Emission sources activity data projections – how to start?

Projections Expert Panel

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Introduction

Methodology

Partial **L**east **S**quares **R**egression

Singular **S**pectrum **A**nalysis

Results

H_2SO_4 production

Solvent-based paints consumption

Conclusions & Remarks

Industrial processes & product use

- Preliminary forecasting in industrial processes.
- Sulfuric acid (H_2SO_4) production.
- Production of solvent-based paints and coatings.
- Activities of emission sources.
- Using mathematical approach (☹).

No Difference

*There is **no difference** between a forecast, a scenario, or a projection*[1] *.*

⋆⋆⋆ *William M. Briggs* ⋆⋆⋆

[1] http://wmbriggs.com/post/13252/

Well, some math, . . .

- PLSR $\rightarrow H_2SO_4$ production process investigation;
- Time series modeling:
  - regression: linear (LIN), power (POW), logarithmic (LOG);
  - spectral (SSA).

but . . .


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H_2SO_4 Pearson's correlation coefficients

	A	B	C	D	E	F	G
A	**1**						
B	-0.015	**1**					
C	0.329	-0.859	**1**				
D	0.356	0.252	-0.029	**1**			
E	0.599	0.604	-0.290	0.407	**1**		
F	0.240	0.661	-0.422	0.289	0.884	**1**	
G	0.857	0.036	0.268	0.436	0.617	0.273	**1**

A, H_2SO_4; B, Cu ores; C, sulfur; D, ammonium sulfate; fertilizers: E, (N)(P)(K); F, (N); G, (P). $|\rho| > 0.5$.

PLSR

Partial **L**east **S**quares **R**egression:

$$\mathbf{Y} = \mathbf{XB} + \epsilon$$

$$w_k = \text{argmaxcov}_{w^T w=1}(\mathbf{X}^T w,\ \mathbf{Y})$$

$$\forall 1 \leq j \leq k,\ w^T \mathbf{X}\mathbf{X}^T w_j = 0$$

B.-H. Mevik, R. Wehrens, *Journal of Statistical Software* 2007, **18**, 2, 1-24.

SSA (1)

Singular **S**pectrum **A**nalysis:

$$Y_T = (y_1, y_2, \ldots, y_T) \tag{1}$$

$$K = T - L + 1 \wedge L \leq 0.5\,T \tag{2}$$

$$\mathbf{X} = [X_1, X_2, \ldots, X_K] = (x_{ij})_{i,j=1}^{L,K} \tag{3}$$

$$\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_L \geq 0 \tag{4}$$

$$U_1, U_2, \ldots U_L \tag{5}$$

$$\mathbf{X} = \mathbf{E_1} + \mathbf{E_2} + \cdots + \mathbf{E_d} \tag{6}$$

where $\mathbf{E}_i = \sqrt{\lambda_i} U_i V_i^T, \; i = (1, 2, \ldots, d)$

SSA (2)

- SSA analysis on time series of length T (1).
- Assuming constants: K (2) and L (window length), the trajectory matrix X is bulit (3).
- SVD of matrix $\mathbf{X}\mathbf{X}^T$ supplies eigenvalues (4) and eigenvectors corresponding to them (5).
- Normalized eigenvector U_i corresponds to eigenvalue λ_i. Trajectory matrixcan be described as (6).

SSA (3)

Further reading:

H. Hassani, S. Heravi, A. Zhigljavsky, International Journal of Forecasting 2009, 25, 103-118, doi: 10.1016/j.ijforecast.2008.09.007.

