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# Modeling of Sectoral Investment for Poland

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# Outline

1. Introduction
2. Investment demand function – variable selection
3. Problems related to the database building
4. Statistical analysis of the sectoral investment
5. Estimation results – sectoral investment models
6. Investments in the energy sector – facts, ideas, threats
7. Summary and directions of further research

# 1. Introduction

Investments play a major role in many areas of the economic life... for example:

## ECONOMIC GROWTH



- Solow-Swan model (1956-1957) and its modifications
- The problem of the accumulation of the capital (Phelps 1961, Domar 1962)

## EMPLOYMENT



- The relationship between investment expenditures and the levels of the income and employment (Keynes 1936 and others)

## INNOVATIONS



- Diffusion of innovations and investments (Schumpeter 1960)

Dual nature of the investment:

- (demand side) generating National Income through the multiplier effects,
- (supply side) increasing production capacities of the economy.

# 1. Introduction

No.	Uses  Products (CPA 2008)	Intermediate consumption (CPA 2008)					Final demand												OUTPUT
		products of agriculture and hunting (01)	products of forestry (02)	etc. divisions following annex 3 ...	private households with employed persons (97-98)	total (01-77) 78	final consumption expenditure				gross capital formation			exports fob			total (82+85+88) 89		
							by households 79	by non-profit institutions serving households (NPISH) 80	by government 81	total (79+80+81) 82	gross fixed capital formation 83	changes in inventories and changes in valuables 84	total (83+84) 85	intra European Union 86	extra European Union 87	total (86+87) 88			
0	1	2	...	77	78	79	80	81	82	83	84	85	86	87	88	89			
01	products of agriculture and hunting	(01)																	
02	products of forestry	(02)																	
03	fish and other fishing products	(03)																	
04	Coal and lignite	(05)																	
...	etc. division following Annex 3	...																	
76	Other personal services	(96)																	
77	Private households with employed persons	(97-98)																	
78	Total products																		
79	Taxes less subsidies on products																		
80	Total intermediate consumption/final demand at purchasers' prices																		
81	Compensation of employees																		
82	Other net taxes on production																		
83	Consumption of fixed capital																		
84	Operating surplus, net																		
85	Operating surplus, gross																		
86	Value added at basic prices																		
87	Output at basic prices																		
88	Imports cif																		
89	Supply at basic prices																		

$$invR = invSCALE[t] * INVbr * invc$$

$$\begin{bmatrix} invR_1 \\ \vdots \\ invR_{77} \end{bmatrix}_{77 \times 1} = [s^0] * [INVbr_{kj}^0]_{77 \times 4} * \begin{bmatrix} invc_1 \\ \vdots \\ invc_4 \end{bmatrix}_{4 \times 1}$$

Pic. 1. Role of the investment in MMM

Source: Own modifications on the basis of CSO of Poland, *Input - output table at basic prices in 2010*, p. 24

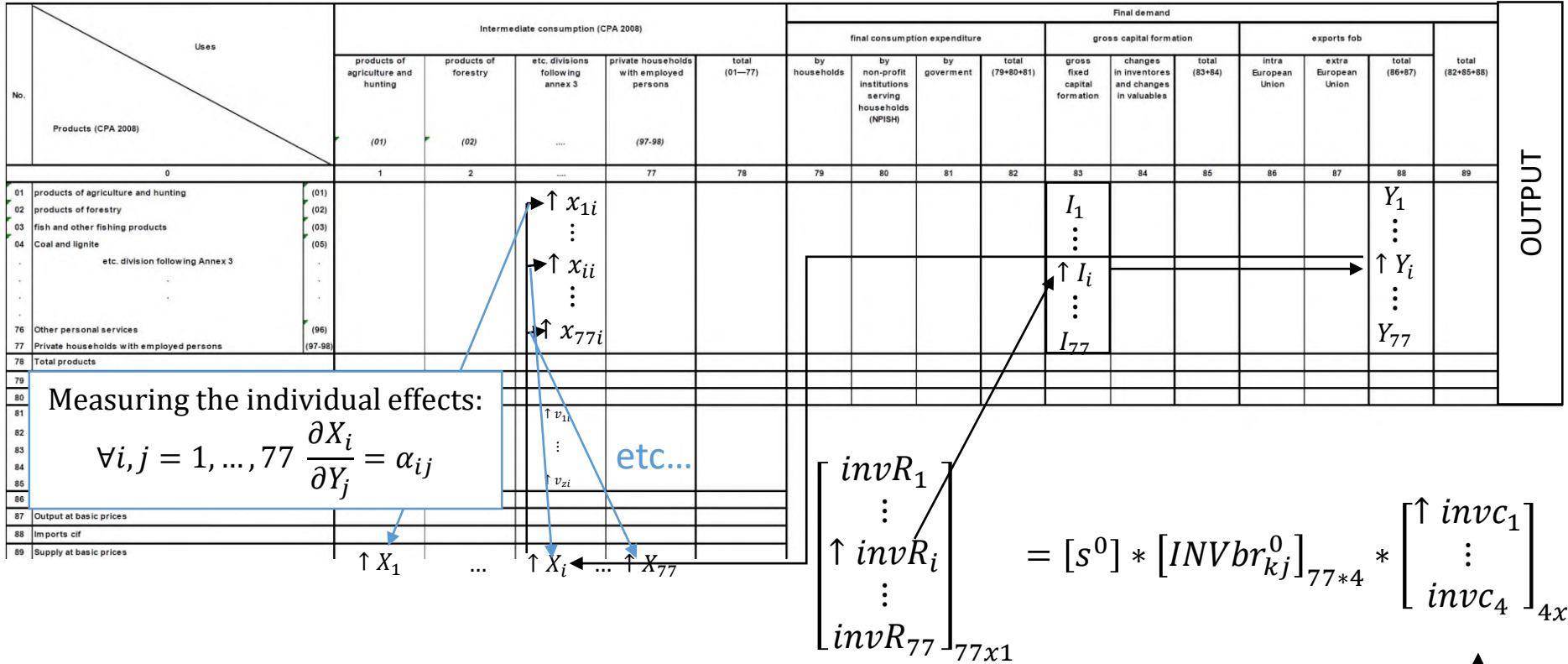
for  $k = 1, \dots, 4, m = 1, \dots, 45, j = 1, \dots, 77$

$$\begin{bmatrix} invc_1 \\ \vdots \\ invc_4 \end{bmatrix}_{4 \times 1} = [BMTRbr_{km}]_{4 \times 45} * \begin{bmatrix} invs_1 \\ \vdots \\ invs_m \end{bmatrix}_{45 \times 1}$$

Modelled elements  
(total gross investment  
of the sector)

$$invc = BMTRbr * invs;$$

# 1. Introduction



Pic. 1. Investments – economic growth path example

Source: Own modifications on the basis of CSO of Poland, *Input - output table at basic prices in 2010*, p. 24

for  $k = 1, \dots, 4$ ,  $m, l = 1, \dots, 45$ ,  $i, j = 1, \dots, 77$

$$\begin{bmatrix} \uparrow invc_1 \\ \vdots \\ invc_4 \end{bmatrix}_{4 \times 1} = [BMTRbr_{km}]_{4 \times 45} * \begin{bmatrix} invs_1 \\ \vdots \\ \uparrow invs_l \\ \vdots \\ invs_m \end{bmatrix}_{45 \times 1}$$

Sector *l* reports a higher demand for the buildings and the structures

## 2. Investment demand function – variable selection

In the literature there exist diverse approaches to the problem of determining factors that have significant impact on the investments. For example:

- Hicks (1937)

$$I_t = f(\Pi_t, r_t)$$

where:  $\Pi_t$  - profits after taxes,  $r_t$  - real interest rate.

