APPLICATION OF NATURAL LANGUAGE PROCESSING IN INNOVATION ECONOMICS

Dr. Daniel Weiss,

Research Group Leader „Market analysis, -design and innovation strategies“,
German Aerospace center (DLR), Institute for Transport Research

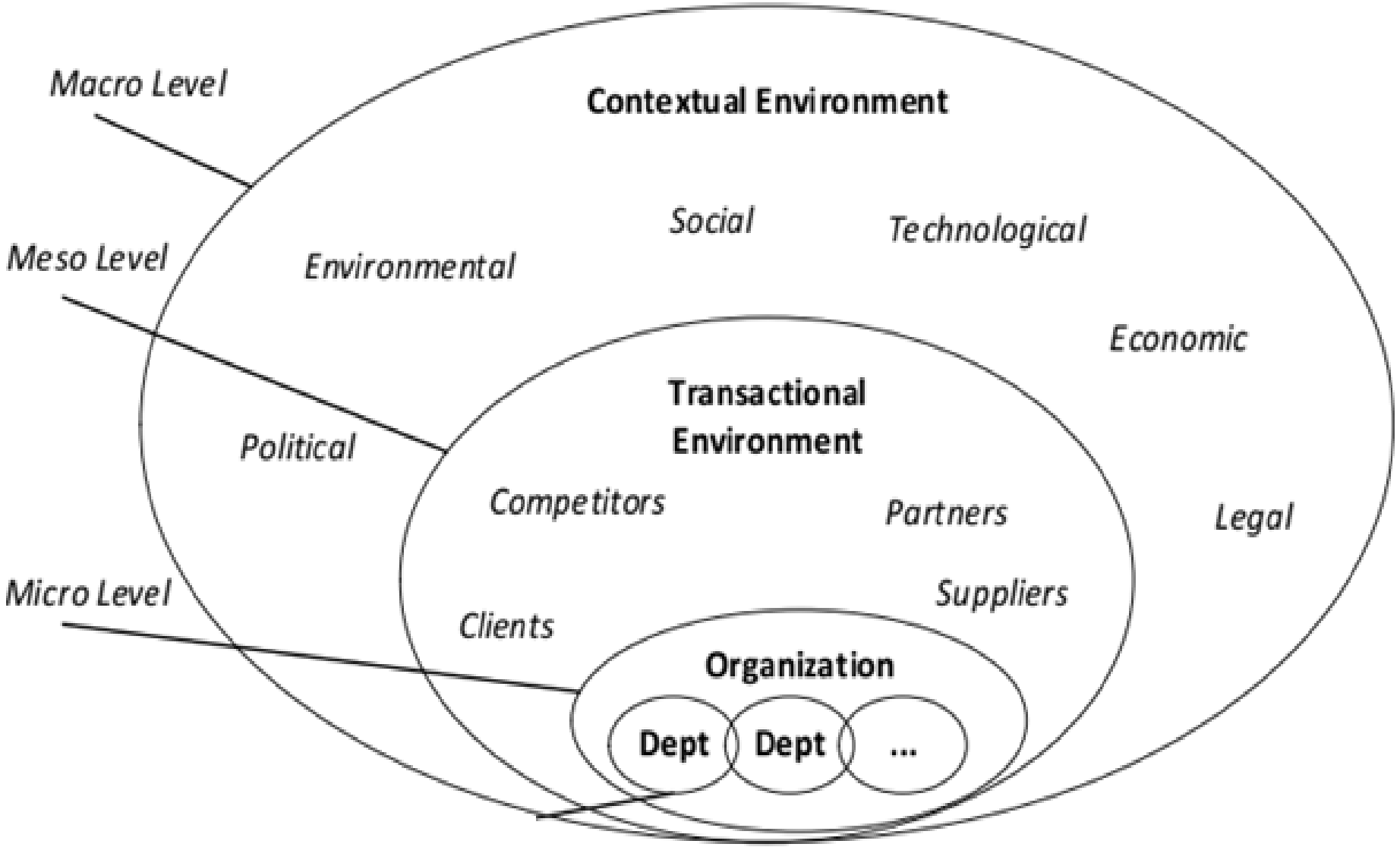