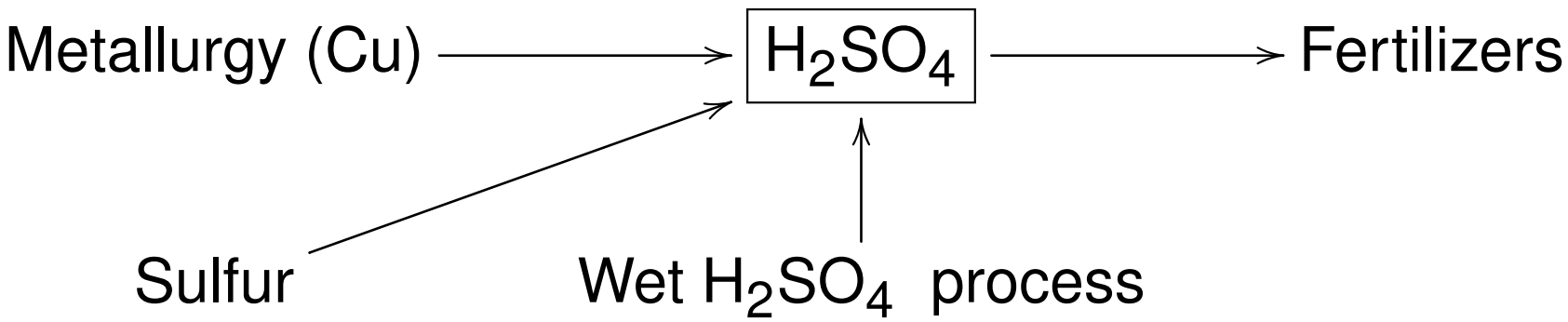
H. Hassani, S. Heravi, A. Zhigljavsky, Journal of Forecasting 2013, 32, 395-408, doi: 10.1002/for.2244.

H. Briceno, C.M. Rocco, E. Zio, Chemical Engineering Transactions 2013, 33, 919-924, doi: 10.3303/CET1333154.

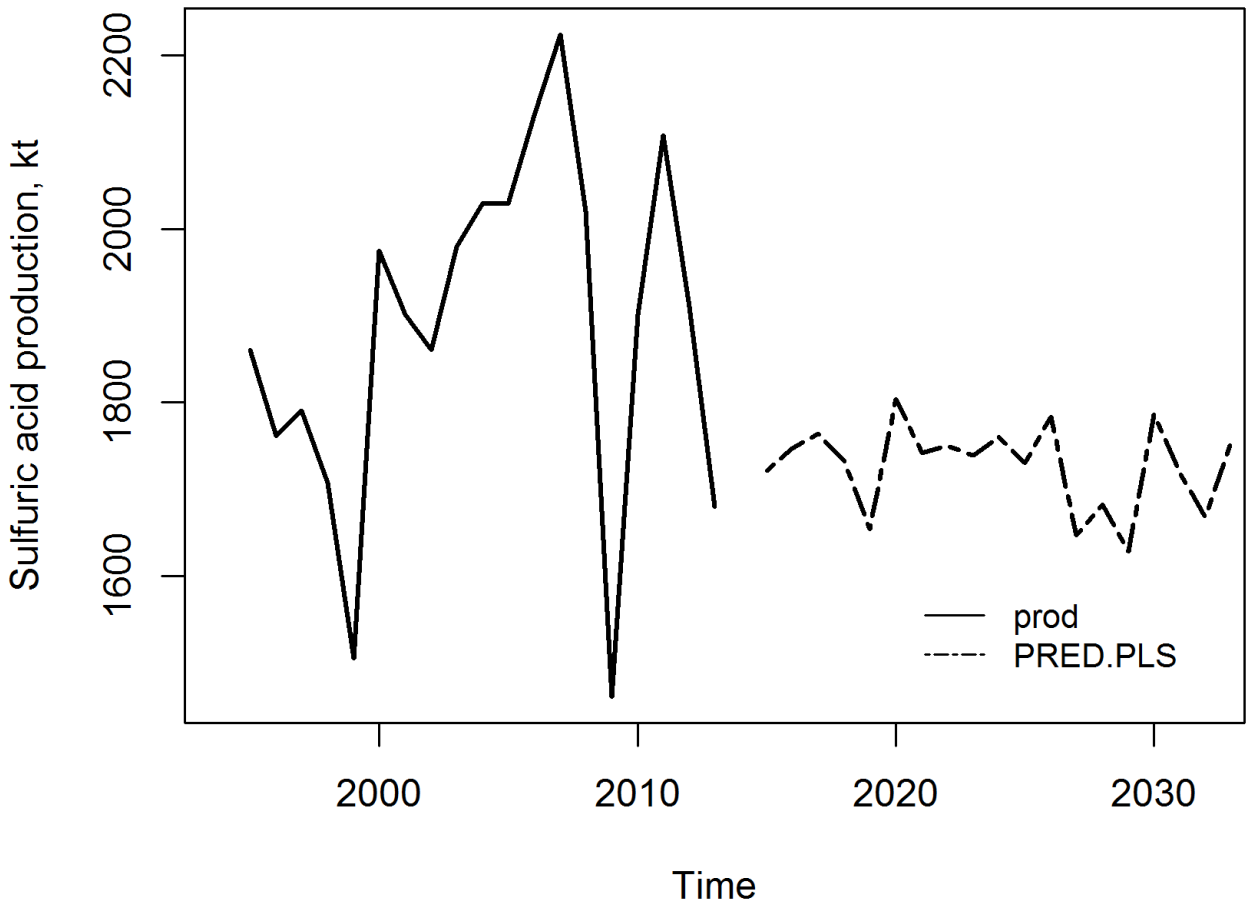
N. Golyandina, A. Korobeynikov, Computational Statistics and Data Analysis 2014, 71, 934-954, doi: 10.1016/j.csda.2013.04.009.