- Clark (1979)

$$I_t = f(\Delta Y_t, \dots, \Delta Y_{t-s}, K_{t-1})$$

where :  $\Delta Y_{t-s}$  - lagged s periods first difference in the production,  $K_{t-1}$  - level of fixed capital from the previous period.

- Hall, Taylor (1995)

$$I_t = f\left(\frac{W_t}{R_t^K}, Y_t, K_{t-1}\right)$$

where :  $W_t$ - wage rate,  $R_t^K$  - rental price of the capital.

- Welfe W. (2012)

$$I_t = f(I_{t-1}, Y_t, KU_{t-1})$$

where :  $KU_{t-1}$  - lagged user cost of the capital (dependent on, inter alia, depreciation rate, interest rate, tax rate or price of investment goods)

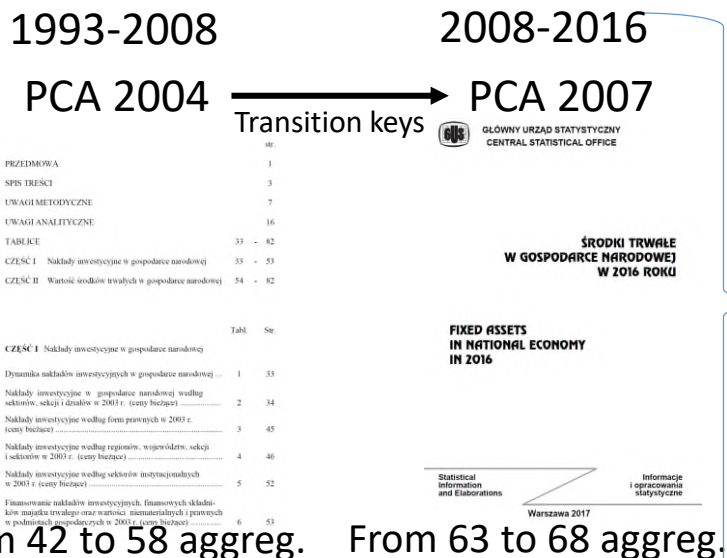
- Almon (2017)

$$I_t = f(rep_t, \Delta Y_{t-1}, \dots, \Delta Y_{t-s}, SP_{t-s}^{500}, \Delta SP_{t-1}^{500}, \dots, \Delta SP_{t-s}^{500})$$

where :  $rep_t$  - capital replacement,  $SP_{t-s}^{500}$  - real value of SP500 index.

Lots of the other examples can be found in: D. Meade (1990), *Investment in a Macroeconometric Interindustry Model*.

# 3. Problems related to the database building

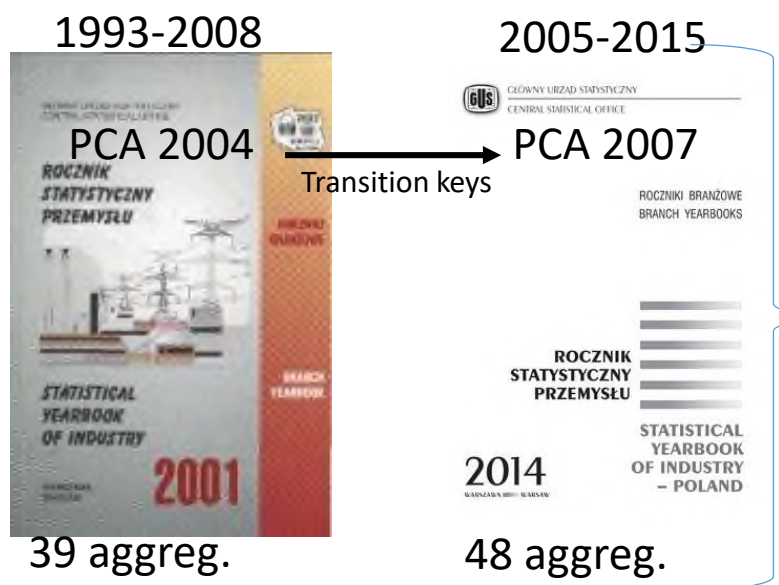


Pic. 2. Data sources

Sectoral investment data

Investment data from National Accounts (yearly macroeconomic indices)

Sectoral output data



Unified database for 44 sectors (+balancing position) in 1993-2016 period

+ as a supplementary document – Statistical Yearbook of Poland

Source: Own elaboration. Graphs taken from CSO of Poland site.

# 4. Statistical analysis of the sectoral investment

According to the publication „*Fixed assets in national economy*” total gross investment (s) contains following categories:

- buildings and structures (b);
- machinery, technical equipment and tools (m);
- transport equipment (t);
- rest of investment (r).

National accounts include additionally:

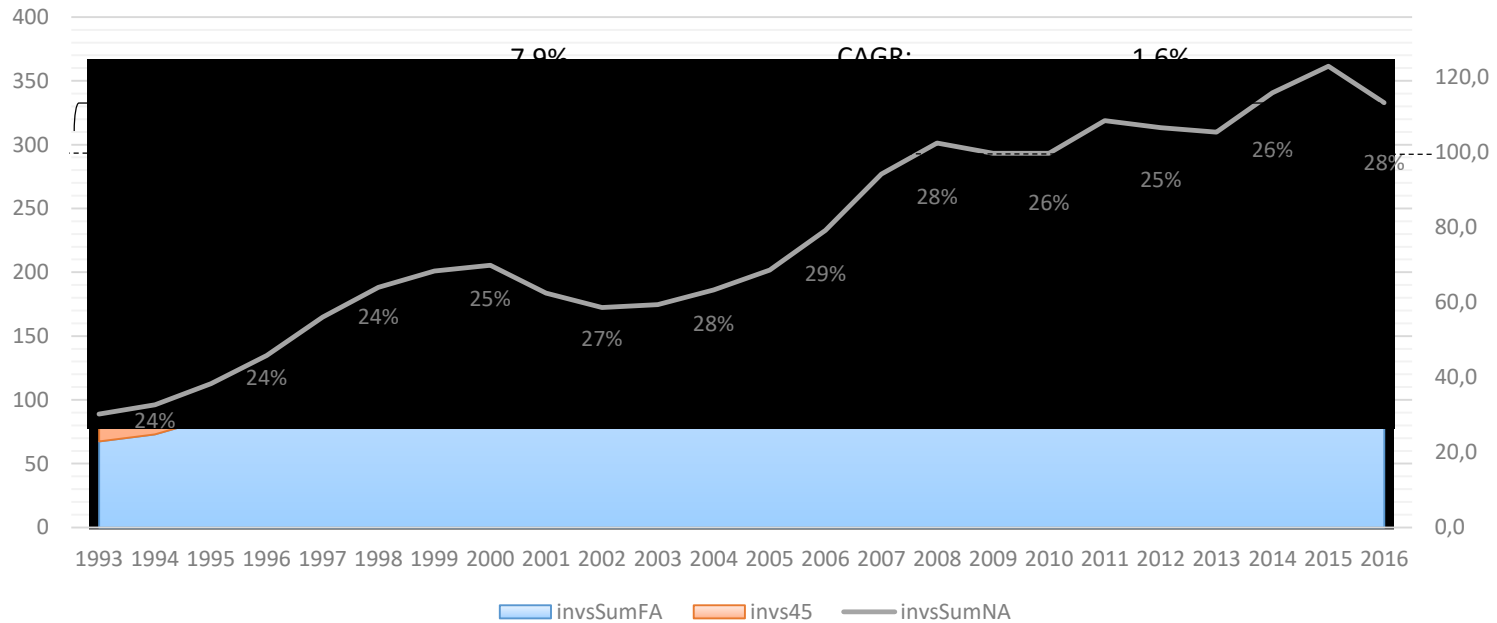
- expenditures on military equipment;
- expenditures on small tools;
- spendings on intellectual property products (like software or R&D spendings).