Content

- Motivation
- Applications to mobility
- Discussion & Outlook

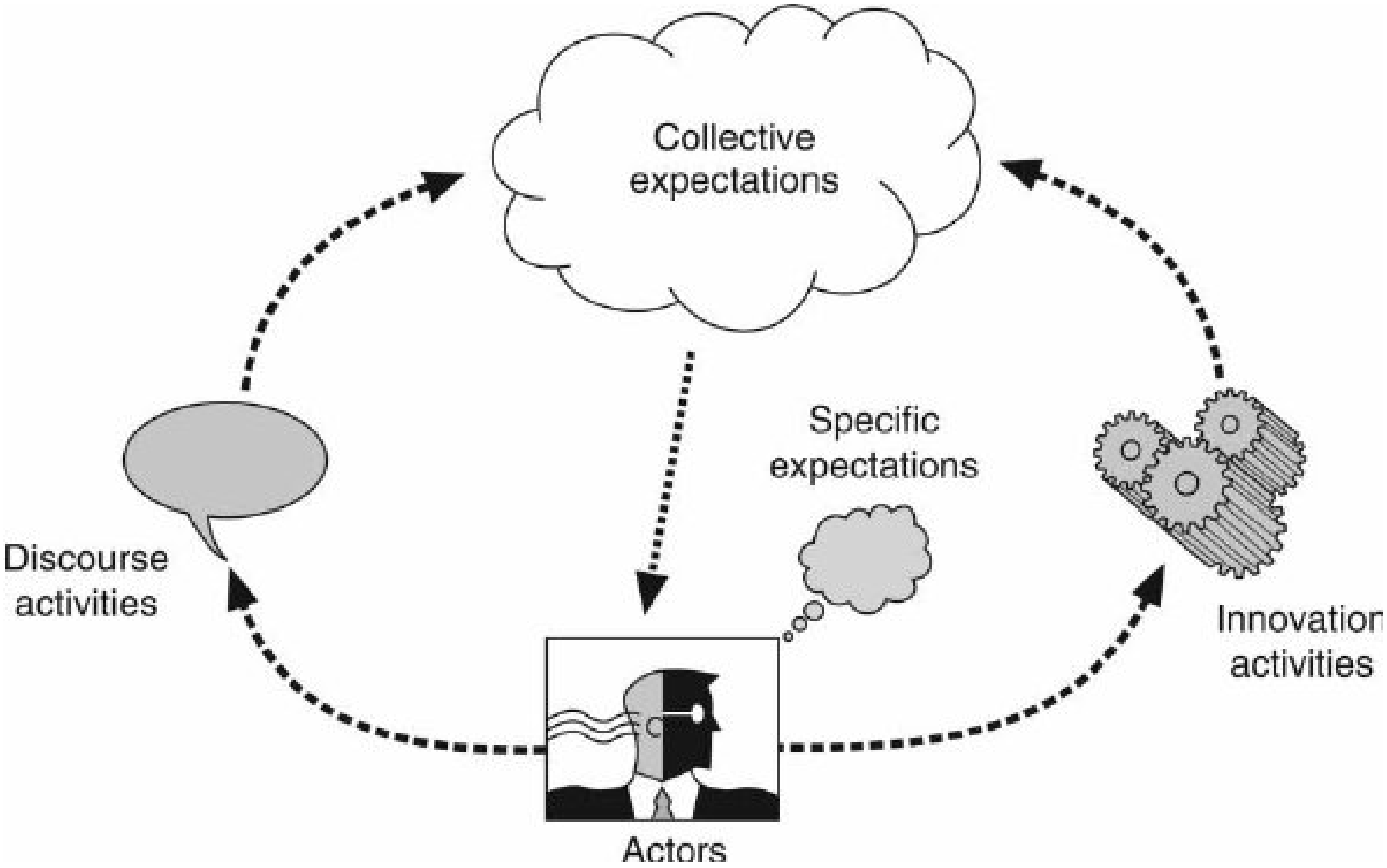
MOTIVATION

Motivation – Complex Transitions

Motivation – Unstructured Text Data



Motivation - Discourse Dynamics



