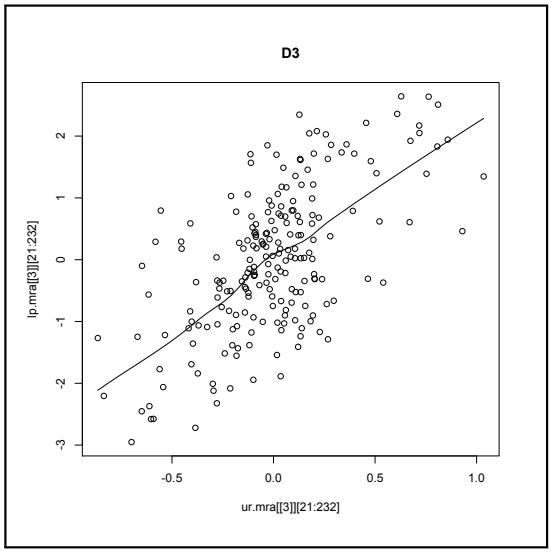
- we use the locally weighted polynomial regression model, i.e. *loess*, Cleveland (1979)
- the (low degree) polynomial is fit locally using weighted least squares
- the value of the regression function is obtained by evaluating the local polynomial at each particular value of the independent variable x_i using a smoothing parameter (span)

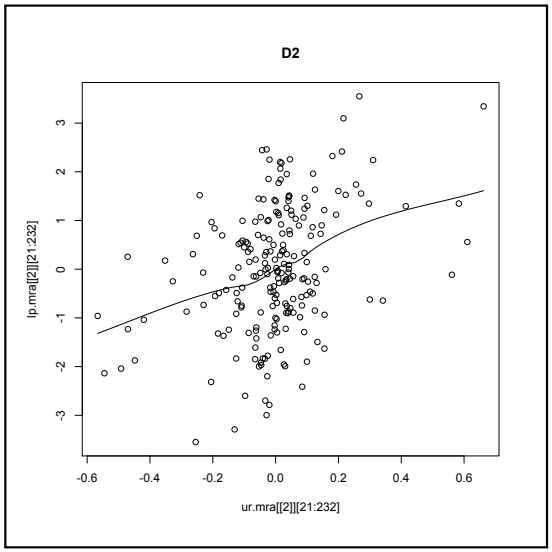
Scatter plot and loess fit at different scale levels

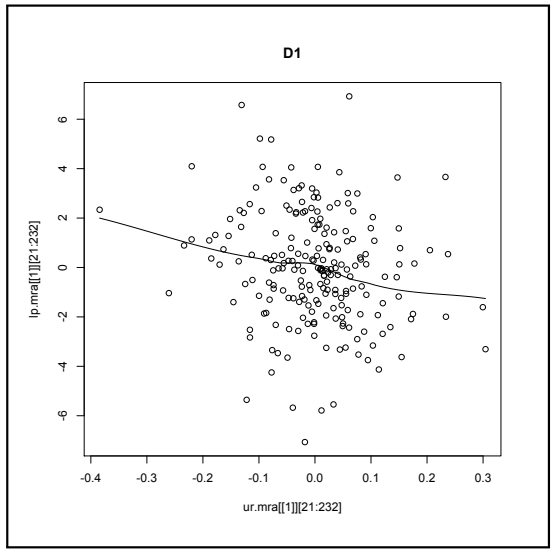












Interpretation

Trade-off at business-cycle time scales due to

- *Biased technological change*: If technological change affects the structure of labour demand, favoring skilled labour at the expense of the unskilled, and if the structure of labour supply is slow in responding to changing skill requirements, then more rapid growth may raise equilibrium unemployment (technological unemployment).
- *Creative destruction*: If economic growth brings about structural change, more rapid growth raises the rate of job destruction and may thereby raise frictional (and structural) unemployment.

... but, in the long-run the results are consistent with the absence of any showing of persistent technological unemployment, *i.e.* good things seems to go together

Which model?

- In Tripier (2006) a model based on the interaction of nominal and real rigidities (as in Ball and Moffitt, 2002) is simulated to replicate the empirical co-movements between the variables.
- In the model, the rates of unemployment and labor productivity growth co-move positively in the short and medium run because prices are sticky, whereas with fair wages and flexible prices the model can only account for the long-term co-movements.
- "I can easily imagine that there is a "true" macrodynamics, valid at every time scale. ..... At short time scales, I think, something sort of "Keynesian" is a good approximation, and surely better than anything straight "neoclassical." At very long time scales, the interesting questions are best studied in a neoclassical framework, ... At the five-to-ten-year time scale, we have to ... look for a hybrid model." Solow (2000, p.158)

Conclusions

- Using wavelets we find that the relationship between productivity growth and unemployment

  - differ strongly according to different time frames;
  - is larger at business cycle time scales than at scales corresponding to the long-run;
  - is negative at the longest scale, but positive at business cycle time scales.

- When Thomas More (Utopia, 1561) was asserting: sheep are eating men, he was, in the short run, right. Due to agriculture innovations, profits in the primary sector were rising, less labor force was employed in agriculture and more lands were devoted to pasture. People had to "invent" new jobs, to increase their purchasing power, but it needed time to adjust.