TOOLS FOR ADEQUATE MODELING OF RUSSIAN REGIONS EVOLUTIONARY DYNAMICS

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PURPOSE OF THE STUDY

- Develop tools for regional economy modeling in Russia
  - Adequacy: models and methods in accordance to analysis and forecasting purposes
  - Evolution: economical dynamics are not stable, continuously adapt or change models
  - Spatial: consider regions neighborhood and geographical position
- Analyze regions of Russia (mesoeconomic level): influence of the sanctions, economic cycles, key sectors of the economy

STATISTICAL BASE

- 78 Russian regions (excluding Moscow, St. Petersburg, Sevastopol, Crimea, Chechnya and some others due to special economic condition and the lack of statistics)
- Operative monthly data on 12 economic indicators in 2005-2017: building, extraction (total, crude oil and gas, metals), manufacturing (total, chemical industry, pharmacy, rubber and plastic production, metallurgy, electronics), retail stocks, prices
- Yearly GRP, employment, capital assets per employee, retail trade per employee in 2012-2016 (before and after the sanctions)

TOOLS: DYNAMICS MODELS

- Components: trend, cycle, seasonal, stochastic
- Structures: additive, multiplicative, combined additive-multiplicative

$$Y_t = T_t + C_t + S_t + \varepsilon_t \qquad Y_t = (T_t + C_t)(1 + S_t) + \varepsilon_t$$

- In previous studies more sophisticated structures were introduced by V.Semenychev and E. Kurkin (cycles weighted by amplitude and frequency)

$$S_t = \sum_{i=1}^{N} A_i \left([1-\gamma_i] + \gamma_i \frac{T_t}{\max(T_t)} \right) \mathrm{Sin}(\omega_i t + \phi_i)$$

$$S^{\Omega_2} = \sum_{i=1}^{N_\Omega} A_i \left(\frac{T_t}{T_{\max}} \right)^{\gamma_i} \sin(\omega_i \int_{t_0}^{t_k} \left[\frac{T(s)}{T_{\max}} \right]^{-\theta_i} ds + \phi_i)$$