N. Golyandina, V. Nekrutkin, A. Zhigljavsky, Analysis of Time Series Structure. SSA and Related Techniques, Chapman & Hall/CRC 2001.

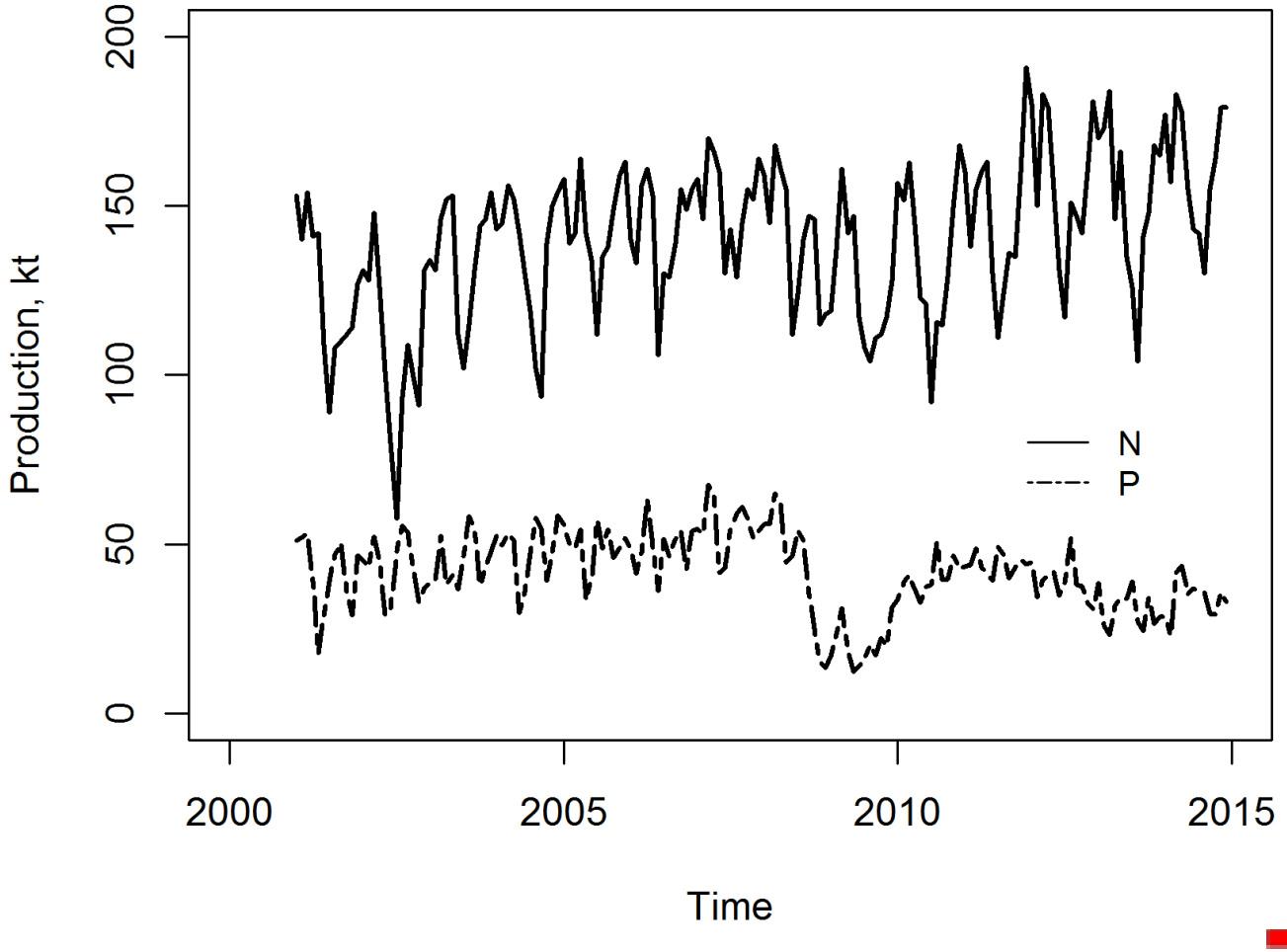
