

Fourth Generation District Heating:

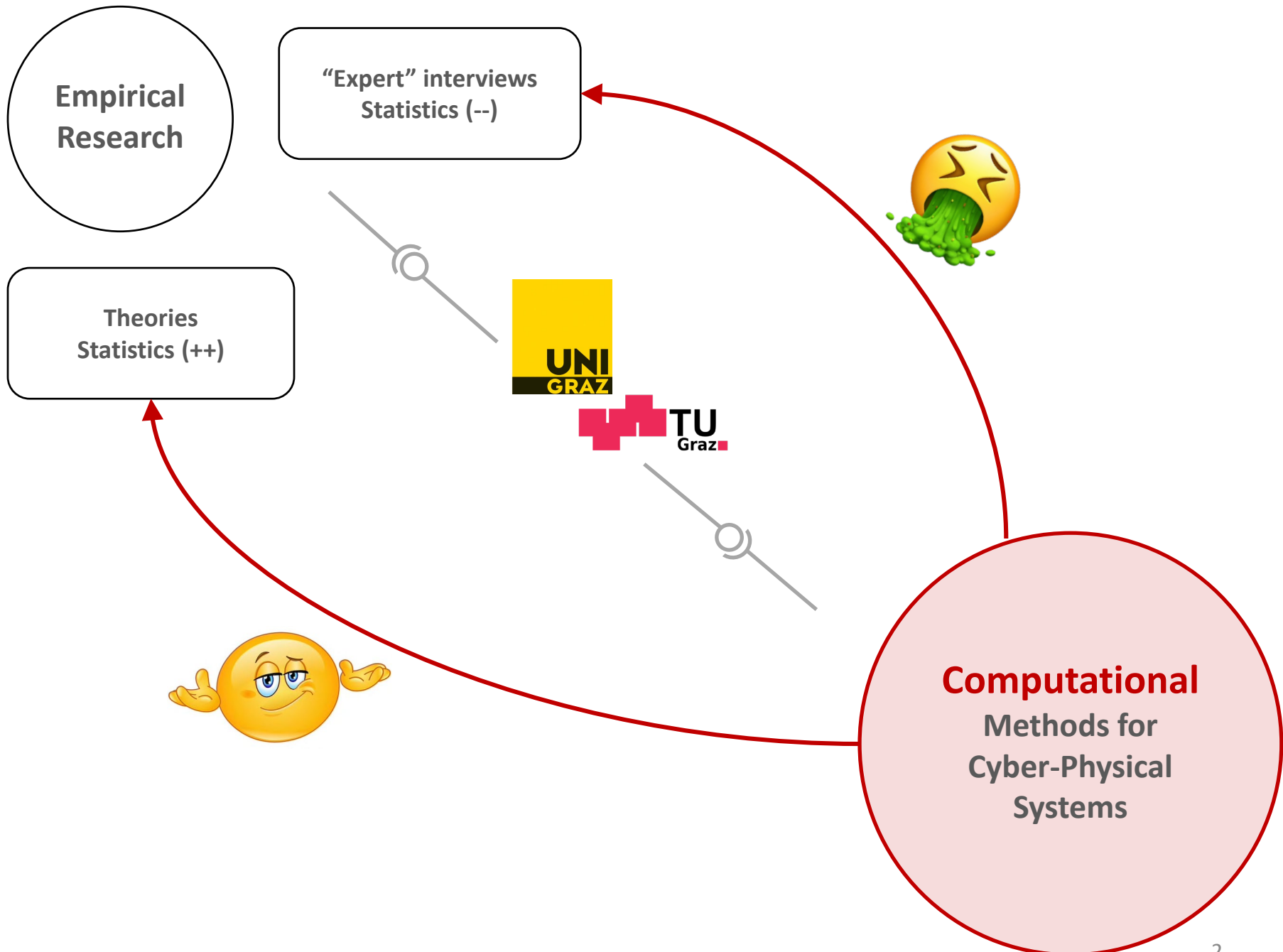
An empirical survey identifies current challenges
and barriers

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Goal

Asking experts to identify current challenges and barriers in the fourth generation district heating

Method

Integrated SWOT/AHP analysis based on a two-step expert survey

First Round



Second Round

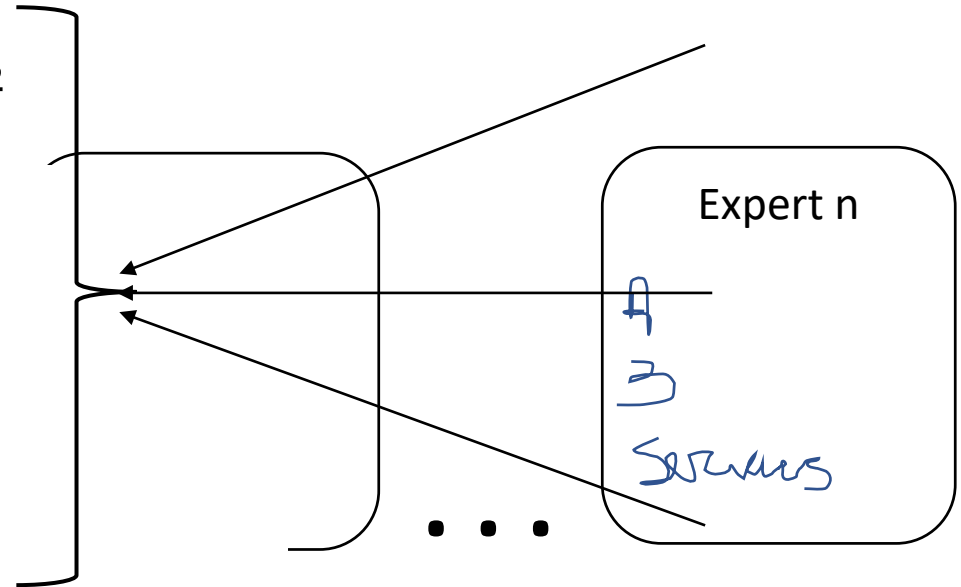


First round



Using Qualitative Content Analysis

- Identifying key-topics
- ↳ • Identifying contradictions
- ↳ • Identifying ...x ...y....



First round



How to ask the right questions in the first round?

- Authors published in the field of 4GDH
 - Schweiger et al. 2017. District heating and cooling systems–Framework for Modelica-based simulation and dynamic optimization. Energy
 - Nageler et al. 2018. Novel method to simulate large-scale thermal city models. Energy
 - Schweiger et al. 2017. The potential of power-to-heat in Swedish district heating systems. Energy.
- Comprehensive literature study

What kind of questions?

- In the first round, the majority of questions asked were qualitative

Second round

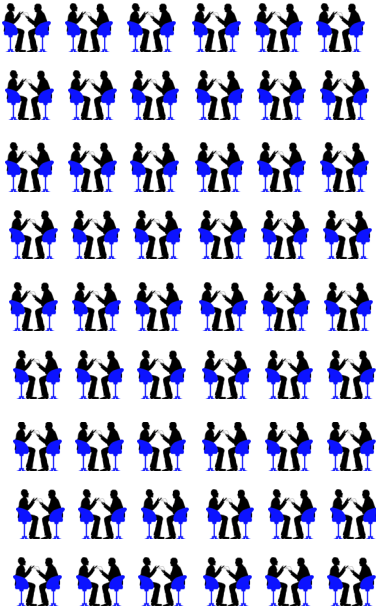
How to ask the right questions in the second round?

