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THE EUROPEAN NATURAL GAS SUPPLY, UNDER PARTICULAR CONSIDERATION OF GAS TRANSIT

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Arguments for the SoS Research

as results from the **European gas market environment**:

• A strong correlation between economic growth and energy consumption (EU-15: $r = 0.95$, $p = <0.0001$);

• Ever-increasing peak demand loads for natural gas in the residential sector;

• Permanently declining gas reserves and gas production all over Europe, while import dependency increases;

• Most of the cross-country pipelines (supplying the increased imports) pass through various states with different objectives;

• Country-actors of the supply chain are inclined to conflict.

Research Objective and Research Questions

The research **objective** pursued in the study is:

To describe and evaluate Europe's gas supply security (SoS), as well as to specify prospective ways for the SoS enhancement, with a focus on European infrastructure projects, in accordance with individual countries' needs and priorities.

The research **questions**, qualified to meet the research objective, are:

(1) How secure are the European countries in terms of their natural gas supplies?

(2) How can the gas-SoS in Europe be improved (with emphasis on infrastructure)?

Structure of the Study

The Ph.D. thesis is organised into *three conceptual parts*:

Chapter 2 provides an overview of the gas chain fundamentals, the European gas sector, and the nature of conflicts among country-actors of gas transportation. It prepares the background for the detailed SoS discussion.

Chapter 3 addresses the **1st** research question. While developing the conceptual framework for SoS and providing the track record of SoS incidents, it constructs **gas security metrics** and evaluates the current SoS situation over Europe.

Chapter 4 addresses the **2nd** research question. Via reporting on a real emergency situation and on the infrastructure-related sustainable development patterns of the (predominantly CSEE) gas supply, it applies the developed SoS-indices.

A Quantification Approach Applied (1)

"*Energy security is too important a concept to be incoherently defined and poorly measured*" (Sovacool & Brown [2010]).
"*An issue that cannot be measured will be difficult to improve*" (Löschel et al. [2010]).

Our **aim** is developing a meaningful synthetic **index** that could help to benchmark and monitor European countries with regard to their SoS state.

The current **status of research**:

• There is **no unique methodology** to access SoS (cf. Cabalu [2010]) – due to a rather elusive nature and high context dependency of the concept:

→ The selection of parameters is left to the taste of the researcher;

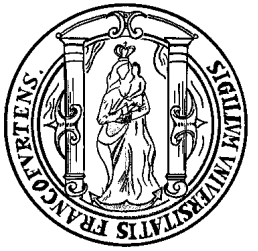
→ "Indefinitely" many ways exist for the weighting of the selected parameters.

We introduce a set of ten **parameters** comprehensively catching the SoS

(• physical supply diversification;
• capacity diversification;
• share of gas imports in the TPEC;
• energy intensity;
• reserves situation (home and supplying regions);
• the ease of switching between suppliers;
• offshore risks;
• geopolitical risks;
• fuel-switching possibilities;
• storage relatively to households demand)

and focusing on its accessibility and availability *dimensions*.

A Quantification Approach Applied (2)



We test different statistical **approaches** of alternative *weighting* and *aggregation* [and of parameters *integration*] to calculate the composite SoS-indicator **HHI'14**:

- The Implicit Weights approach (Neumann [2004], Jansen et al. [2004], Le Coq & Paltseva [2009]) → by using the multiplicative combination of unnormalized SoS aspects, introduced on a step-by-step basis;
- The Equal Weights approach (Gnansounou [2008], Cabalu [2010], Reymond [2012]) → by unifying the scales on which the SoS parameters are measured and aggregating them as the *root mean square (RMS)*;
- Gupta's [2008] approach → by adjusting the weights of correlated relative variables using the *principal components analysis (PCA)* and aggregating them after Gupta [2008].

Data **comparisons** in respect of:

- The **"N-1"** approach ($\mathrm{N}-1_{\mathrm{B}} = \frac{P_m + S_m + LNG_m + IP_m - I_m}{D_{\max} - D_{eff}} \times 100$) proposed by the EU Commission (cf. OJL [2010]);
- Selected SoS metrics proposed by other researchers.

Empiric Value of the Study

The real **challenge** for SoS-indices seems to be their predictive ability – which has never been tested before.

"*Composite indicators often measure concepts that are linked to well-known and measurable phenomena […]. These links can be used to test the explanatory power of a composite. […] Attempts should be made to correlate the composite indicator […]" with such measurable phenomena* (Nardo et al. [2008]).

⇒ *The **focus** of this study's attention is, thus, on exploring the **applicability/usefulness** of the indices*.