H_2SO_4 production process in Poland



H_2SO_4 projection [kt]: PLSR

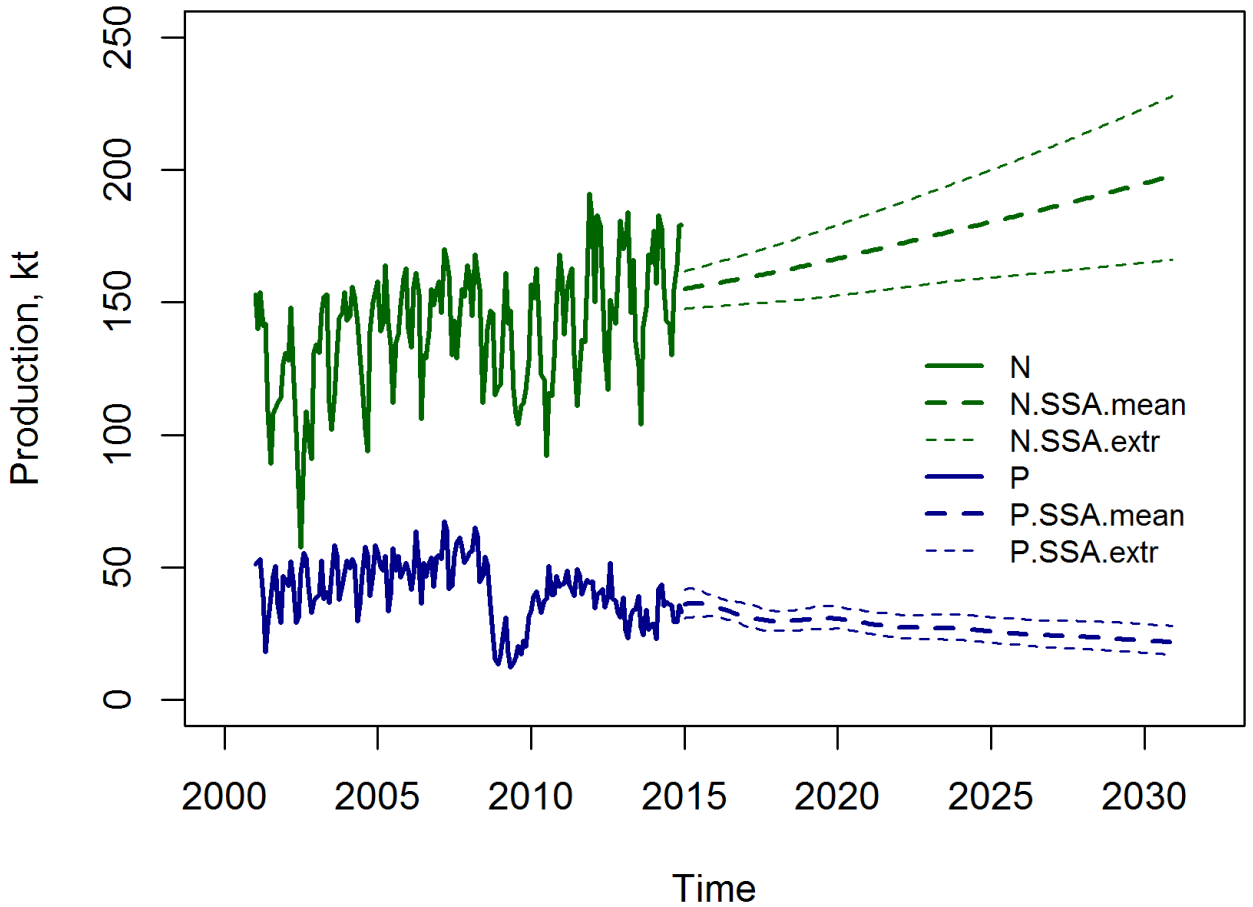


Monthly production of fertilizers 2001-2014 [kt]