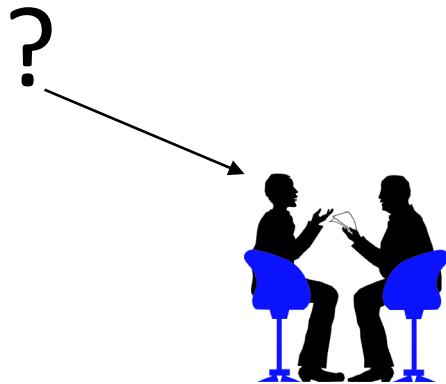
- Analyze the first round!



What kind of questions?

- In the second round, the majority of questions asked were quantitative



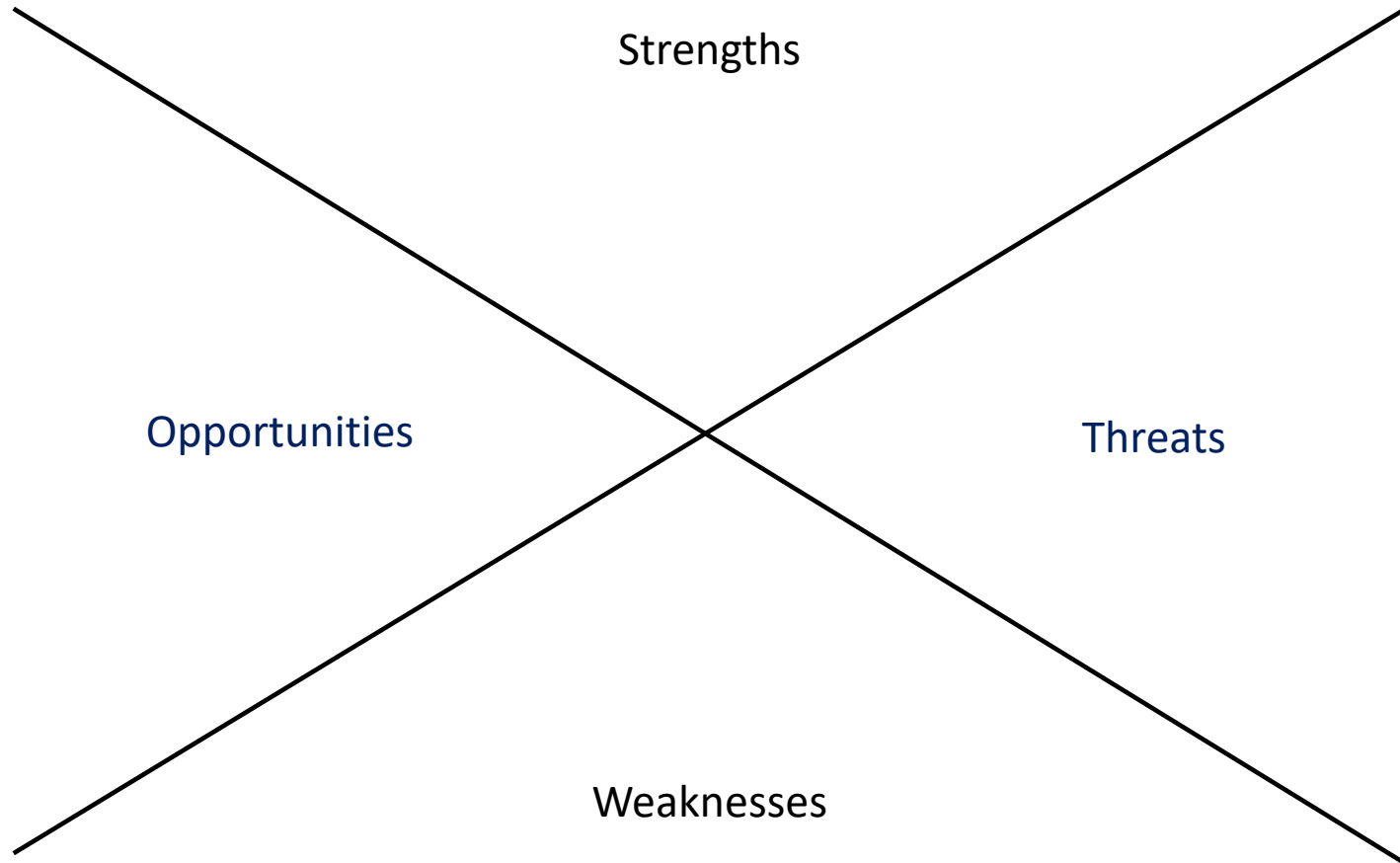


transparent and unbiased selection of experts

Experts

TOTAL: 40 EXPERTS

SWOT



SWOT AHP [Analytic Hierarchy Process]

Much more important

Equally important

9 = much more important; 1 = equally important

9 7 5 3 1 3 5 7 9

Factor A

Factor B

Factor B

Factor C

Factor C

Factor A

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Strengths

	much more important		equally important				much more important		
	9	7	5	3	1	3	5	7	9
Computational performance of co-simulation compared to monolithic simulation	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Weaknesses

	much more important		equally important				much more important		
	9	7	5	3	1	3	5	7	9
Computational performance of co-simulation compared to monolithic simulation	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Opportunities

	much more important		equally important				much more important		
	9	7	5	3	1	3	5	7	9
Computational performance of co-simulation compared to monolithic simulation	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Threats

	much more important		equally important				much more important		
	9	7	5	3	1	3	5	7	9
Computational performance of co-simulation compared to monolithic simulation	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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SWOT AHP

Please compare the SWOT-categories and rate their relative importance for co-simulation.