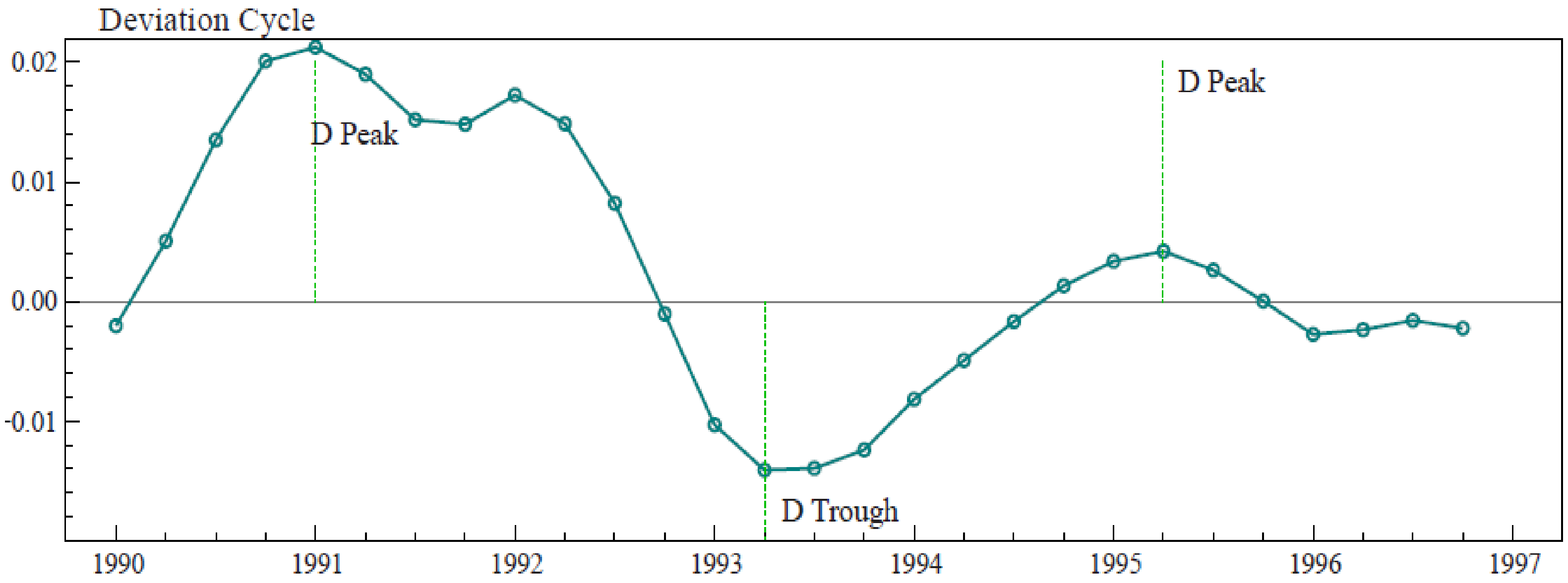
TOOLS: TRENDS

- Trends used:
  - Linear
  - Growth/decline: generalized exponential and power function
  - S-shaped: generalized sigmoid (Verhulst model) and arctangent
  - Bell-shaped: generalized gaussian and asymmetric rational (Cauchy)
- Prepared but not implemented: over 20 S-shaped and bell-shaped logistic curves

$$T_t = C_0 + A_0 e^{\alpha t} \qquad T_t = C_0 + \frac{A_0}{1+e^{-\alpha(t-t_0)}} \qquad T_t = C_0 + \frac{A_0}{1+\alpha(t-t_0)^2} \cdot \frac{1}{1+\exp(-\sigma(t-t_0))}$$

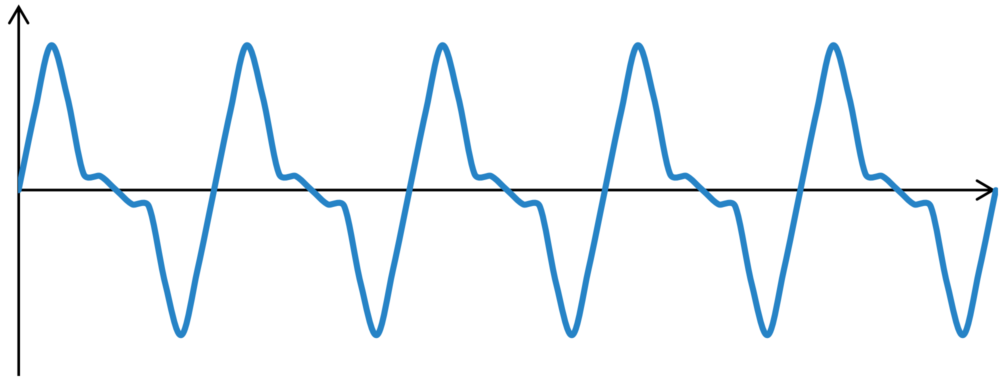
TOOLS: CYCLES

- Cyclic indicators (ISM index, PMI, LII, ZEW) only detect upcoming decline and mark cycle points: no models, no quantitative forecast; introduced for developed economics
- **E. Slutsky hypothesis for mesoeconomy:** combined stochastic factors create wave-like dynamics that could be described by a sum of a few (3-4) sines

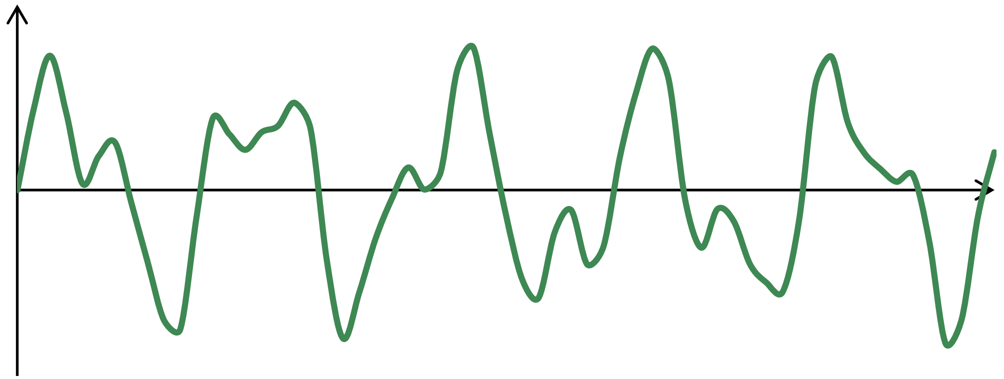


TOOLS: CYCLES

- Unlike single sinus economic cycles are asymmetric and not strictly periodic
- Unlike Fourier series the periods of sines are not multiplies of n. Non-proportional sines generate complex changing waves