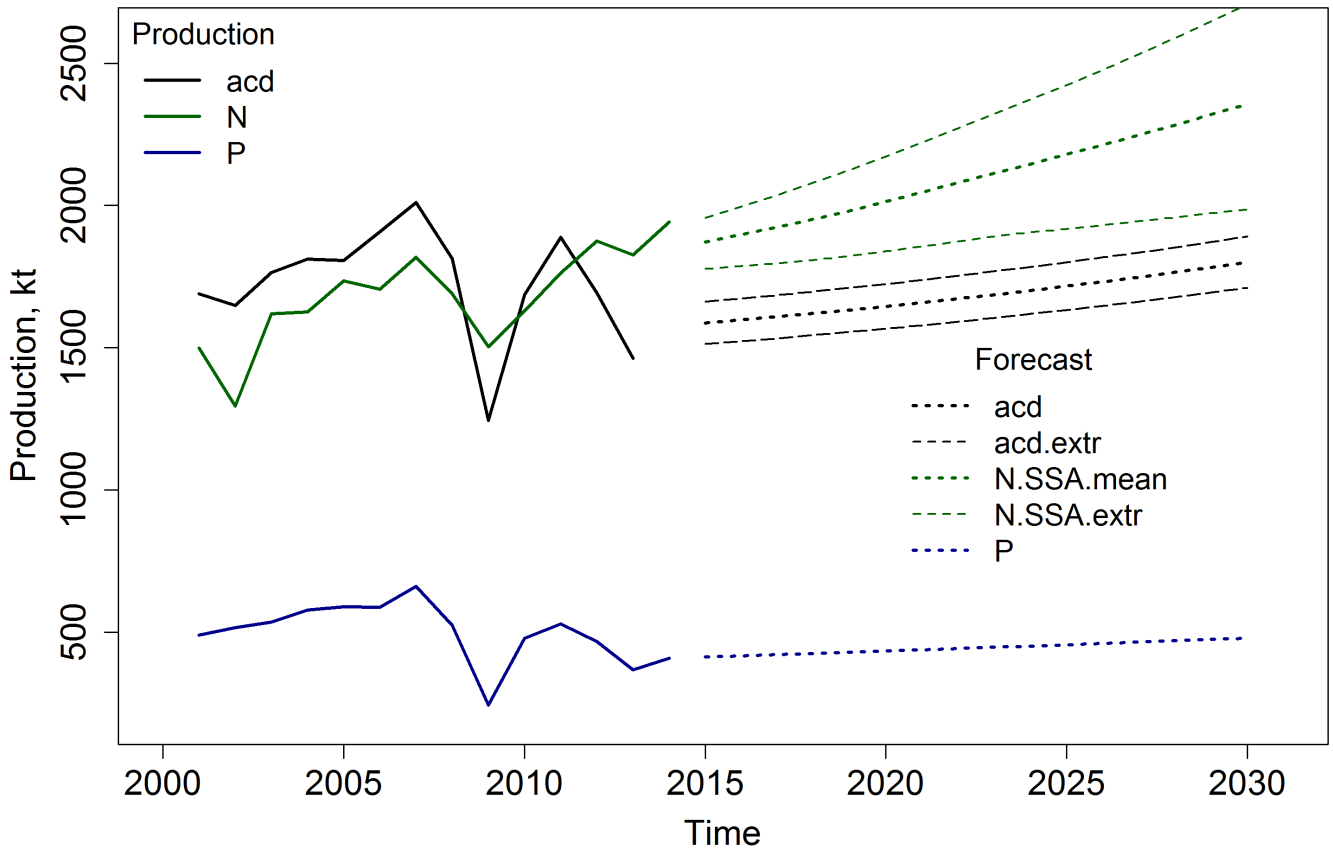


N, nitric and multi-compound; P, phosphatic