9 = much more important; 1 = equally important

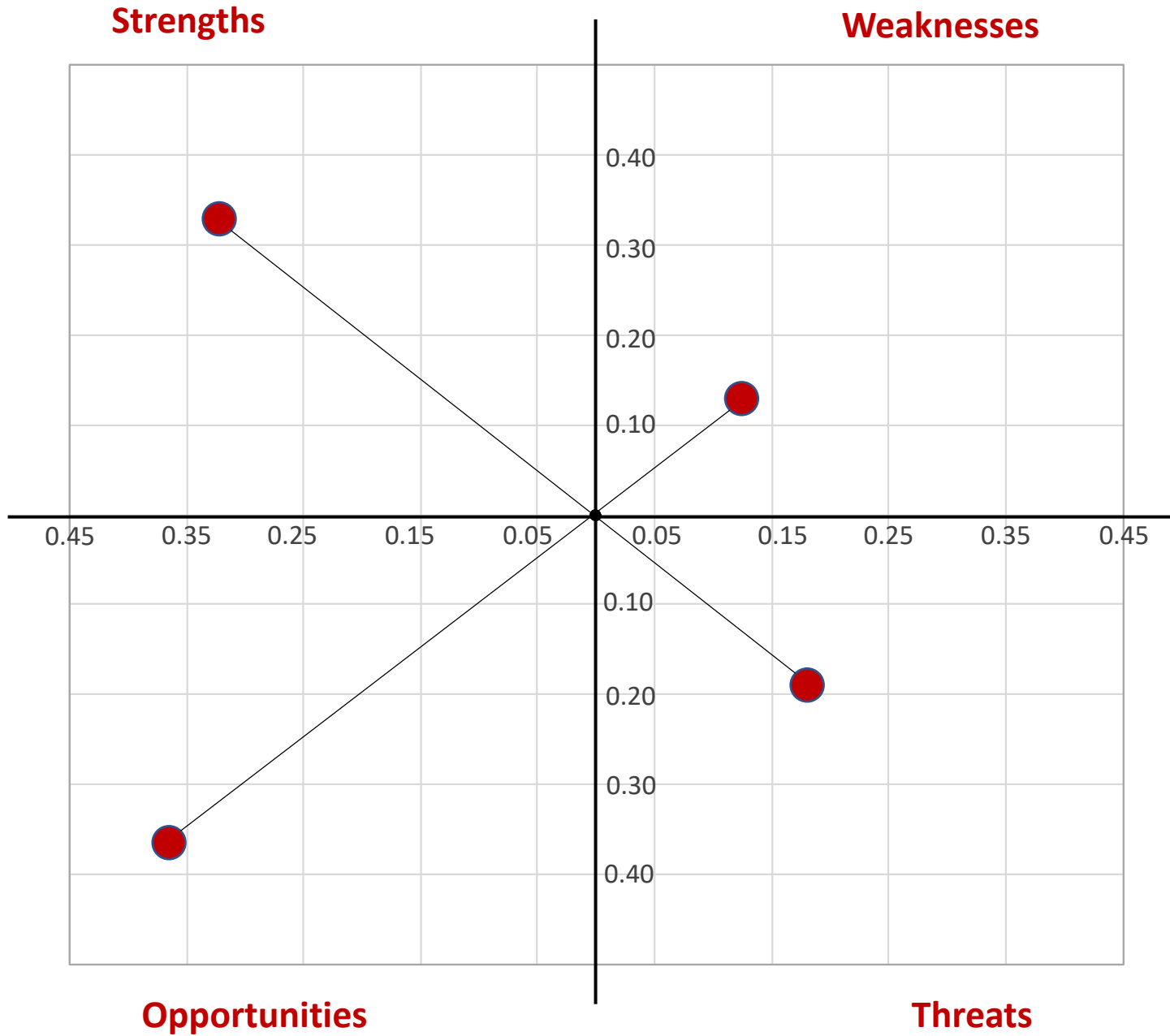
		much more important		equally important		much more important						
		9	7	5	3	1	3	5	7	9		
	Strengths	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Weaknesses	
	Strengths	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Opportunities	
	Strengths	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	Threats	
	Weaknesses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Opportunities	
	Weaknesses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Threats	
	Opportunities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Threats	