Academic novelty: We check (for policy decisions) the predictive success of SoS indices by conducting three **tests**:

Test #1: Clarifying whether the indices reflect the economic losses in the Jan. 2009 disruption in gas supply;

Test #2: Testing whether a relationship exists to the EEPR funding;

Test #3: Demonstrating how the energy situation (and, hence, SoS-indices) improves being driven by the EU-initiated infrastructure projects.

Target goal: Gaining insights into the indices adequacy as a policy tool for present and future energy security developments.

Findings - 1(a): „How secure are the European countries in terms of their gas supplies?“

(a) Results of the SoS calculation:

Figure: HHI'14$_2$ versus N-1$_B$

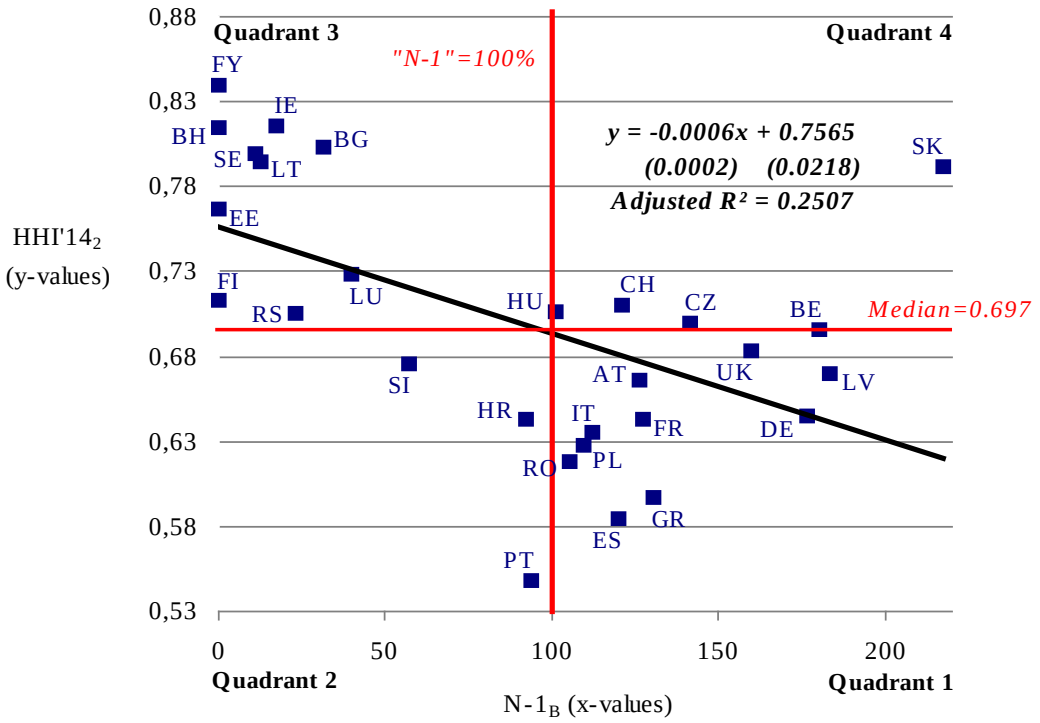


Table: Correlation between SoS-indices and N-1$_B$

SoS-index	Correlation	*p*-value
HHI'14$_1$	-0.5207	0.0045
HHI'14$_2$	-0.6910	<0.0001
HHI'14$_3$	-0.6540	0.0002
HHI'14$_4$	-0.4368	0.0201
HHI'14$_5$	-0.7132	<0.0001
Neumann [2004]	0.2468	0.6373
Scheepers et al. [2007]	0.0788	0.7207
Röller et al. [2007]	0.0312	0.8931
Gnansounou [2008]	-0.0726	0.7302
Le Coq & Paltseva [2009]	-0.1405	0.5330
Ramboll [2010]	**0.8066**	<0.0001
Sovacool & Brown [2010]	-0.3331	0.2662
N-1$_B$ *(%)*	1	

***Proposition*:** It is sensible to evaluate SoS by **two** families of indices:

- **HHI'14s** describe the **average** ability of a country to cope with supply disruptions (i.e., with big and small ones and of any kind);
- **"N-1"s** address the largest single risk in the system and describe a "**worst case** scenario".