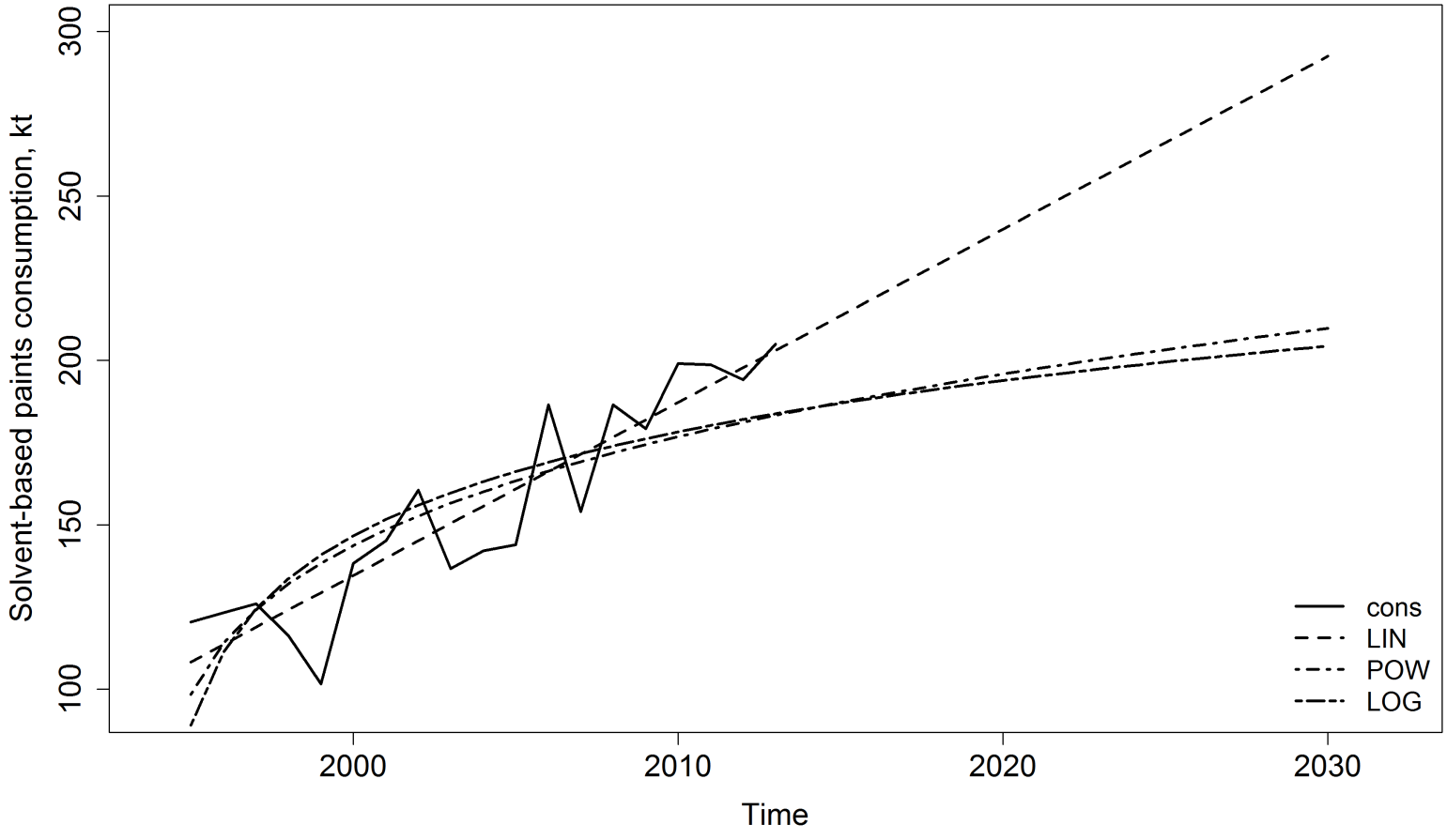
Fertilizers projection [kt]: SSA