Results

Practitioners

Academics

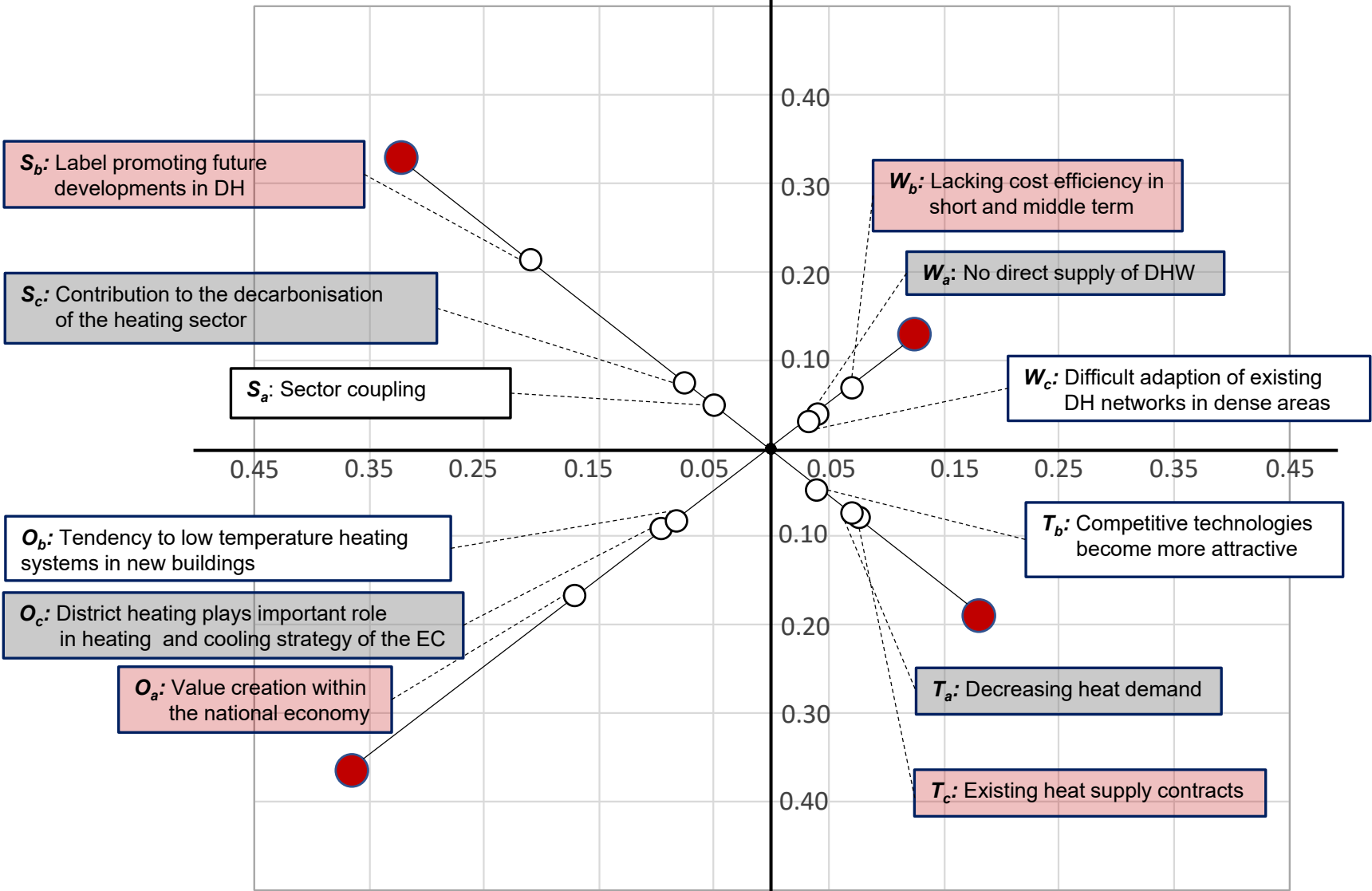
Academics



Academics

Strengths

Weaknesses



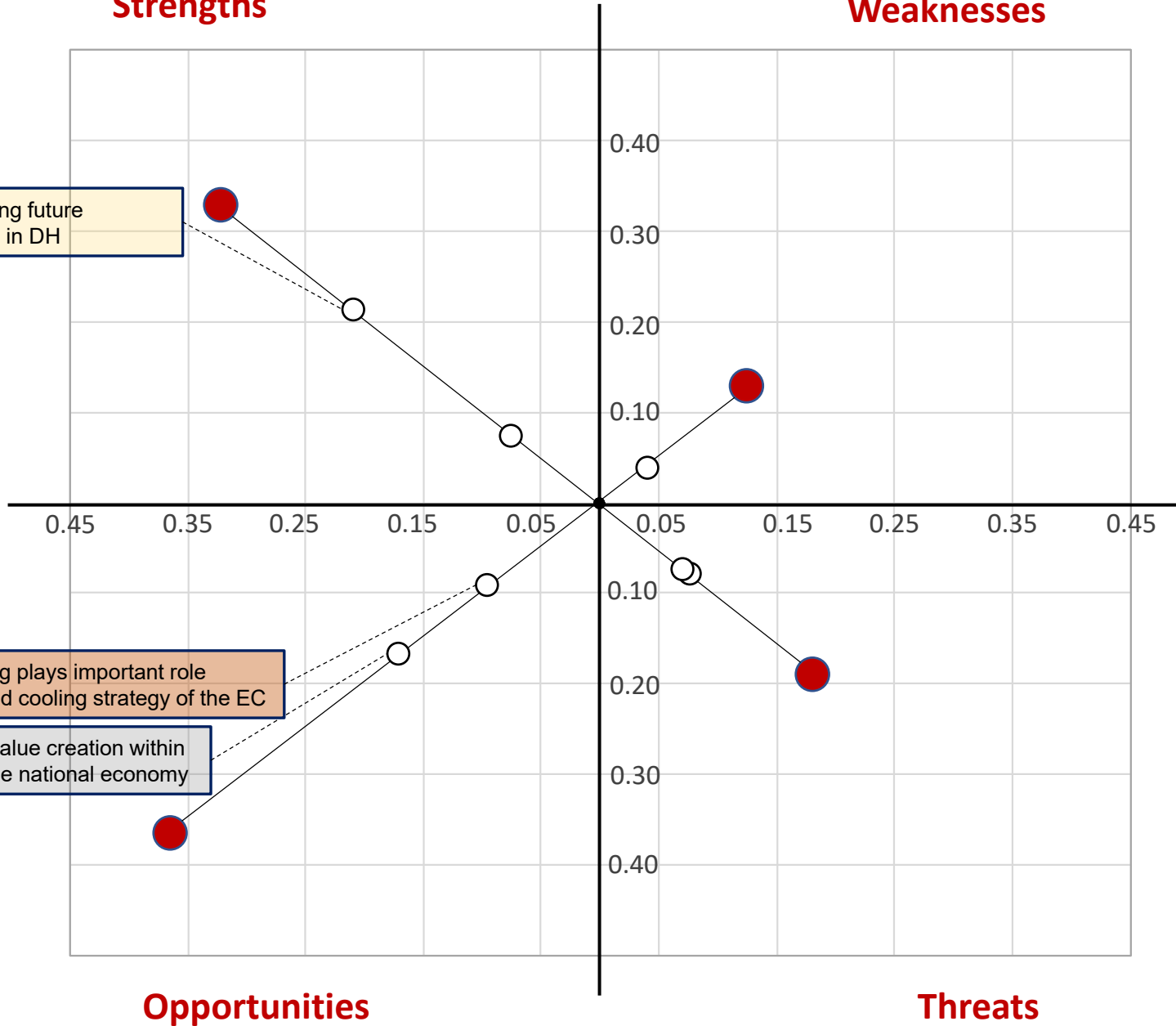
Opportunities

Threats

Academics

Strengths

Weaknesses

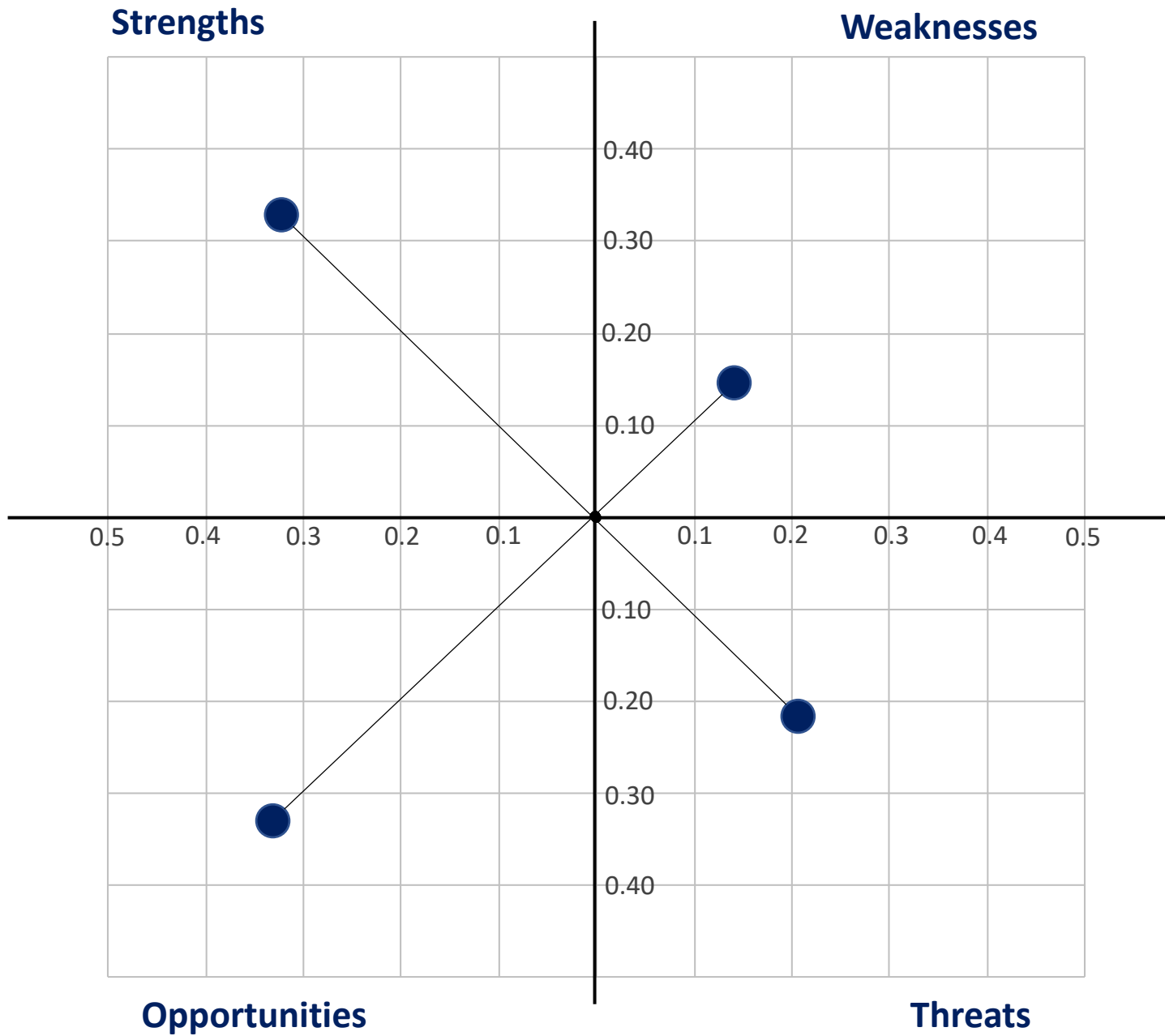


Opportunities

Threats

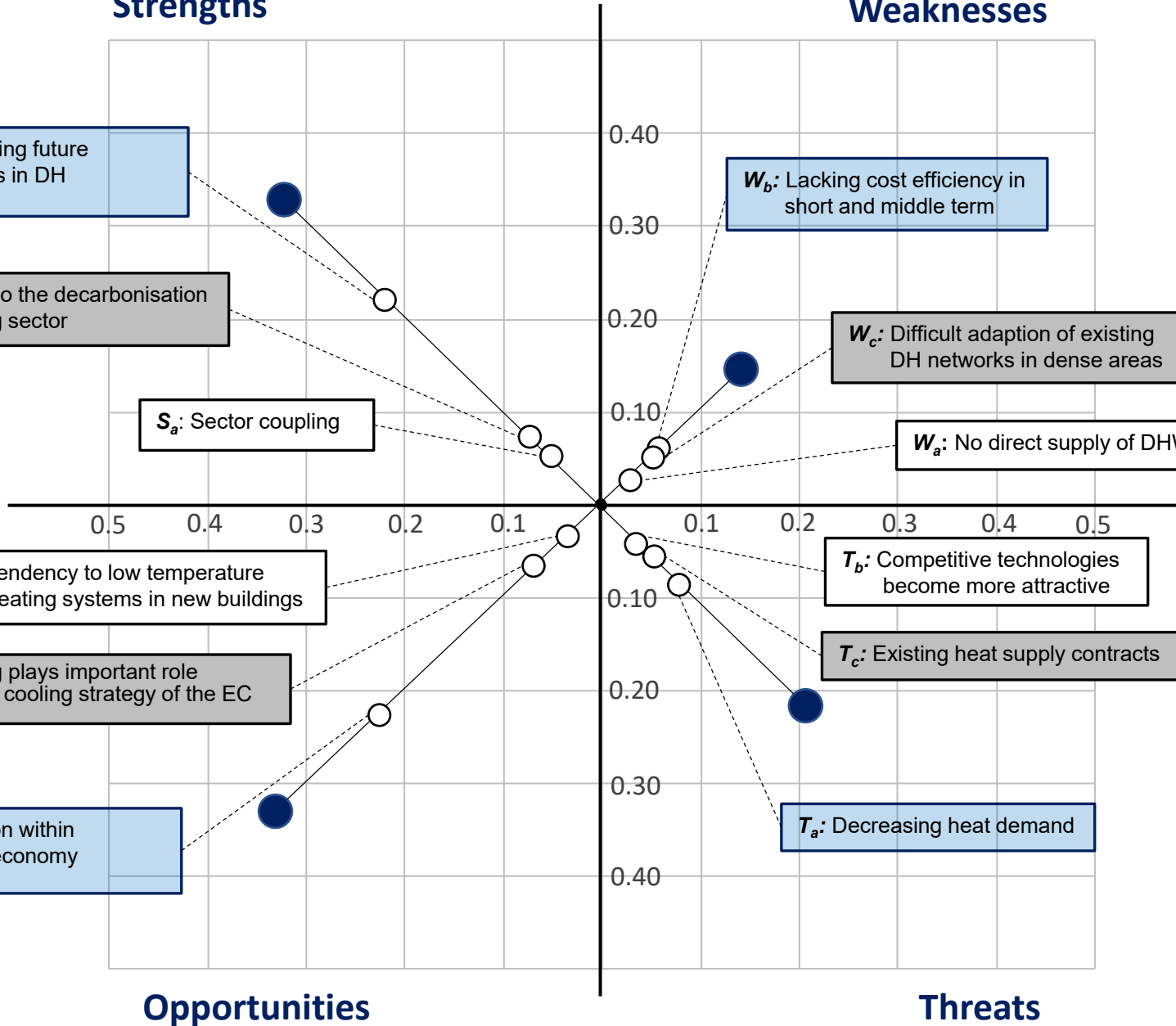
Practitioners

Academics



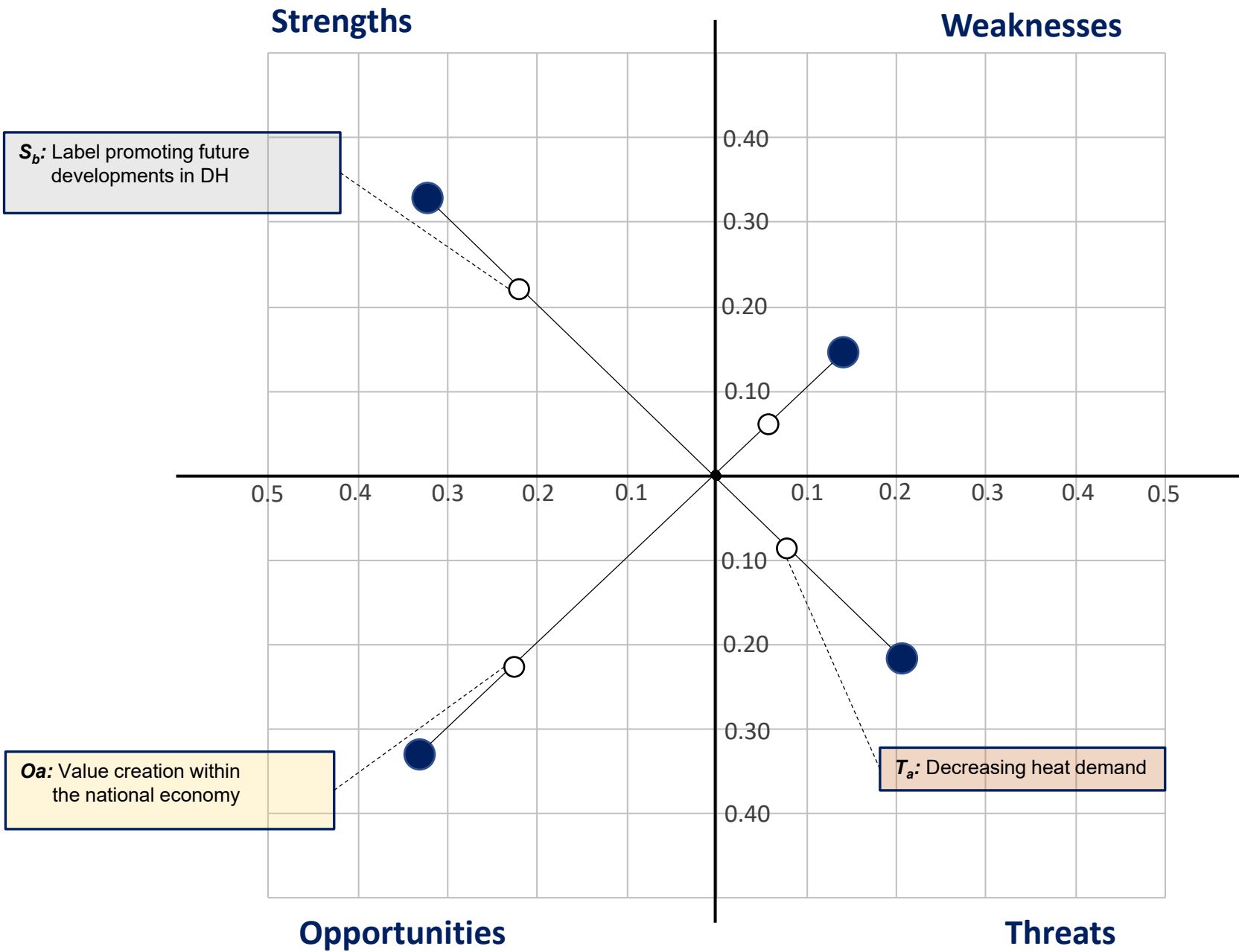
Strengths

Weaknesses

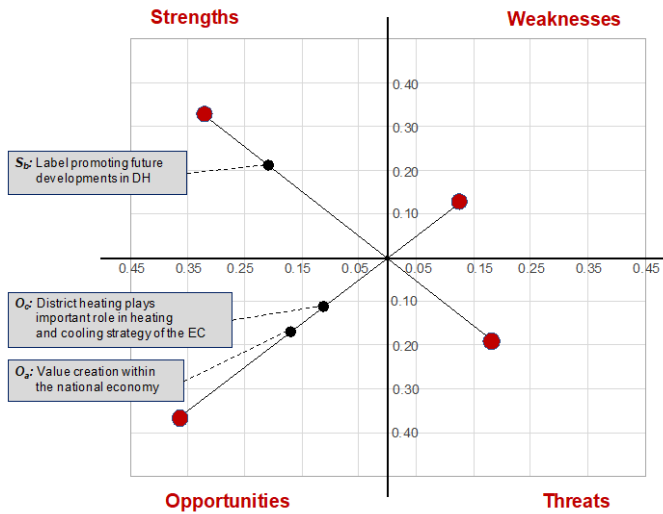


Opportunities

Threats

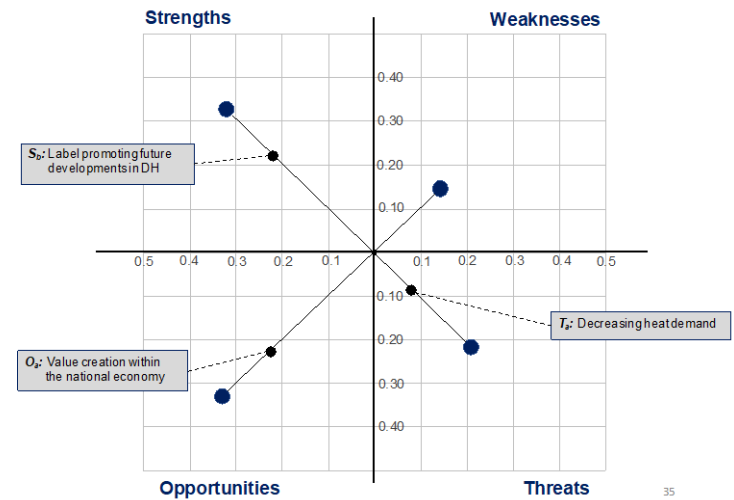


Academics



31

Practitioners



35

Rank 1

S_b : Label promoting future developments in DH

O_a : Value creation within the national economy

Rank 2

O_a : Value creation within the national economy

S_b : Label promoting future developments in DH

Rank 3

O_c : District heating plays important role in heating and cooling strategy of the EC

T_a : Decreasing heat demand

Quantitative questions



Based on results in the first rounds.

To which extent do you agree to the following statements?

Regulatory frameworks for 4GDH are already developed (e.g. bans of oil and gas boilers, CO ₂ taxes ...).
The impact of temperature errors in DH systems have been sufficiently investigated (e.g. substations generating too high return temperatures).
Renovation cost for buildings have been sufficiently investigated.
Construction standards have been consequently considered to avoid peak demands (e.g. by integrating storage mass into buildings).
Smart metering (with intelligent control systems) has been sufficiently investigated.
User behaviour has been sufficiently investigated (e.g. increasing comfort standard).
User confidence in new technology has been sufficiently investigated.

Alternative options to avoid Legionella growth in domestic hot water have been sufficiently investigated (e.g. infrared cleaning, apartment substations instead of central hot water supply).
Sophisticated planning tools are already developed (cross-domain, fully dynamic analysis).