Differences between data sources give rise to the necessity of creating a balancing position.



# 4. Statistical analysis of the sectoral investment

Pic. 2. The level (left scale, constant prices from 2010, in bln zł) and the dynamics (right scale, 2010=100) of the total gross investment by two data sources in Poland in 1993-2016



Tab. 1. The structure of investment spendings in Poland in chosen periods

Category	% of total gross investment			
	1993	2004	2009	2016
buildings & structures	59	56	60	55
machinery & tech.equip.	28	32	30	34
transport equip.	7	10	9	10
other investments	6	3	1	1

Source: Own elaboration.

# 4. Statistical analysis of the sectoral investment

Tab. 2. Five sectors with the highest share in total gross investment in Polish economy in chosen periods

1993		2004		2009		2016		Change in 2016 in relation to 1993	
Sector	% share	Sector	% share	Sector	% share	Sector	% share	% change	change in p.p.
Real estate services	14.3	Real estate services	14.5	Transportation and storage	17.3	Transportation and storage	17.1	19.4	2.8
Transportation and storage	14.3	Transportation and storage	12.3	Real estate services	13.1	Real estate services	13.2	-8.0	-1.1
Electricity, gas, steam and a/c	11.1	Sale and repair of motor vehicles	9.4	Sale and repair of motor vehicles	9.0	Electricity, gas, steam and a/c	9.5	-14.6	-1.6
Sale and repair of motor vehicles	7.5	Electricity, gas, steam and a/c	6.1	Electricity, gas, steam and a/c	6.2	Sale and repair of motor vehicles	7.4	-1.2	-0.1
Natural water	5.5	Natural water	4.7	Natural water	5.8	Motor vehicles	3.6	569.0	3.0
Other sectors	47.3	Other sectors	53.0	Other sectors	48.6	Other sectors	49.3	x	x

Source: Own elaboration.

Tab. 3. Sectors with the highest share of particular category of the investment in total investments of the sector in 2016.

Category	% of total investment (s) in sector in 2016			
	highest	sector	lowest	sector
buildings & structures	97.1	Real estate services	6.4	Office administrative services
machinery & tech.equip.	89.1	Tobacco products	2.0	Real estate services
transport equip.	70.3	Office administrative services	0.4	Tobacco products
other investments	11.6	Agriculture and hunting	0.0	Repair and inst. of mach. and equip.

Source: Own elaboration.

# 5. Estimation results – sectoral investment models

The process of building the sectoral investment models for Poland was as follows:

1. Estimation of the parameters of the investment model for each of 45 sectors (basic model form). Method - OLS:

$\forall i = 1, 2, \dots, 45 \text{ i } t = 1(1996), \dots, 21(2016)$

$$\mathit{inv}_{it} = a_1 \mathit{caprep}_{it} + a_2 \mathit{dout}_{it} + \dots + a_4 \mathit{dout}_{it-2} + a_5 \mathit{rlomr}_t + a_6 \mathit{rlomr}_{t-1} + e_{it} \quad (1)$$

`r invsR%1 = !caprep, doutR%1, doutR%1[1], doutR%1[2], rlomr, rlomr[1]`

Soft constraints: `con [] 1=a1`

where:

***caprep<sub>it</sub>*** – the capital replacement (see: Almon 2017. *The craft...*), computed on the basis of the fixed capital stock estimation. Capital stock here is the sum of the investment spendings from a previous periods (minus an appropriate amount of depreciation),

`fdates 1990 2050`

`f ub20 = @cum(ub20,1.,.20)`

`f caprep = @cum(invcum, invs%1[1], .20)/ub20`

***dout<sub>it</sub>*** – first difference in the real output in *ith* sector in the moment *t*,

***rlomr<sub>t</sub>*** – real weighted lombard rate.

# 5. Estimation results – sectoral investment models

The process of building the sectoral investment models for Poland was as follows:

2. Estimation of the parameters of the investment model with external production effects of the entire economy:

$$inv_{it} = a_1 caprep_{it} + a_2 dout_t + \dots + a_4 dout_{t-2} + a_5 rlomr_t + a_5 rlomr_{t-1} + e_{it} \quad (1)$$

Soft constraints: `con [] 1=a1`

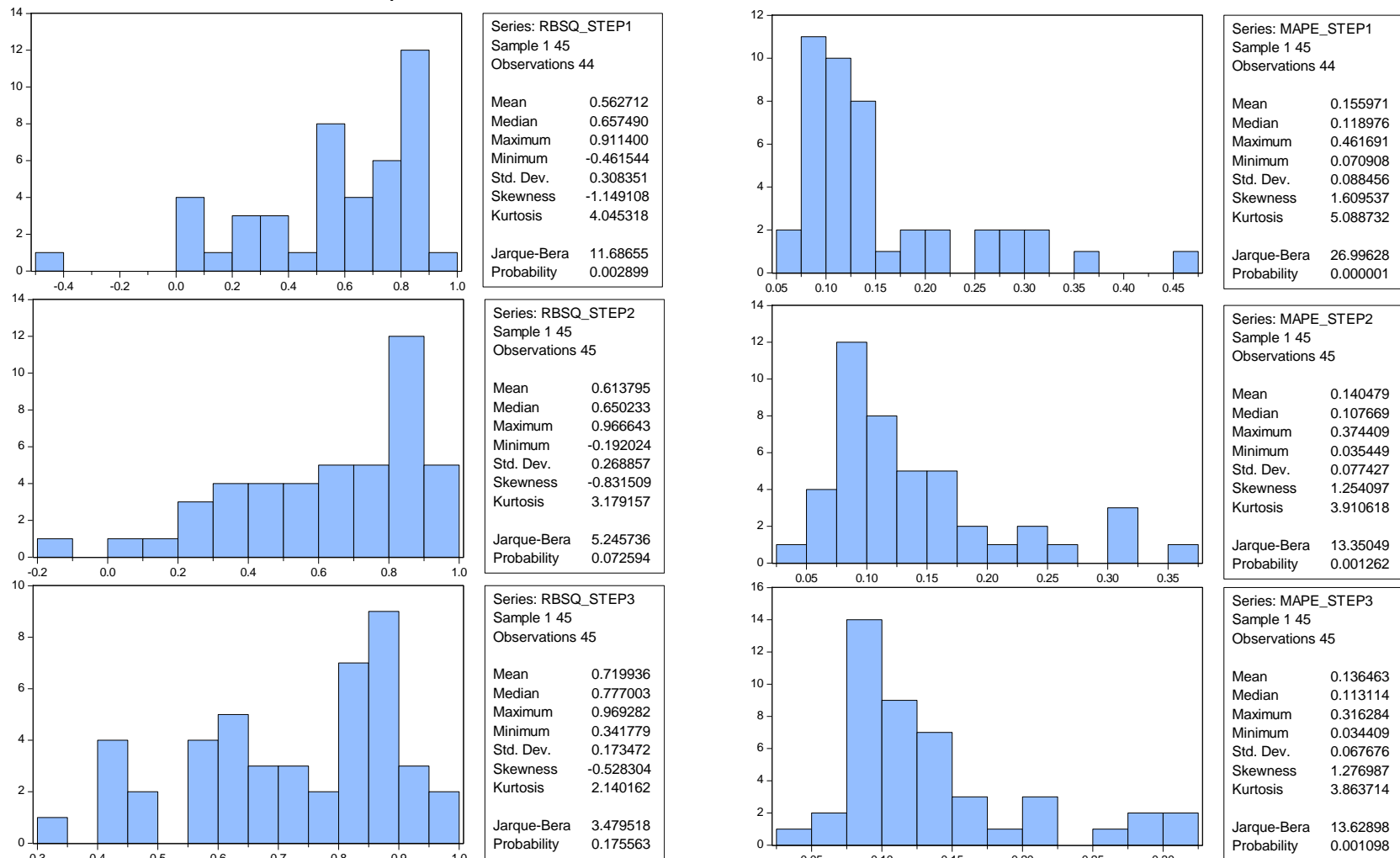
$dout_t$  – first difference in the real output of the economy in the moment  $t$ .