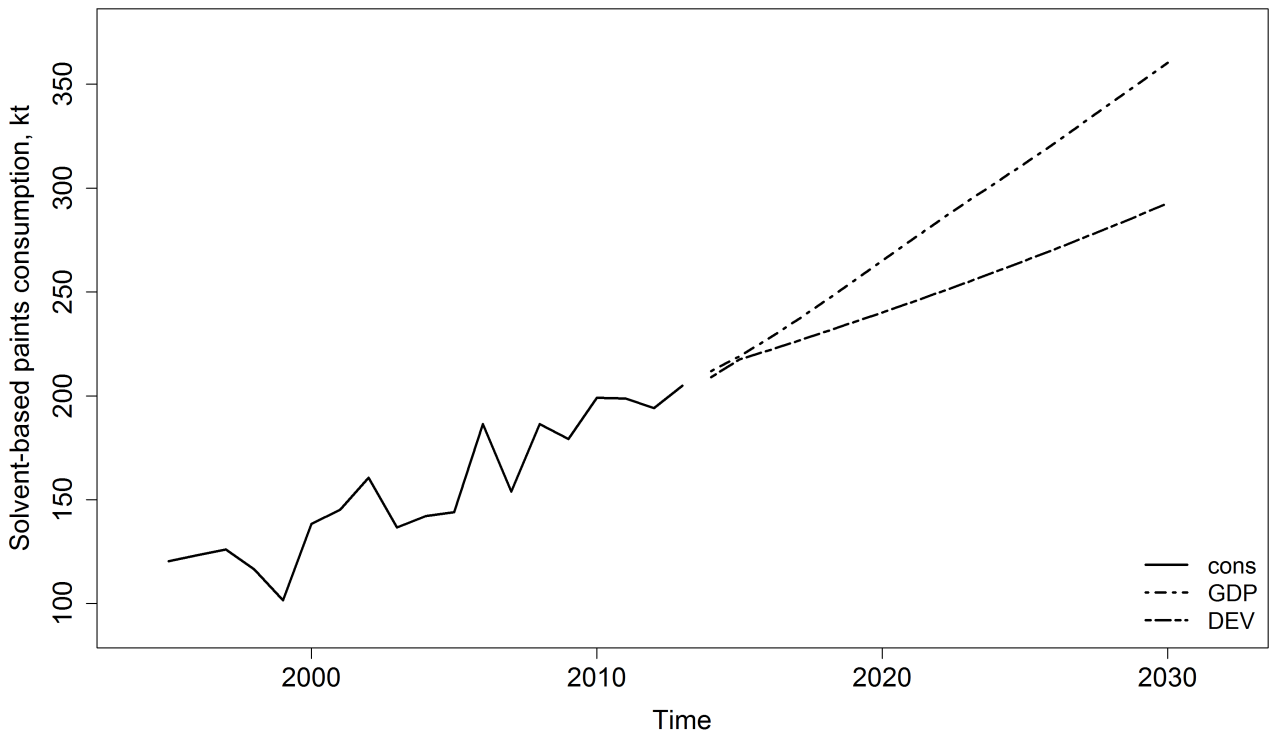
Fertilizers & H_2SO_4 projection [kt]: SSA