Sines with proportional frequencies



Sines with non-proportional frequencies

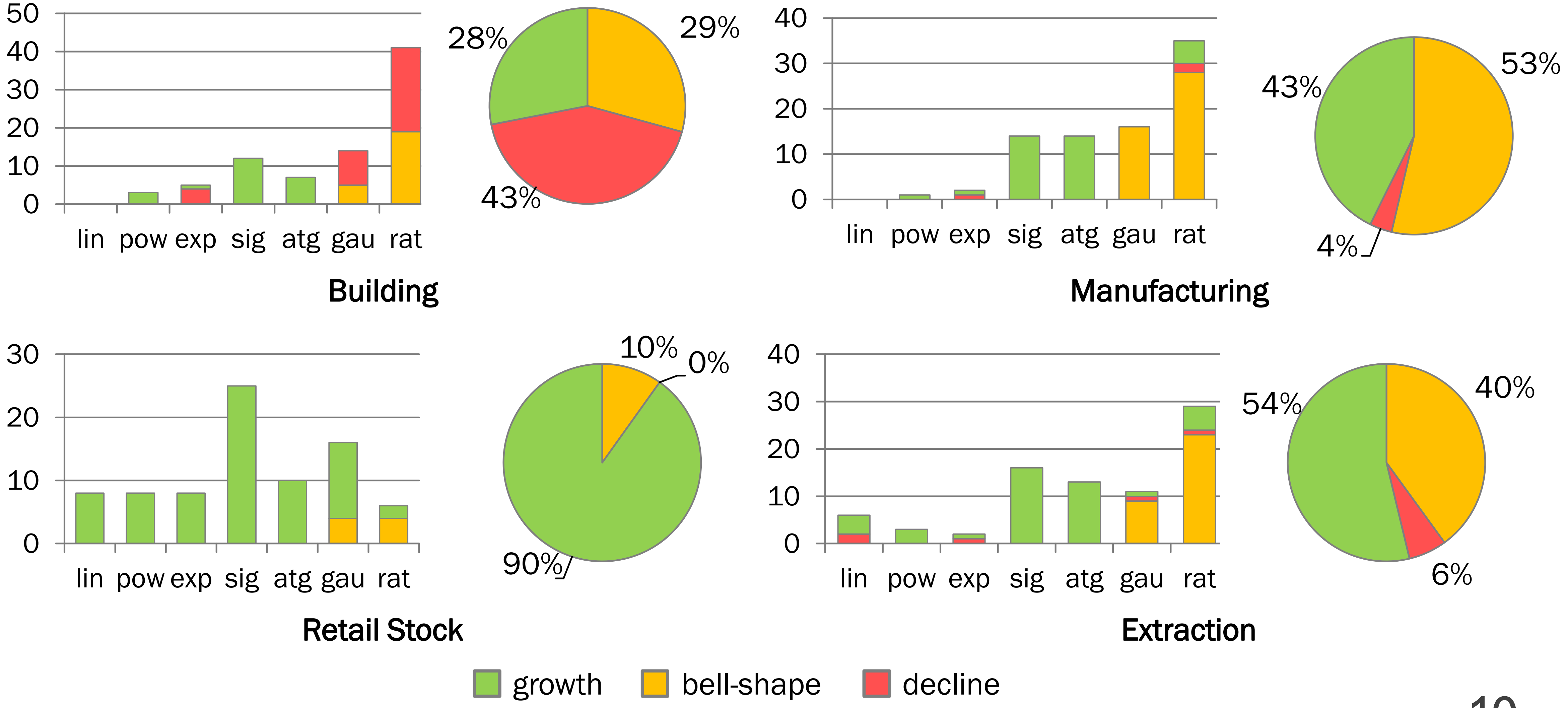
TOOLS: METHODS

- Implemented using R
- Strategy: iterative decomposition
- Seasonal: LOESS
- Cycles: authors' technique based on V. Semenychev's generalized ARMA construction method
- Trends: simulated annealing, nonlinear LS (Gauss-Newton, Levenberg-Marquardt), RPROP