3. In the last step individual approach to each of the sector was used. The modifications consisted in:
  - the elimination of the variables, which were characterized by statistically insignificant structural parameter,
  - the elimination of the variables with the parameter's sign that was inconsistent with theory,
  - including PMI index instead of real weighted lombard rate in some equations.

# 5. Estimation results – sectoral investment models

General conclusions from the estimation:

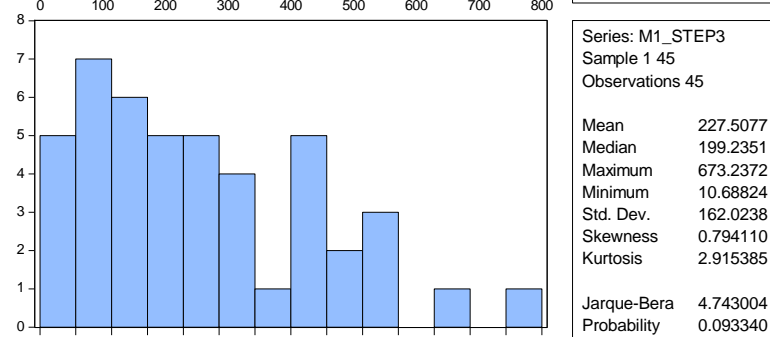
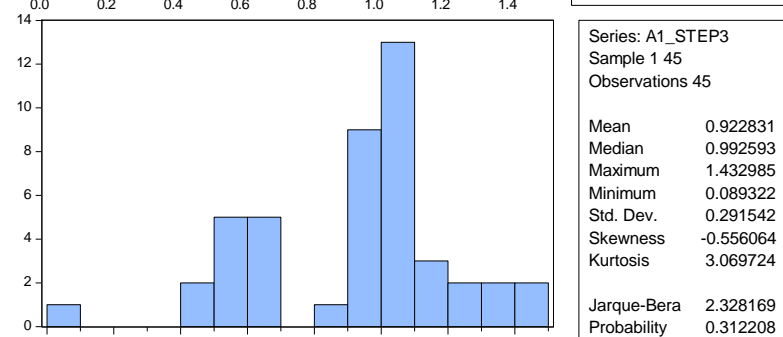
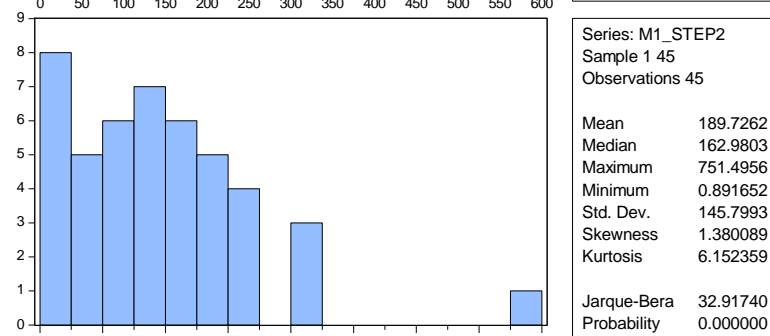
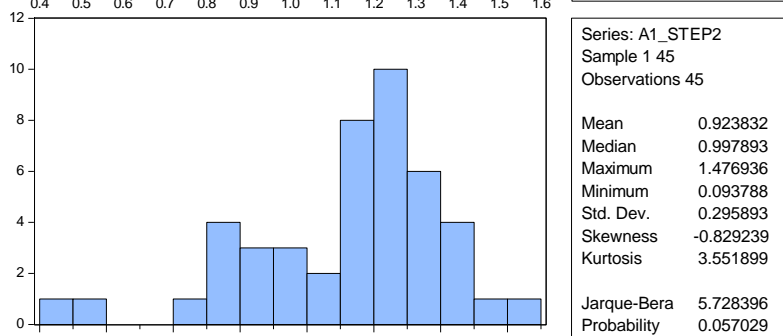
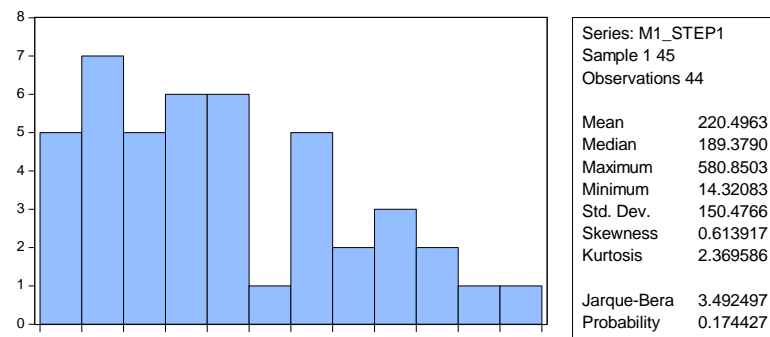
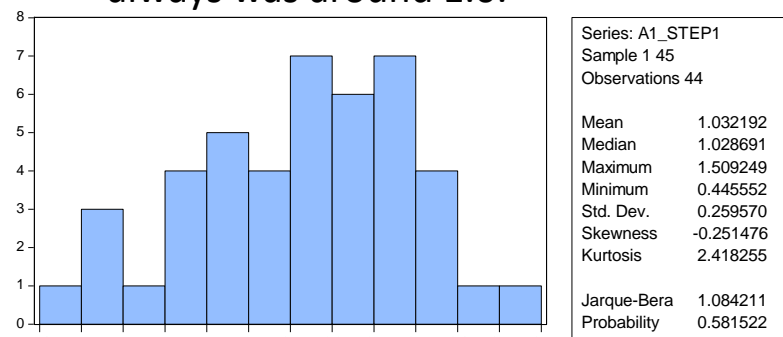
1. In 30 sectors the inclusion of the external production effects of the entire economy gives better stochastic structure parameters of the model.



Source: Own elaboration based on Eviews software.