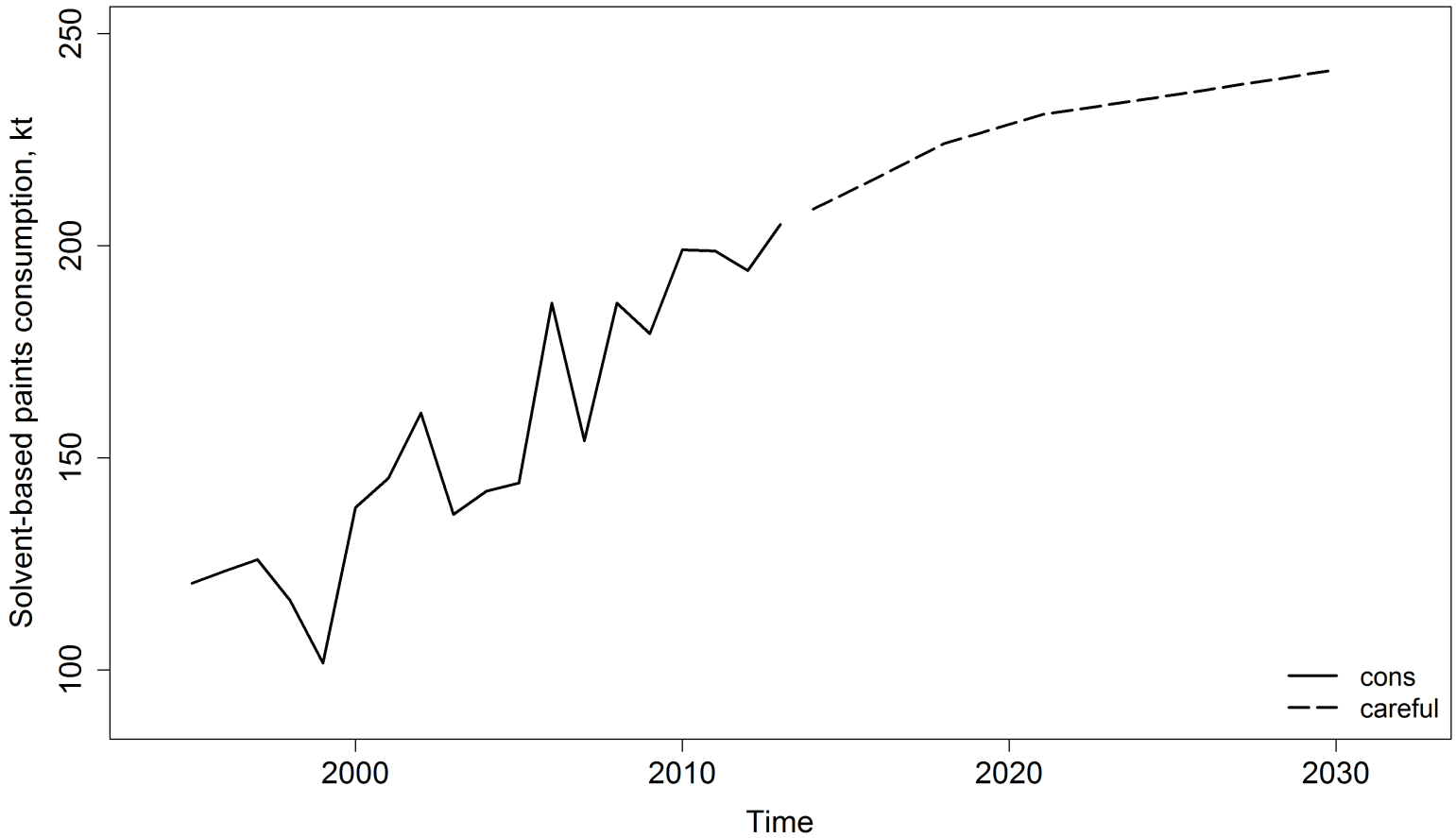
Paint application [kt]



Paint application trend (cons) based on GDP forecast (GDP) and sectoral analysis (DEV)



Paint application trend using 'conservative estimate'



Conservative forecast: +1.8%, 2014-2018; +1%, 2019-2021; +0.5%, 2022-2030.

Conclusions & Remarks

- Prediction is very difficult, especially if it's about the future. (Niels Bohr)
- H_2SO_4 production: observed demand–supply structure using PLSR method.
- Solvent-based paints consumption: prediction based on GDP forecasts and market analysis.
- Time series analysis is (probably) not more irrational than unrealistic assumptions about economy and development.


"That's all Folks!"
Isberg©
TFEIP

You can contact with us ☺

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