Sophisticated control tools are already developed (cross-domain, fully dynamic analysis; predictive control algorithms).
Load forecasting methods have been sufficiently investigated (e.g. based on artificial intelligence techniques).
Facilitating active consumer participation has been sufficiently investigated (e.g. via mobile applications, gamification).
The impact of increasing pump energy demand caused by a lower temperature difference between supply and return temperature has been sufficiently investigated.



7

Entirely agree

6

Mostly agree

5

Somewhat agree

4

Neither agree nor disagree



3

Somewhat disagree

2

Mostly disagree

1

Entirely disagree



7

Entirely agree

6

Mostly agree

5

Somewhat agree

4

Neither agree nor disagree

3

Somewhat disagree

2

Mostly disagree

1

Entirely disagree





Academics



7

Entirely agree

6

Mostly agree

5

Somewhat agree

4

Neither agree nor disagree



3

Somewhat disagree

2

Mostly disagree

1

Entirely disagree

**Interp.
Median**



Academics



7

Entirely agree

6

Mostly agree

5

Somewhat agree

4

Neither agree nor disagree

3

Somewhat disagree

2

Mostly disagree

1

Entirely disagree



Interp. Median

The impact of increasing pump energy demand caused by a lower temperature difference between supply and return temperature has been sufficiently investigated.

4.4

Load forecasting methods have been sufficiently investigated (e.g. based on artificial intelligence techniques).

4.2

Alternative options to avoid Legionella growth in domestic hot water have been sufficiently investigated.

4.0

Sophisticated planning tools are already developed (cross-domain, fully dynamic analysis).

4.0

Renovation cost for buildings have been sufficiently investigated.

4.0

Academics



**Interp.
Median**

Academics



	Interp. Median
Regulatory frameworks for 4GDH are already developed (e.g. bans of oil and gas boilers, CO2 taxes ...).	2.2
User confidence in new technology has been sufficiently investigated.	2.5