# 5. Estimation results – sectoral investment models

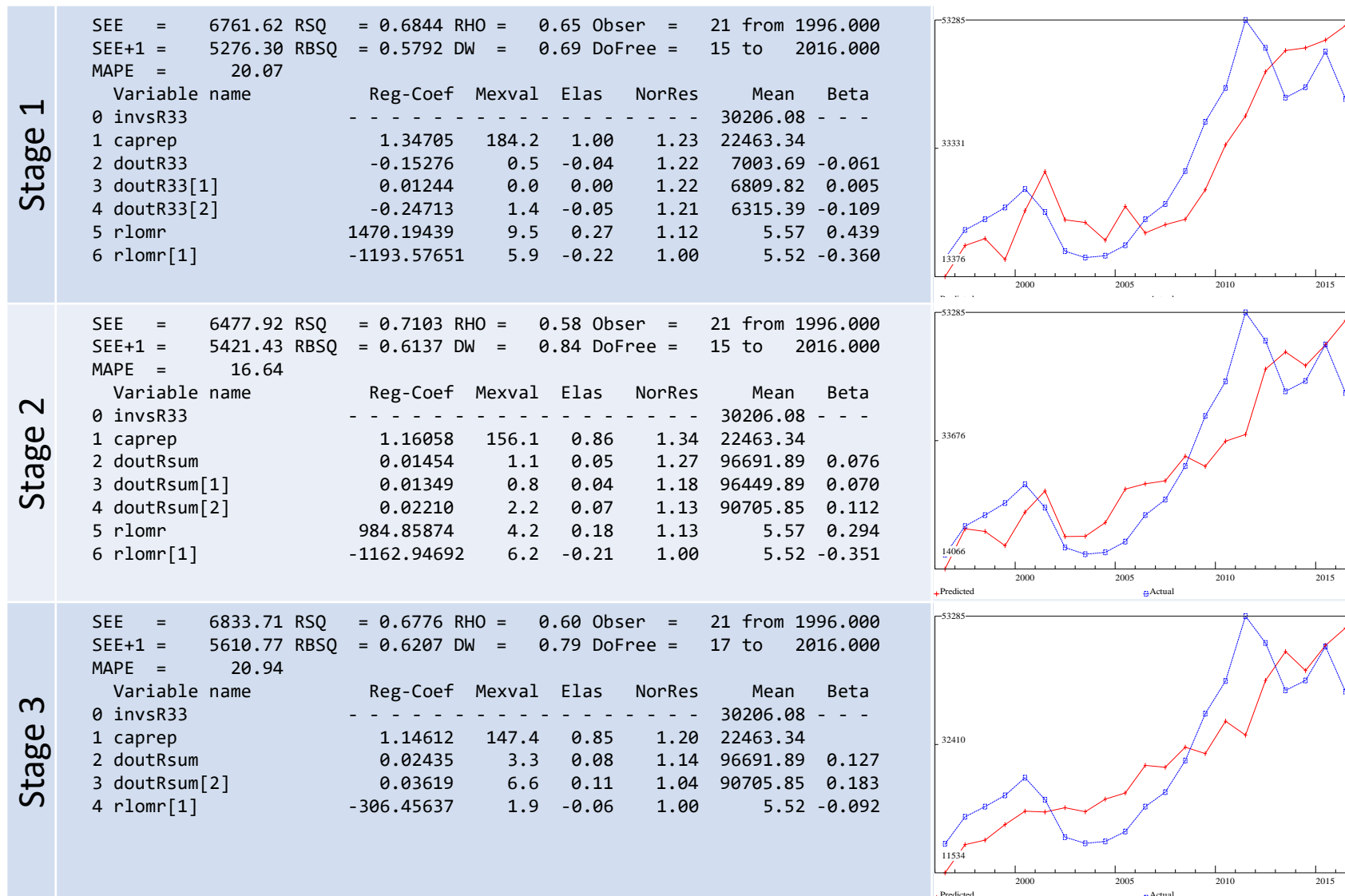
2. Structural parameter of the lombard rate and its lags often took a positive value.
3. Structural parameter next to replacement was always statistically significant, but not always was around 1.0.



Source: Own elaboration based on Eviews software.

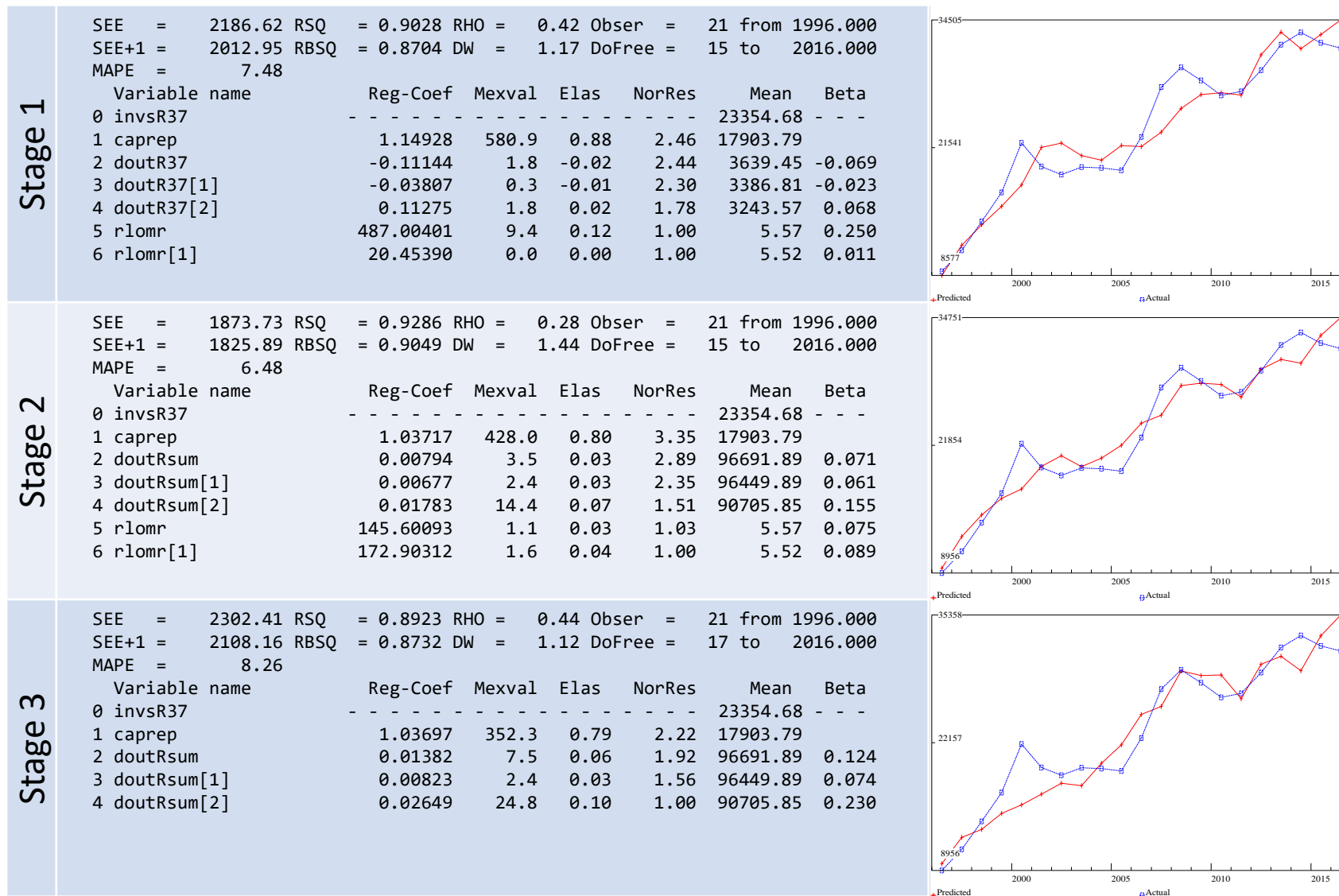
# 5. Estimation results – sectoral investment models