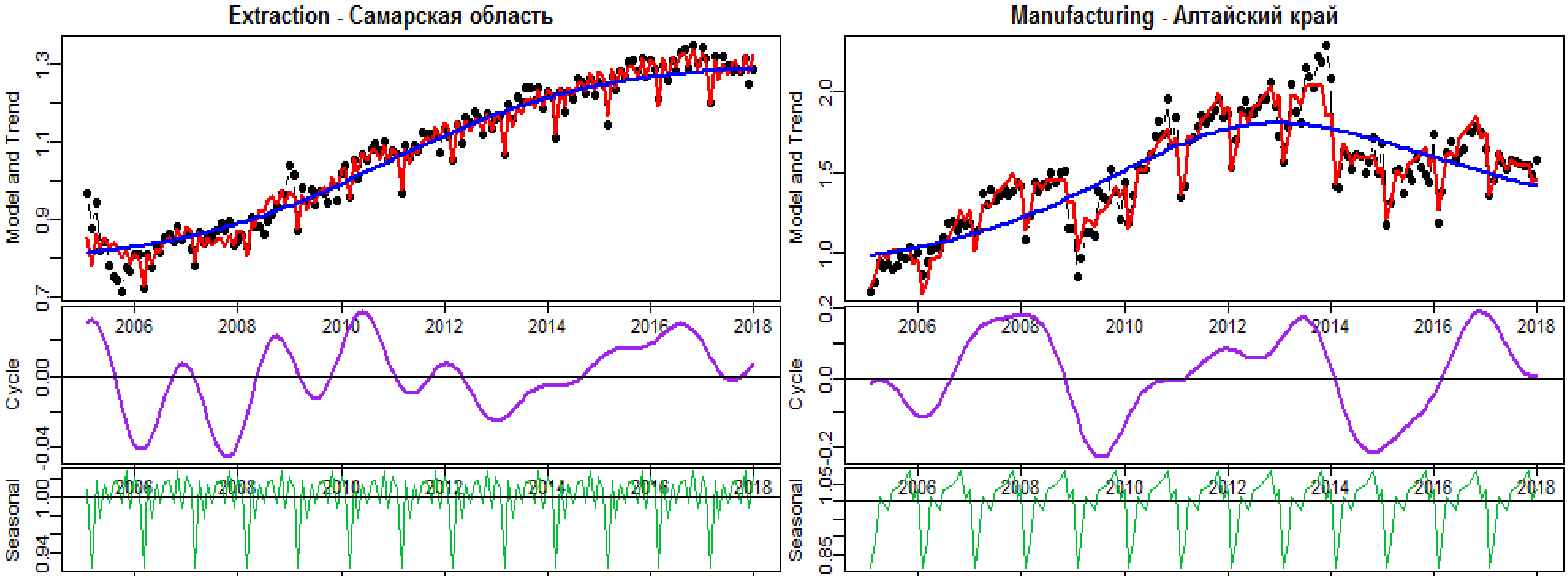
RESULTS

- Prerequisites: regions clustering (4 clusters, typical representatives)
- Trend, cycle & seasonal models for each region for each economic sector (156 models)
- Trend frequencies among the models
- Cycle stages dating (retrospective and forecasts)
- Generalization of cycles, regions’ comparison: pro-cycled, a-cycled, counter-cycled