Findings - 1(b): „How secure are ...“

(b) Testing the explanatory power of the SoS-indices:

TEST #1: Confronting of SoS-indices with the Supply Disruption Costs → *Data*

	Jan.2009 gas import cut *(%)*	**“Specific Jan.2009 disruption losses”** (relatively to GDP)	**Industrial production index** (*% change*, Jan.2009 to Jan.2008)
Bulgaria	100	0.017	-22.6
Bosnia	100		-11.1
Macedonia	100		-19.3
Serbia	100	0.005	-25.5
Slovakia	97	0.040	-31.6
Greece	80		-14.8
Czech Rep.	71	0	-23.8
Austria	66	0	-11.7
Slovenia	50	0	-16.9
Hungary	45	0.002	-23.5
Croatia	40	0.012	-13.9
Romania	34		-18.5
Poland	33		-13.9
Italy	25		-20.4
France	15		-19.0
Germany	10		-20.1

TEST #2: Confronting of SoS-indices with the EEPR Funding → *Data*

	“Specific country funding within the EEPR” (relatively to GDP)		**“Specific country funding within the EEPR”** (relatively to GDP)
Austria	0.09	Bulgaria	7.28
Belgium	0.50	Czech Rep.	0.75
Finland	0	Estonia	0
France	0.27	Hungary	2.63
Germany	0	Latvia	0.97
Greece	0.61	Lithuania	0.19
Ireland	0	Poland	0.87
Italy	0.17	Romania	1.84
Luxembourg	0	Slovakia	0.28
Portugal	0.12	Slovenia	1.91
Spain	0.08		
Sweden	0		
UK	0		

Findings - 1(b): „How secure are ...“

TEST #1: SoS-indices Vs. the Supply Disruption Costs → *Results*

SoS-index	"Specific" losses		Industrial production index	
	Correlat.	*p*-value	Correlat.	*p*-value
$HHI'14_1$	0.3143	0.4483	-0.0296	0.9132
$HHI'14_2$	0.7729	**0.0245**	-0.3586	0.1726
$HHI'14_3$	0.7004	**0.0530**	-0.2589	0.3330
$HHI'14_4$	0.3406	0.4090	-0.0082	0.9760
$HHI'14_5$	0.7216	**0.0433**	-0.4052	0.1195
$N\text{-}1_B$ *(%)*	-0.5359	0.1710	0.1663	0.5382
Neumann [2004]	–	–	0.0740	0.9529
Scheepers et al. [2007]	0.4339	0.3900	-0.0170	0.9581
Röller et al. [2007]	0.5842	0.3010	-0.5295	0.1155
Gnansounou [2008]	-0.2549	0.5812	0.1348	0.6606
Le Coq & Paltseva [2009]	0.6662	0.1485	-0.6752	**0.0160**
Ramboll [2010]	0.3012	0.5618	-0.0211	0.9482
Sovacool & Brown [2010]	–	–	-0.6979	0.1901

⇒ *We weakly supported the **hypothesis** that European nations with "good" SoS scores have suffered smaller **losses** in the Jan. 2009 gas crisis than those with "bad" scores. (This result is based, however, on a small sample of countries for which economic losses have been estimated.)*

⇒ *Figures of reduced **industrial production** as the consequence of the 2009 gas crisis did not show significant relation to any of the HHI'14s.*

⇒ *Also in terms of **"N-1"**, no significant relation could be found.*

Findings - 1(b): „How secure are ...“

TEST #2: SoS-indices vs. the EEPR Funding → *Results*

SoS-index	Correlation	*p*-value
HHI'14$_1$	-0.0767	0.7278
HHI'14$_2$	0.2008	0.3583
HHI'14$_3$	0.3708	**0.0815**
HHI'14$_4$	-0.1263	0.5657
HHI'14$_5$	0.1983	0.3643
N-1$_B$ *(%)*	-0.1117	0.6120
Neumann [2004]	0.2437	0.6417
Scheepers et al. [2007]	-0.0467	0.8325
Röller et al. [2007]	0.0574	0.8046
Gnansounou [2008]	0.1866	0.3940
Le Coq & Paltseva [2009]	0.3128	0.1563
Ramboll [2010]	-0.1050	0.6335
Sovacool & Brown [2010]	0.1534	0.6341

⇒ *The **conjecture** that the EU nations with "worse" SoS scores might have enjoyed stronger EEPR **subsidies** could not be supported for the SoS-indices.*

(Since a correlation of some of the indices with the amount of losses in a gas crisis has been discovered, this puts in doubt the efficient distribution of EEPR funds.)