## 33. Transportation and storage



# 5. Estimation results – sectoral investment models

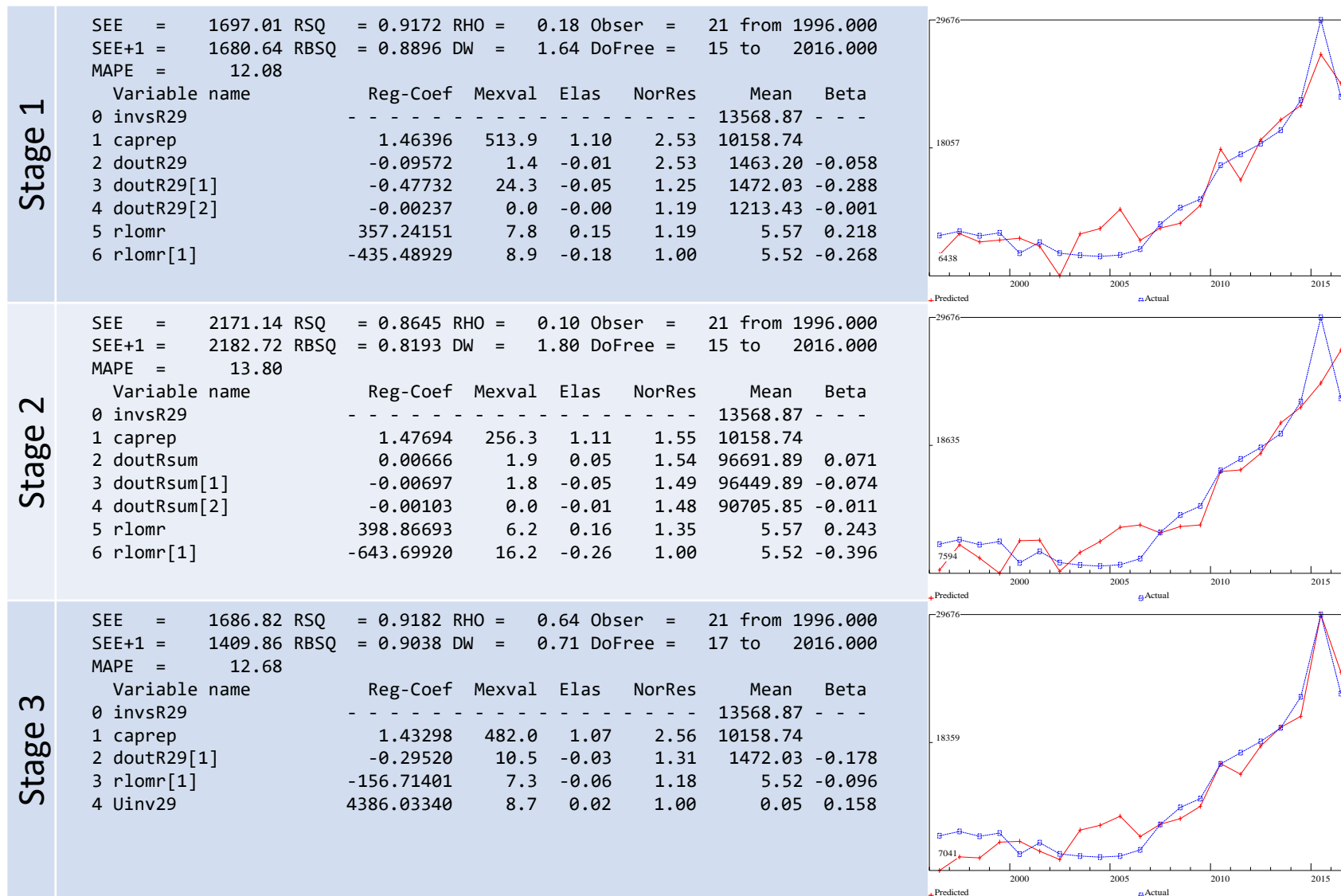
## 37. Real estate services





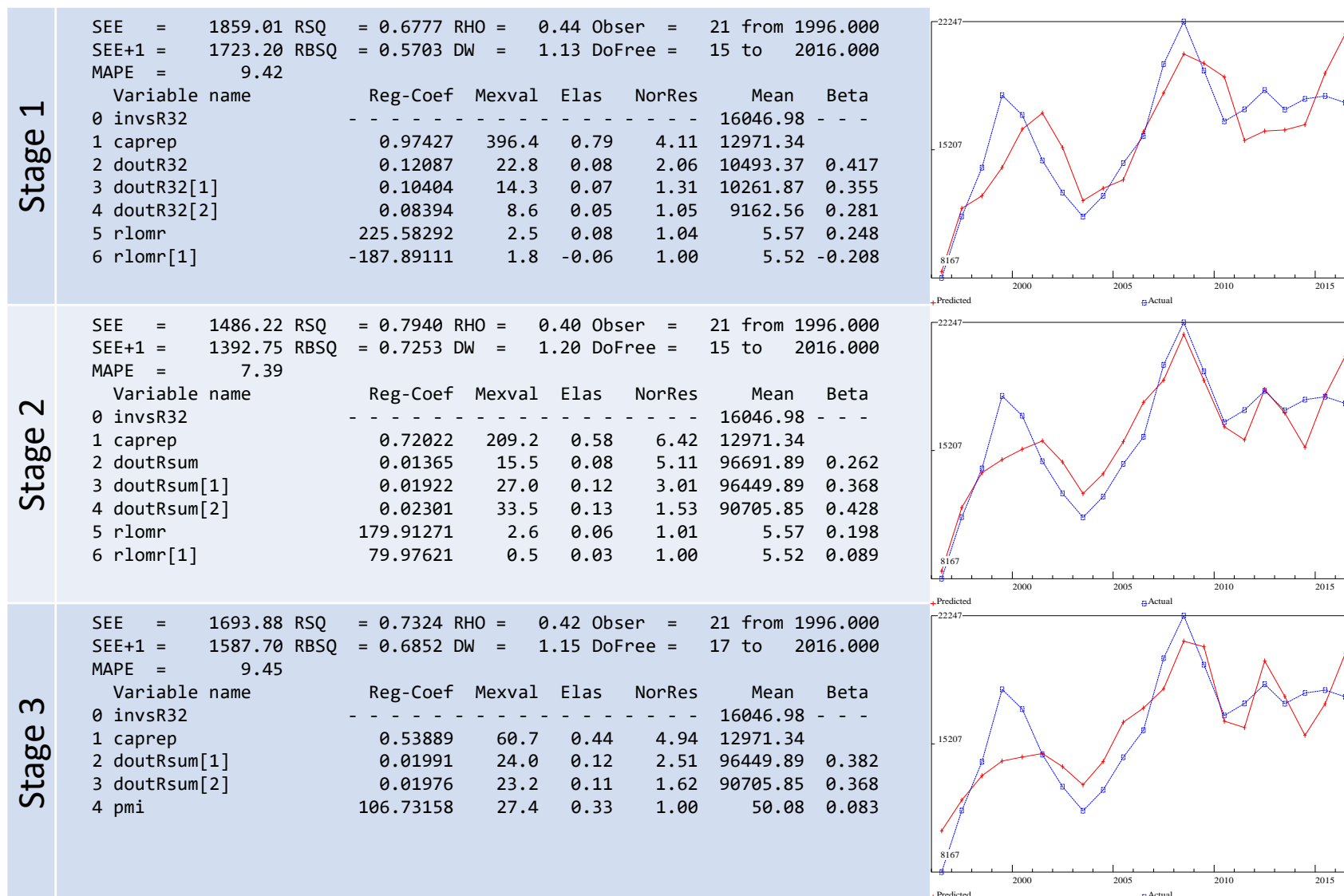
# 5. Estimation results – sectoral investment models