Facilitating active consumer participation has been sufficiently investigated (e.g. via mobile applications, gamification).	3.1
User behaviour has been sufficiently investigated (e.g. increasing comfort standard).	3.2



Practitioners



7

Entirely agree

6

Mostly agree

5

Somewhat agree

4

Neither agree nor disagree



3

Somewhat disagree

2

Mostly disagree

1

Entirely disagree

**Interp.
Median**



Practitioners



7

Entirely agree

6

Mostly agree

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Somewhat agree

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Neither agree nor disagree

3

Somewhat disagree

2

Mostly disagree

1

Entirely disagree



Interp. Median

The impact of increasing pump energy demand caused by a lower temperature difference between supply and return temperature has been sufficiently investigated.

4.7

Smart metering (with intelligent control systems) has been sufficiently investigated.

4.4

Renovation cost for buildings have been sufficiently investigated.

4.3

Alternative options to avoid Legionella growth in domestic hot water have been sufficiently investigated.

4.2

User behaviour has been sufficiently investigated

4.0



**Interp.
Median**



	Interp. Median
Regulatory frameworks for 4GDH are already developed (e.g. bans of oil and gas boilers, CO2 taxes ...).	2.5
User confidence in new technology has been sufficiently investigated.	3
Construction standards have been consequently considered to avoid peak demands (e.g. by integrating storage mass into buildings)	3
Sophisticated planning tools are already developed (cross domain, fully dynamic analysis).	3.3

Insights

- Noise around *“Neither agree nor disagree”*
 - Still useful results?

Outlier 1

- **A+P Experts do not agree:** Regulatory frameworks for 4GDH are already developed (e.g. bans of oil and gas boilers, CO2 taxes ...)

Outlier 2

- **A+P Experts do not agree:** User confidence in new technology has been sufficiently investigated.