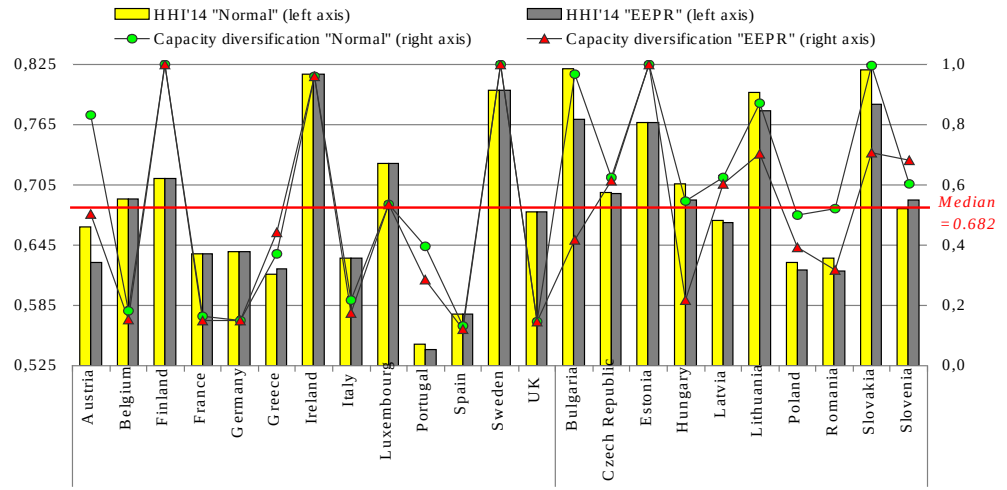
Other essential **findings** of the study:

- Small European nations suffer from lower SoS than large ones;
- Central/South-East Europe (**CSEE**) suffers from lower SoS than the EU-15.

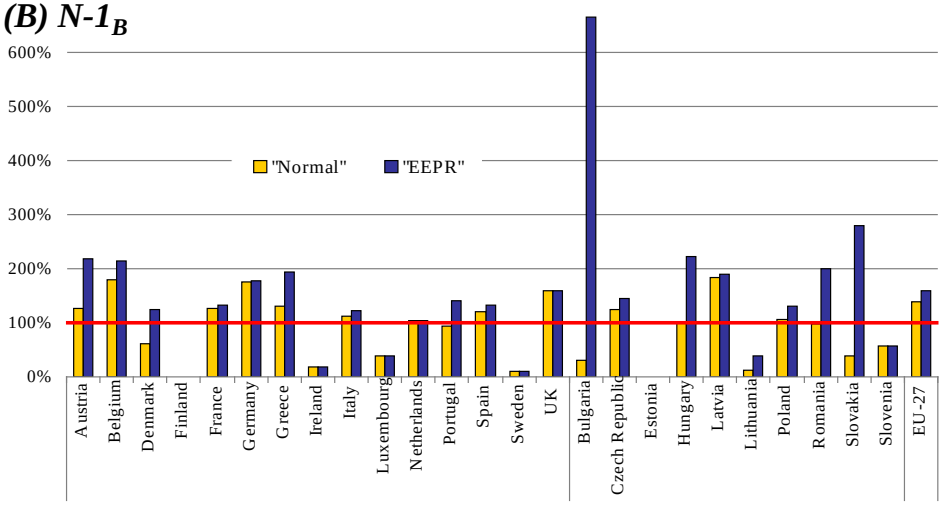
Findings - 2: „How can the gas-SoS be improved?“

Figure: The SoS “Normal” Vs. “EEPR” Calculation

(A) HHI'14$_2$



(B) N-1$_B$



(1) Due to SoS-enhancing infrastructure projects. The measurable impact of the EEPR on EU’s security (TEST #3) can thus be calculated:

⇒ *Investment in infrastructure, made after the gas cut of Jan. 2009, resulted that a number of EU member states have improved their SoS scores (HHI’14 and “N-1”).*

(2) Due to a progressive unification of gas networks in Europe:

⇒ *NETS (“New Europe Transmission System”);*

⇒ *ETSO (European Transmission System Operator).*

Discussion

• The proposed indices **HHI'14** integrate key characteristics of gas-consuming and -supplying countries. They, thus, promise to grasp a country's SoS situation the best. This may be an important step for improving the understanding of the *multifaceted* concept of SoS.

• Based on our **findings**, the study has concluded that the SoS-indices *somewhat* favoured the ability to explain measurable SoS-relevant phenomena (like supply problems or economic losses). This was, however, insufficient to firmly recommend their **adoption by policymaking**.

• **Further work** is definitely worthwhile. One needs to produce more evidence of the ***applicability/usefulness*** of the SoS-indices.

• SoS-indices clearly are rather important for a quick and coherent overview over the state of SoS for a large and diversified region like Europe.

They cannot completely substitute, however, a detailed discussion of the SoS situation in each member state.

Thank you for your attention!