## 29. Electricity, gas, steam and a/c



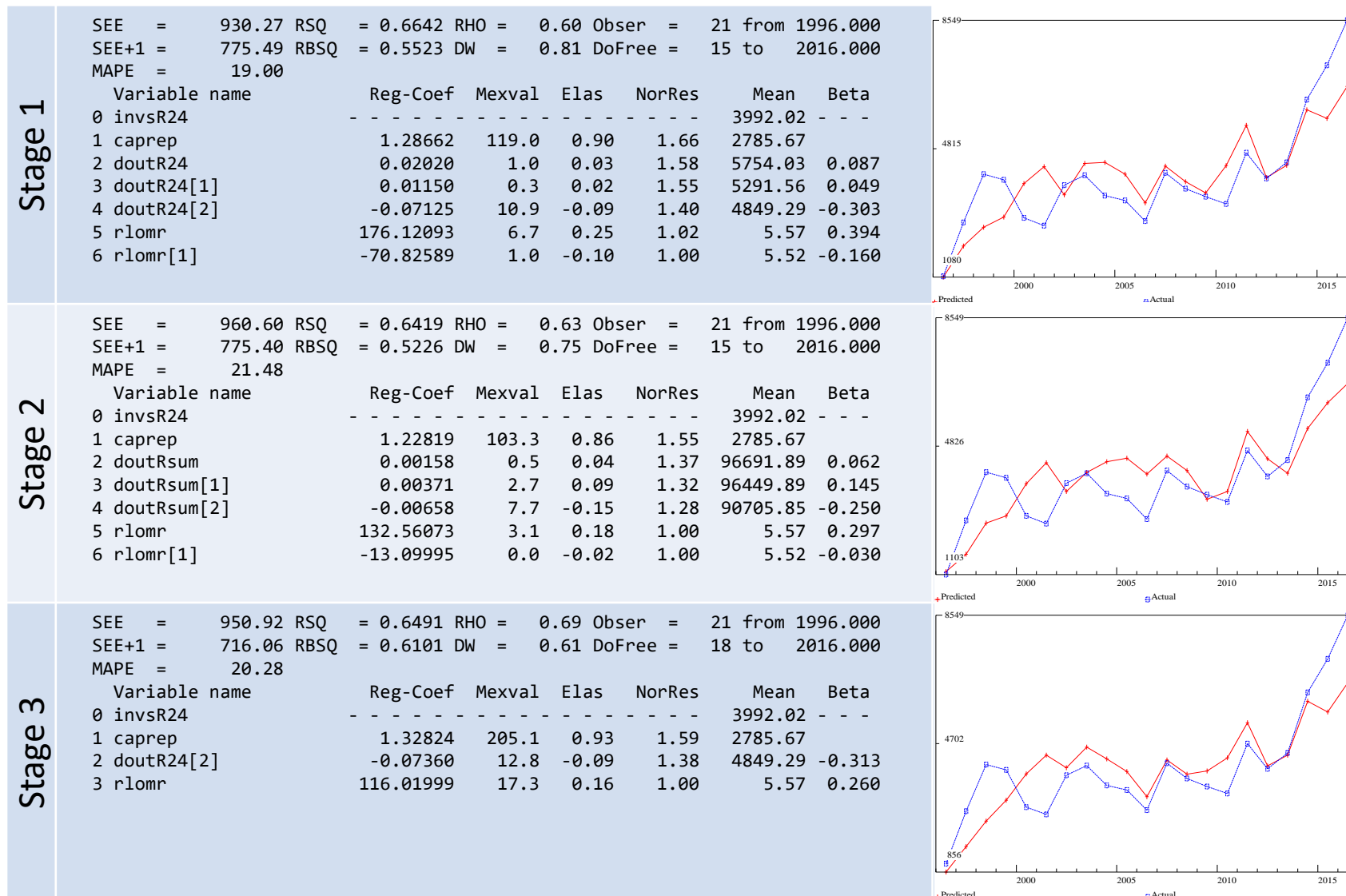
# 5. Estimation results – sectoral investment models

## 32. Sale and repair of motor vehicles



# 5. Estimation results – sectoral investment models

## 24. Motor vehicles



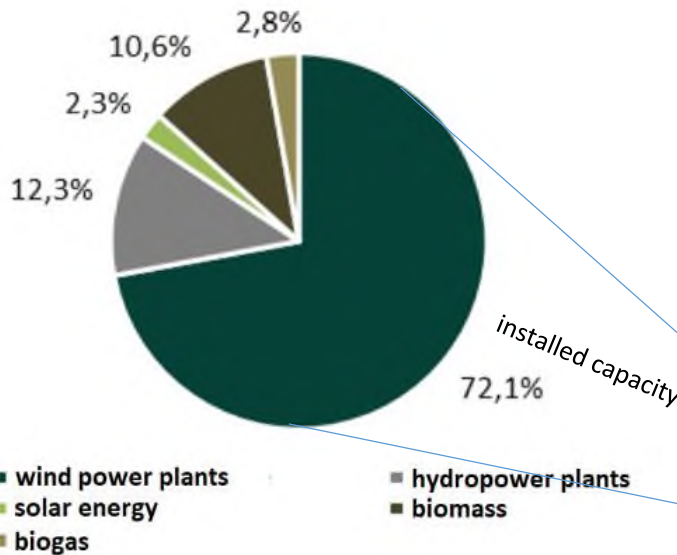
# 6. Investments in the energy sector – facts, ideas, threats

Why am I interested in the topic...?

## Facts:

- Polish energy sector has been historically based on the fossil fuels;
- the majority of existing power plants and installations are old;
- the energy sector requires significant investments...

Tab. 4. The structure of installed capacity and electricity generation in Polish electric power system as at 31 December 2017