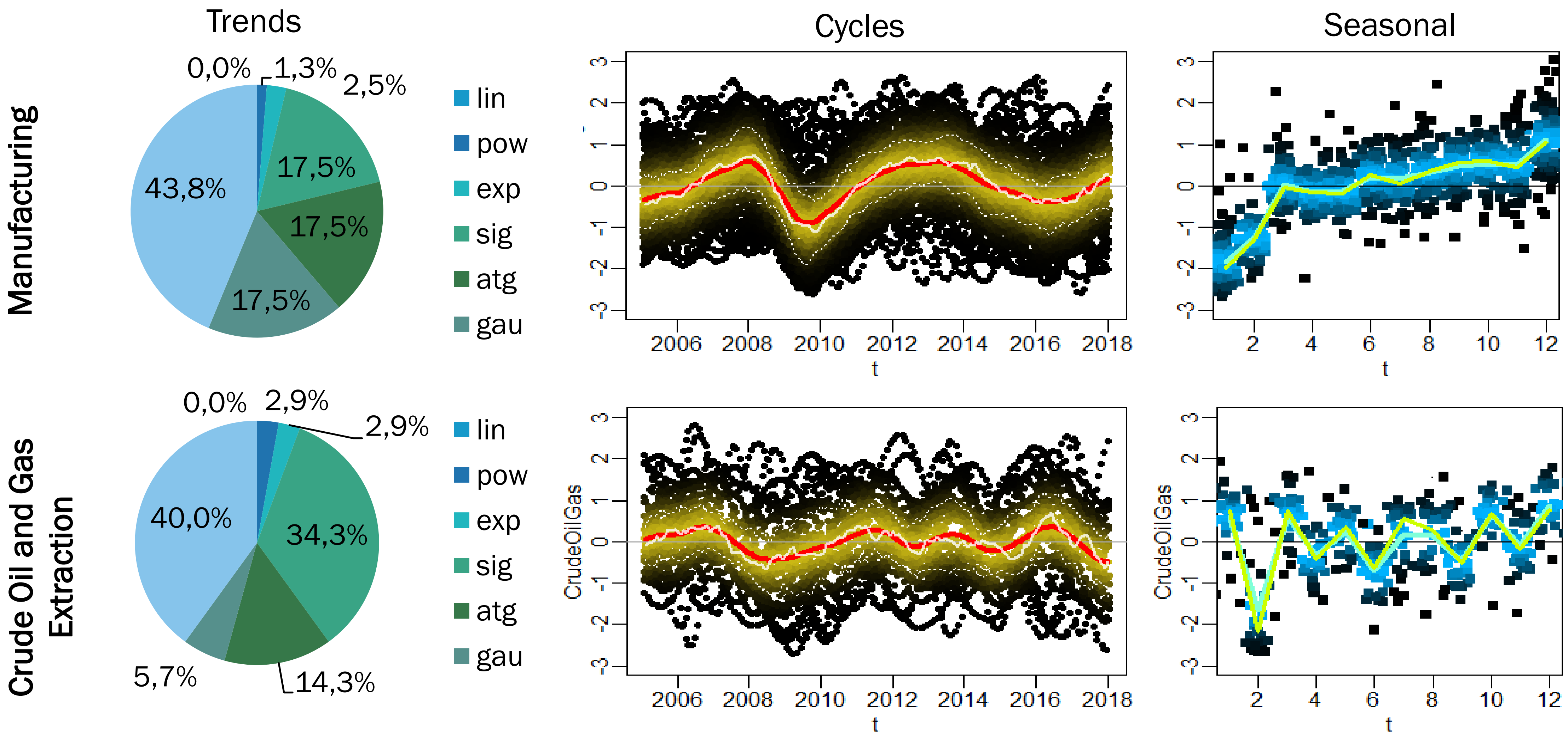
TREND FREQUENCIES AMONG THE MODELS



RESULTS ON EACH REGION



RESULTS: GENERALIZATION



TOOLS: SSFA

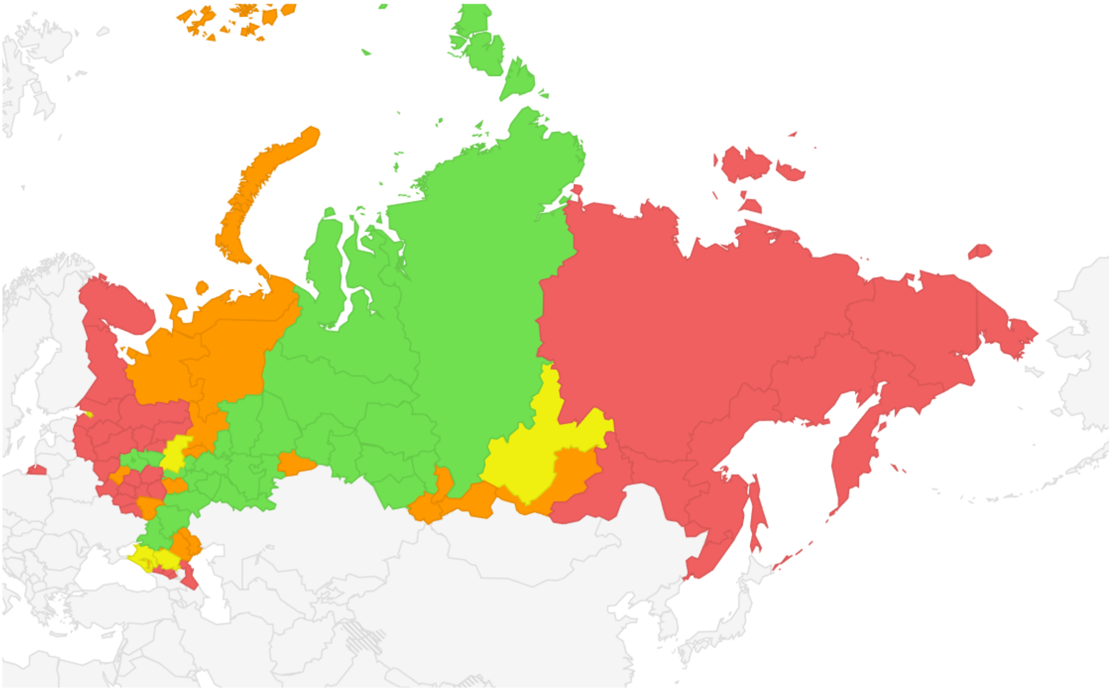
- **Spatial Stochastic Frontier Analysis**: production model (production quantity on its factors) including neighborhood weight matrix
- Considered 9 factors but only employment, capital assets and retail trade were proven relevant
- Considered 3 **weight matrixes**: nearest neighbor weights, power distance weights, exponential distance weights
- Influence of the factors compared
- Comparative technical efficiency of each region over each year
- **Moran's index** and diagram