Conclusion



Strength:

Label promoting future developments in DH

Opportunity:

Value creation within the national economy



Future research on:

- Regulatory frameworks for 4GDH
- Impact on user confidence in 4GDH (and new technologies in general)

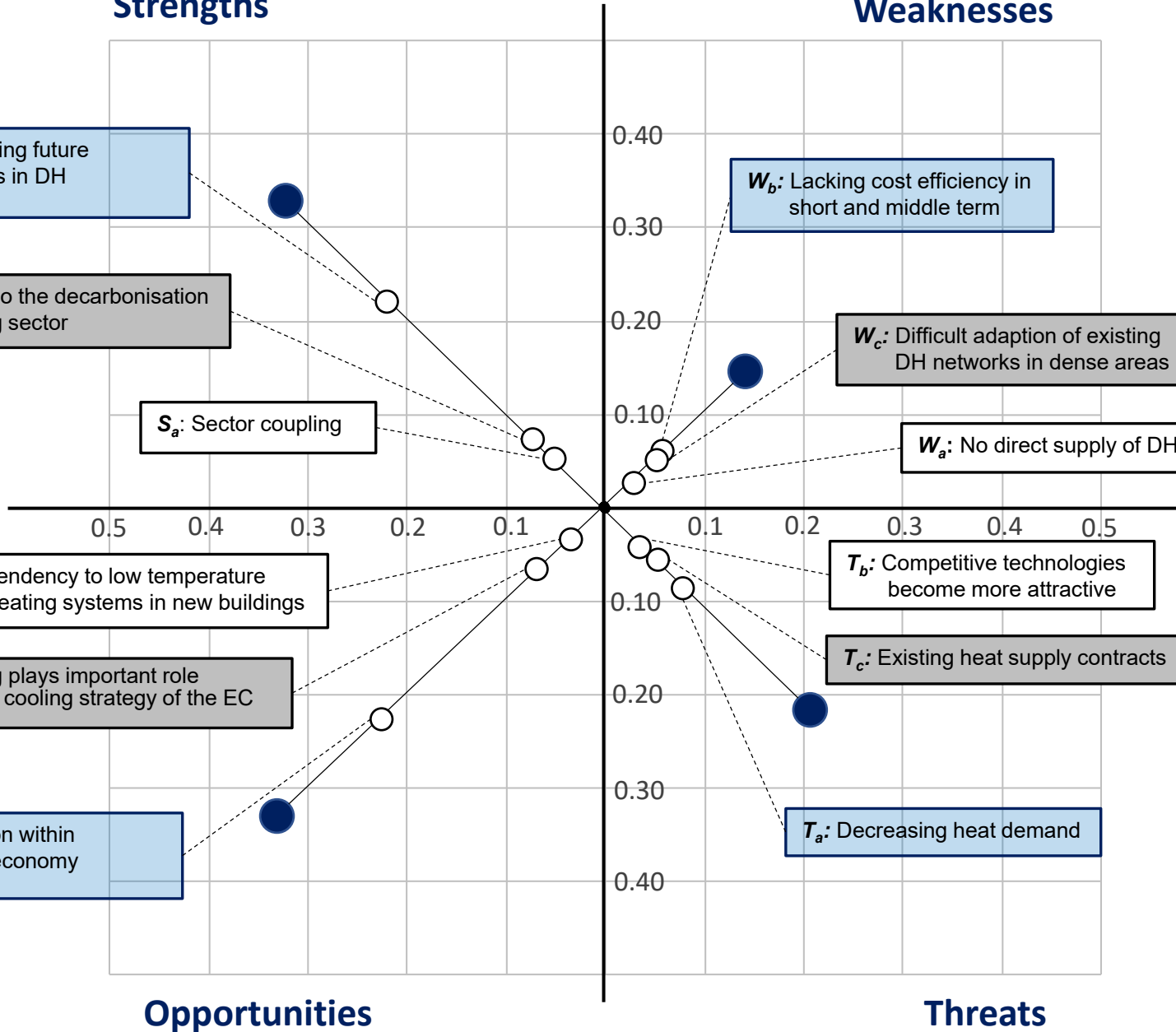
Expert survey

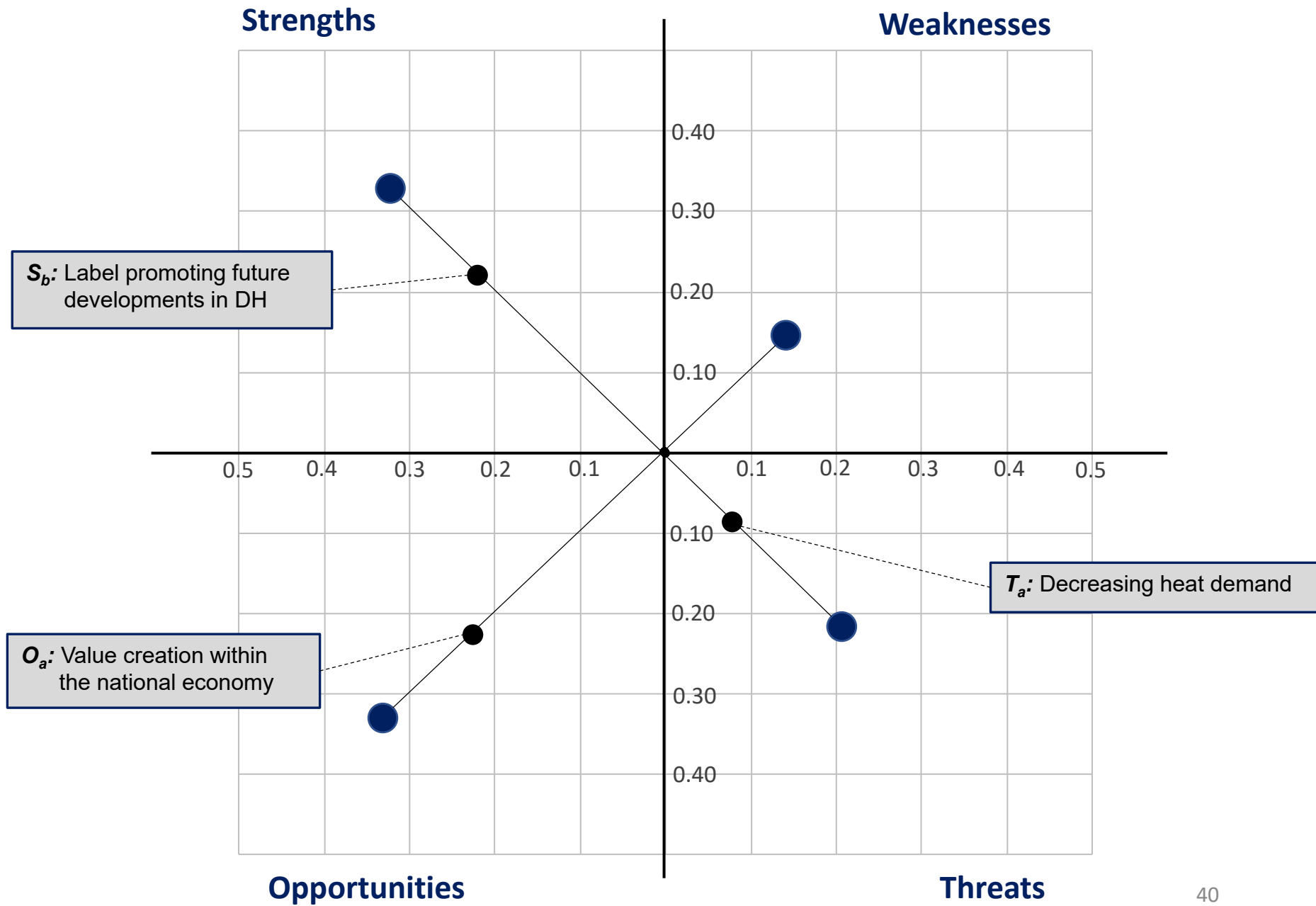


End

Strengths

Weaknesses