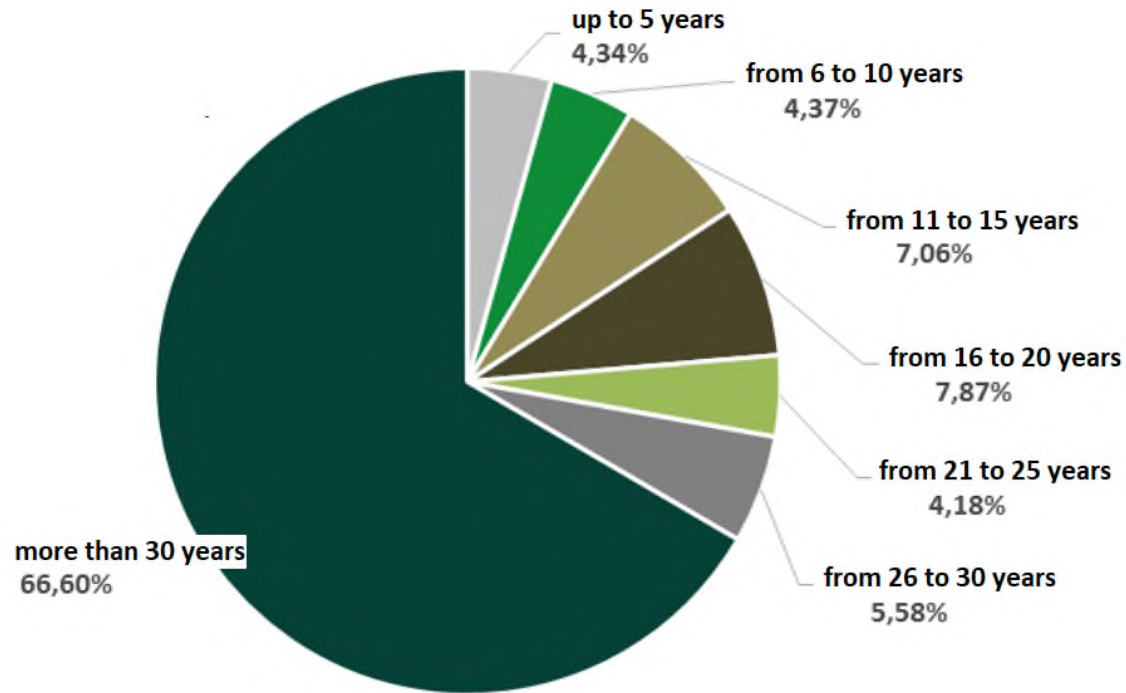
Power plant type:	Installed capacity [in MW]	%share	Electricity generation [in GWh]	%share
hard coal	20 247	46.6	79 868	48.2
lignite	9 352	21.5	51 983	31.3
natural gas	2 341	5.4	7 172	4.3
captive	2 813	6.5	10 057	6.1
hydropower	2 328	5.4	2 767	1.7
wind and other renewables	6 341	14.6	14 005	8.4
<b>TOTAL</b>	<b>43 422</b>	<b>100.0</b>	<b>165 852</b>	<b>100.0</b>

Source: PSE S.A. (Polish Electricity Networks Inc.) Databases.

# 6. Investments in the energy sector – facts, ideas, threats

## Facts:

Pic. 3. Age structure of the power plant blocks [with respect to their installed capacity] at the end of 2015



Tab. 5. Scenarios for disabling the obsolete power plant blocks [power loss in MW]

	2020	2025	2030	2035
„Modernization” scenario	3000	3200	5700	13900
“Turn off” scenario	6600	9900	17300	20300

Source: PSE S.A. (Polish Electricity Networks Inc.) Databases.

# 6. Investments in the energy sector – facts, ideas, threats

## Ideas:

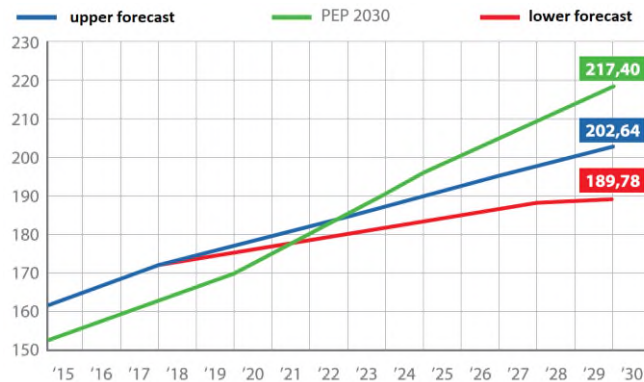
- In the public debate, there exists a lot of ideas how the future of Polish energy sector should develop, but...
- ... policy makers still are not determined to choose the main path of development.

Tab. 6. The example of the paths of the energy system development from domestic documents

Public		Private (think tank)
Polish Energy Policy (PEP) 2050 (2014)	National Programme for the Development of a Low-emission Economy (2015)	<i>Polish Energy sector 2050. 4 scenarios</i>
<ul style="list-style-type: none"> <li>• Balanced scenario</li> <li>• Nuclear scenario</li> <li>• „Natural Gas+RES” scenario</li> </ul>	<ul style="list-style-type: none"> <li>• Central scenario</li> <li>• High scenario</li> <li>• Low scenario</li> </ul>	<ul style="list-style-type: none"> <li>• Hard coal scenario</li> <li>• Diversified scenario (with the nuclear power)</li> <li>• Diversified scenario (without the nuclear power)</li> <li>• Renewable scenario</li> </ul>

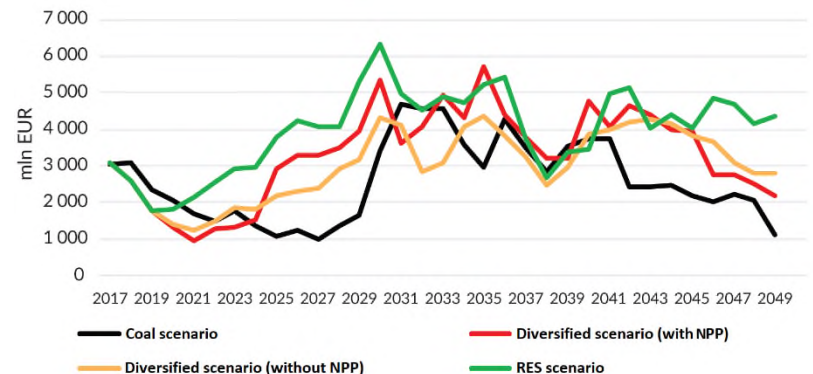
Source: Own research.

Pic. 4. Electricity annual demand forecast up to 2030 [in TWh]



Source: The Friendly State Foundation (2018), *Polish power engineering*, p. 10.

Pic. 5. Annual investment expenditures according to 4 scenarios



Source: P. Mikusek ed. (2017), *Polish Energy sector 2050. 4 scenarios*, Energy Forum, p. 7.

# 6. Investments in the energy sector – facts, ideas, threats

## Threats:

<b>Hard coal</b>	<b>Nuclear power</b>
<ul style="list-style-type: none"><li>• delays in the diversification of Polish energy system;</li><li>• low elasticity of installed capacity;</li><li>• strong dependence on world CO<sub>2</sub> emission allowance prices,</li><li>• the necessity of import of a high amount of coal in the future.</li></ul>	<ul style="list-style-type: none"><li>• the increase in electricity prices;</li><li>• delays in construction schedule due to high investment cost</li><li>• problems with balancing the installed power (in case of a breakdown)</li></ul>
<b>Shale gas</b>	<b>RES</b>
<ul style="list-style-type: none"><li>• possibility of overestimating an amount of the resources;</li><li>• high degree of the devastation of the natural environment;</li><li>• the increase of the mining costs over the time.</li></ul>	<ul style="list-style-type: none"><li>• problems connected with energy storing and system stability.</li><li>• strong dependence on future weather conditions.</li></ul>

# 7. Summary and directions of further research

## SUMMARY

- I. Modelling investment on the high disaggregation level is associated with limited selection of the determinants (data availability).
- II. Estimation results indicate that in many sectors better results are achieved by including the macroeconomic business cycle.
- III. Individual approach is time-intensive but allows the researcher to deal with the specificity of the sector's performance and helps with obtaining better quality of the structural and stochastic parameters of the model.
- IV. Polish energy sector needs one clear scenario of development, where investments made will contribute to shift the economy to the low-emission growth path.

## DIRECTIONS OF FURTHER RESEARCH:

- I. Determining the shape of the energy block, which will be a part of MMM.
- II. Giving the multisectoral energy model a purpose – conducting simulations of future energy carriers usage and its emissions levels on the basis of various scenarios of the development of Polish energy sector.



# Chosen literature

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