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

\[
Y_t = T_t + C_t + S_t + \varepsilon_t
\]

\[
Y_t = (T_t + C_t)(1 + S_t) + \varepsilon_t
\]

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

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

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

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

**Building**
- 28% Growth
- 29% Bell-shape
- 43% Decline

**Manufacturing**
- 43% Growth
- 6% Bell-shape
- 4% Decline

**Retail Stock**
- 90% Growth
- 10% Bell-shape
- 0% Decline

**Extraction**
- 54% Growth
- 40% Bell-shape
- 6% Decline

Legend:
- Green: Growth
- Orange: Bell-shape
- Red: Decline
RESULTS ON EACH REGION
RESULTS: GENERALIZATION

Trends

Manufacturing

0,0% 1,3% 2,5%
43,8% 17,5% 17,5%

Crude Oil and Gas Extraction

0,0% 2,9% 2,9%
40,0% 34,3%
5,7% 14,3%

Cycles

Seasonal

lin
pow
exp
sig
atg
gau

Manufacturing

0,0% 2,9%
2,9% 34,3%
40,0%
5,7% 14,3%

Crude Oil and Gas Extraction

Seasonal

Cycles
**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

Moran Diagram Quarters

Legend:
- 1 (H surrounded H)
- 2 (L surrounded H)
- 3 (L surrounded L)
- 4 (H surrounded L)
RESULTS: SSFA IN 2013

Technical Efficiency

Moran Diagram Quarters

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


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