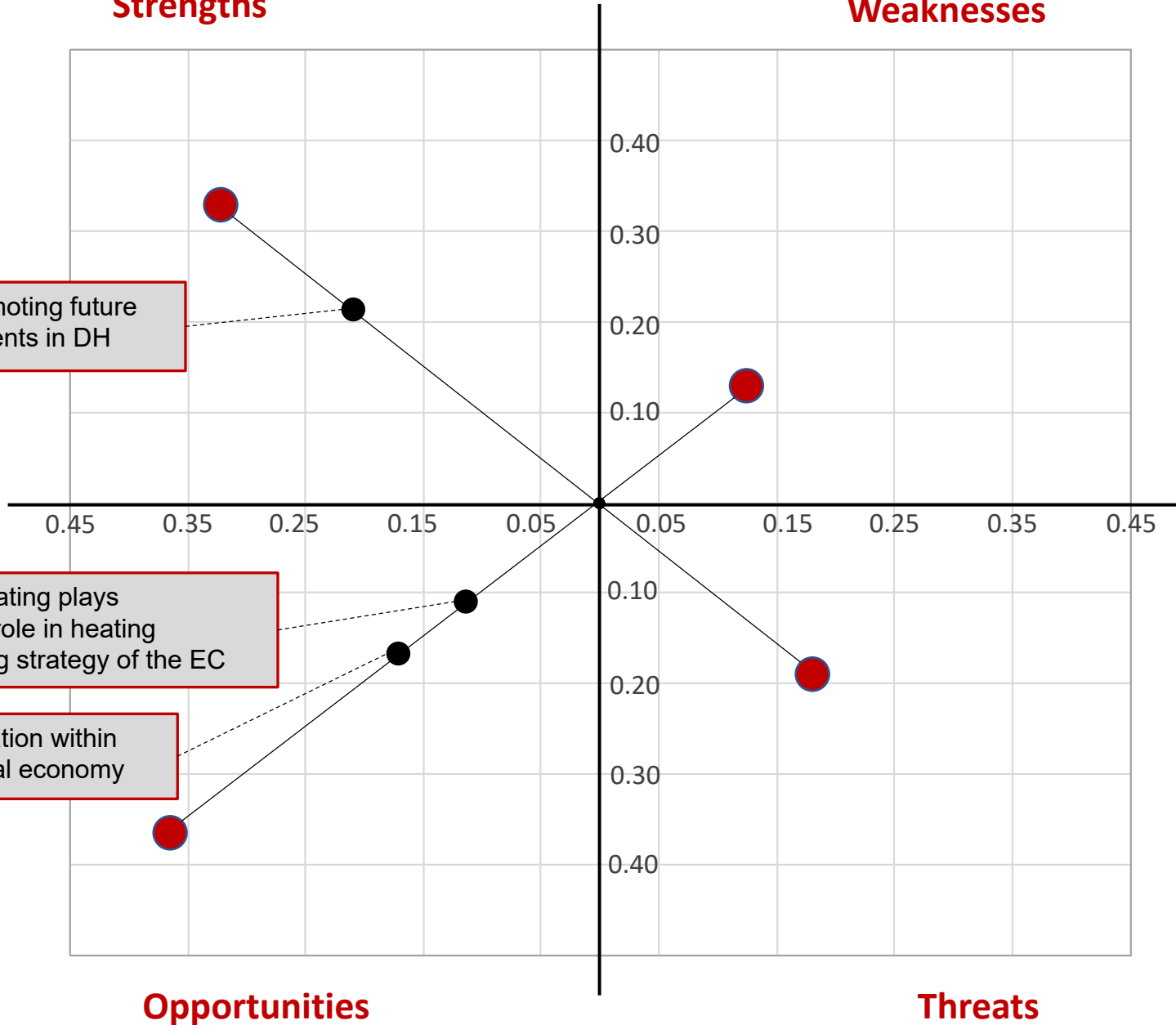




Academics

Strengths

Weaknesses

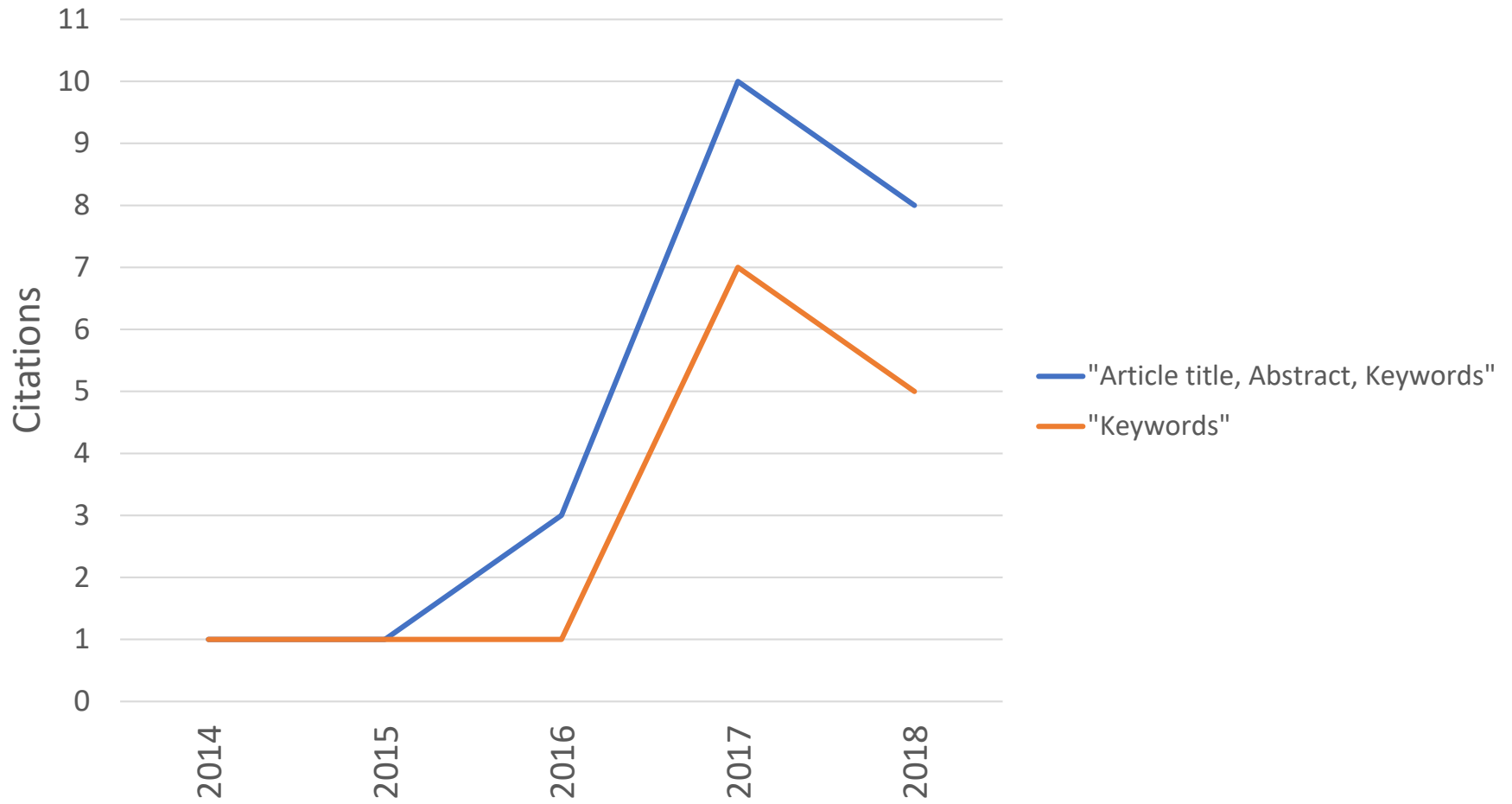


S_b : Label promoting future developments in DH

O_c : District heating plays important role in heating and cooling strategy of the EC

O_a : Value creation within the national economy

Keyword "4GDH", "4th generation district heating",
"4th generation DH"



Keyword "Smart Energy System"