RESULTS: SSFA IN 2016

Technical Efficiency

L H

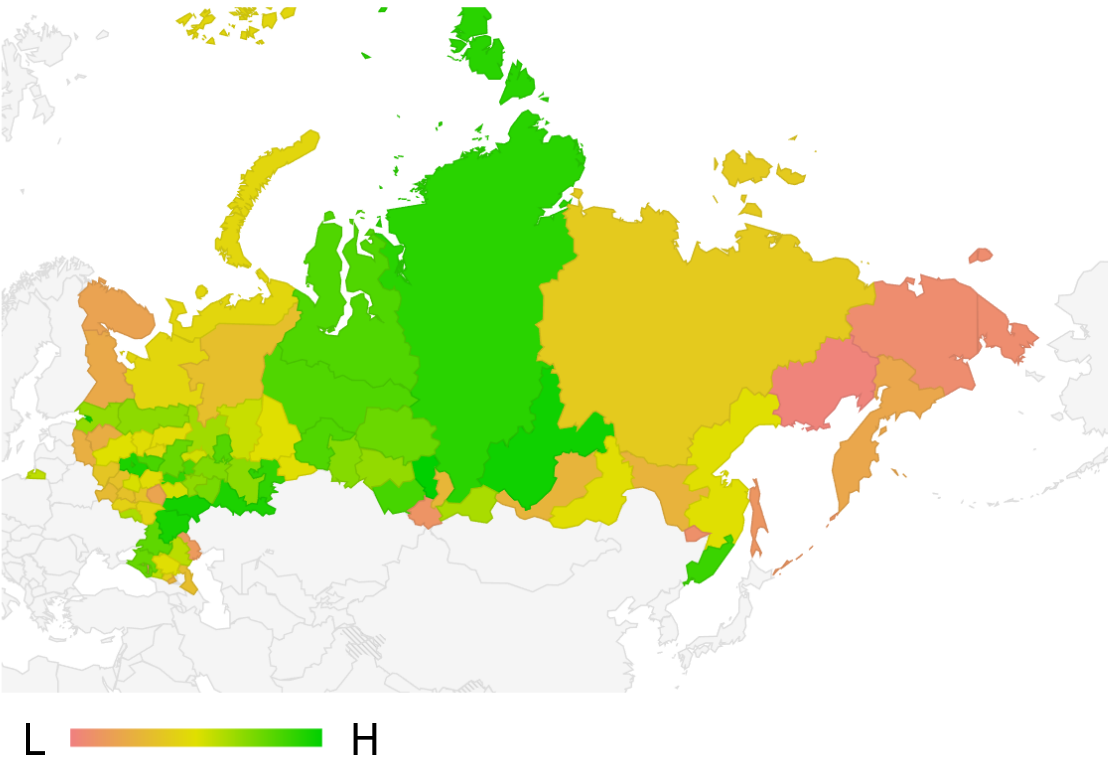
Moran Diagram Quarters



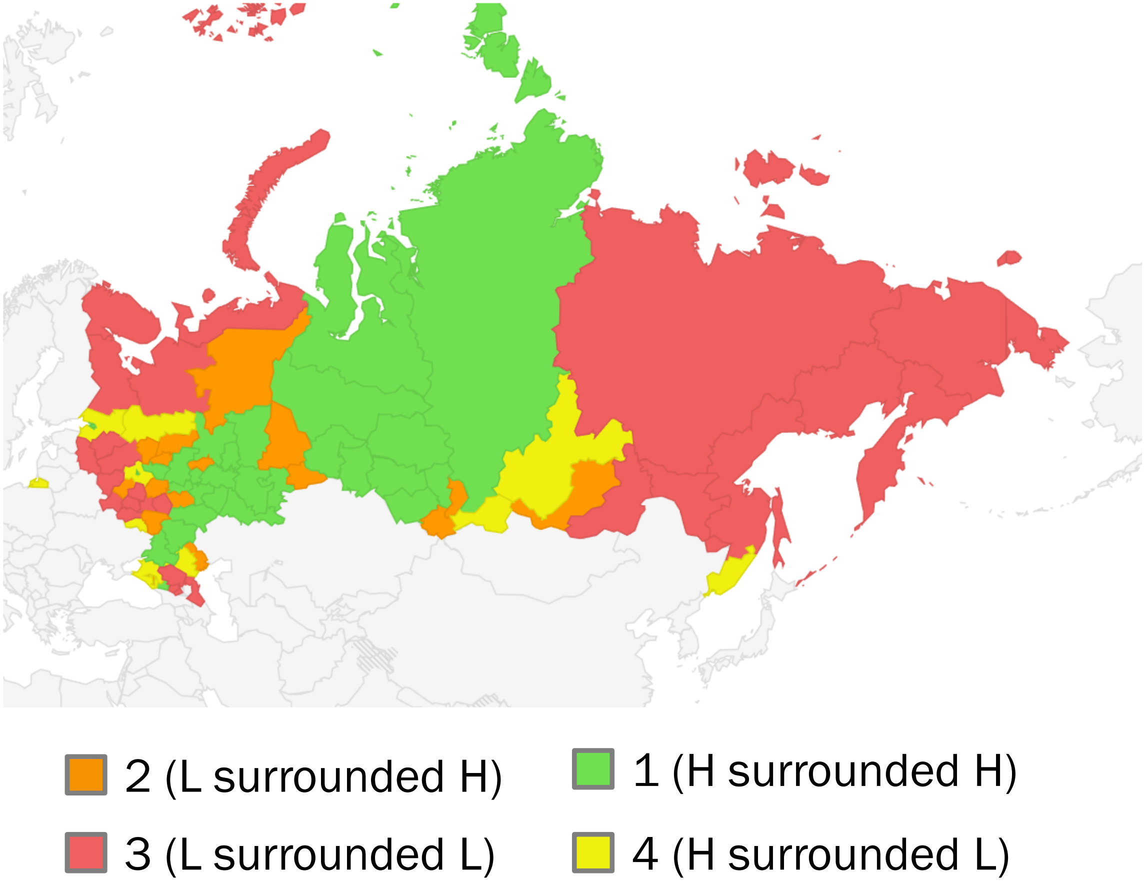
2 (L surrounded H)
1 (H surrounded H)
3 (L surrounded L)
4 (H surrounded L)

RESULTS: SSFA IN 2013

Technical Efficiency



Moran Diagram Quarters



PERSPECTIVES

- Models: other trends, evolution (trends switching, sines amplitudes changing)
- Methods: genetic algorithms, other seasonal measuring methods
- Metrics: least absolute instead of least squares
- Updating and widening of the data
- Combining techniques: cyclical-spatial analysis
- Stochastic components analysis as a mixture of the heavy-tailed Pareto distribution and a normal distribution
- Bootstrap technique
- Bayesian approach

MORE DETAILS

- V. Semenychev, A. Korobetskaya (2019). Multimodel Estimation for Innovative Development of 78 Russian Regions Using Leading Indicators During 2005-2017:
  Available at SSRN: http://dx.doi.org/10.2139/ssrn.3373579 (in Rus.)
- V. Semenychev, G. Khmeleva, V. Kozhukhova, (2018) The Evolution of Technical Efficiency of Russian Regions in 2011-2016: SFA Stochastic Analysis Method with Spatial Effects.
  Available at SSRN: http://dx.doi.org/10.2139/ssrn.3245728 (in Rus.)

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