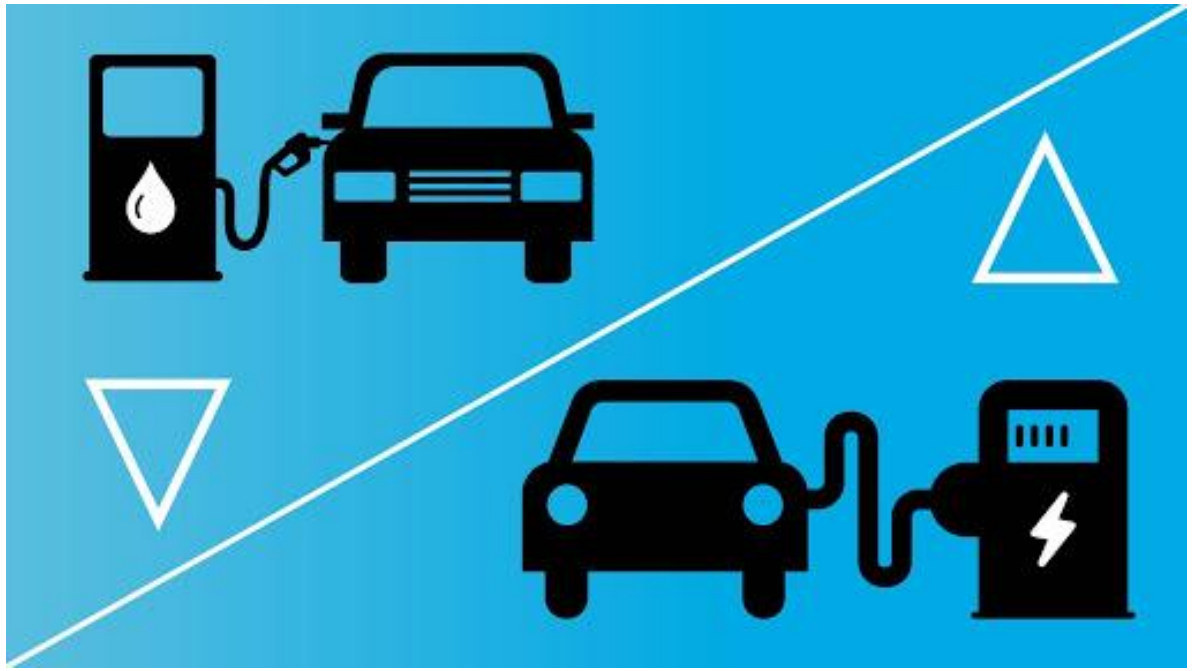
Konrad 2006

A TEXT-BASED MONITORING TOOL FOR THE LEGITIMACY AND GUIDANCE OF TECHNOLOGICAL INNOVATION SYSTEMS (WEISS AND NEMECZEK 2021)

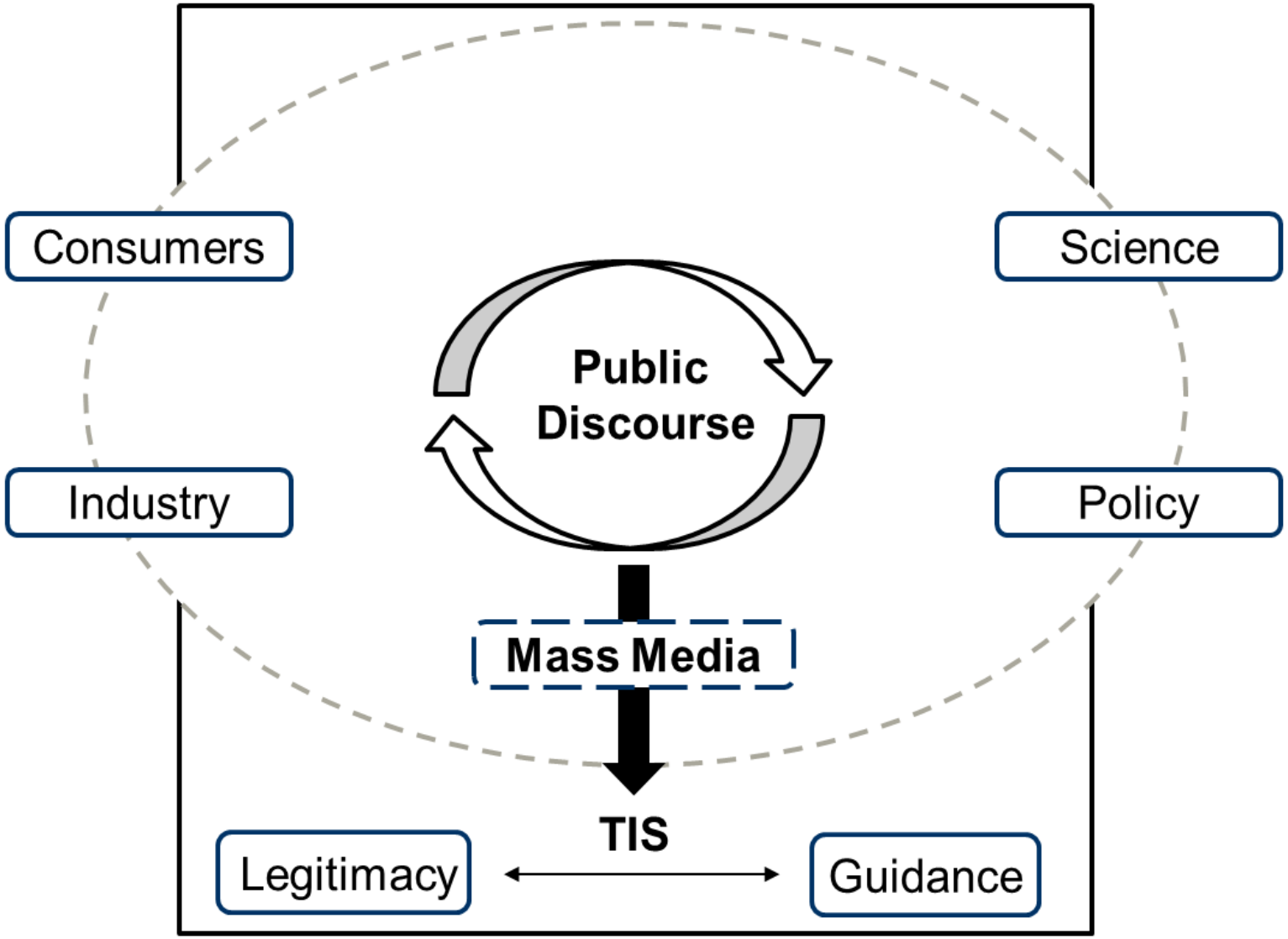
Liability of newness and discourse activities

- ‘Liability of newness’ of BEVs
- Compliance issues and uncertainty (*Legitimacy/Guidance*)
- Reflected in public discourse but drawbacks of manual text analysis

➢NLP-based monitoring tool

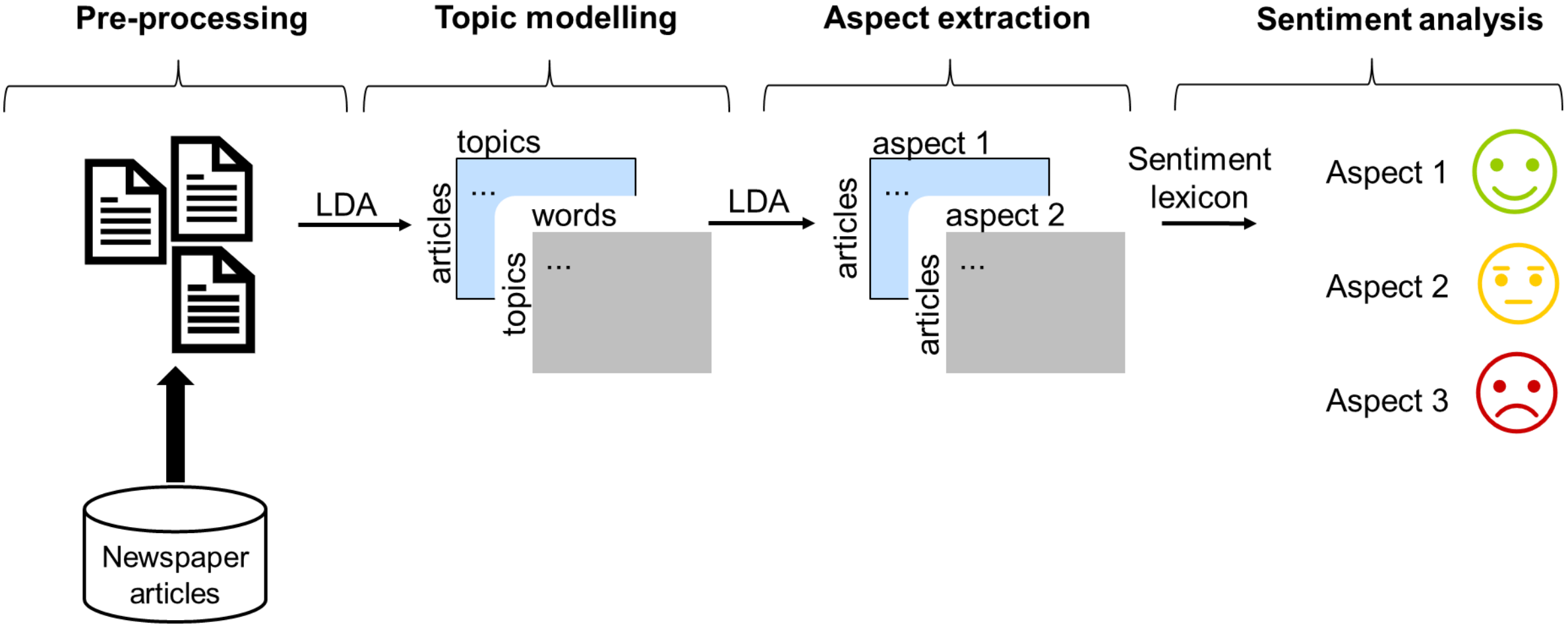


Public discourse – Technology Legitimacy, and Guidance



own illustration with reference to Waldherr (2012) and Kayser (2017)

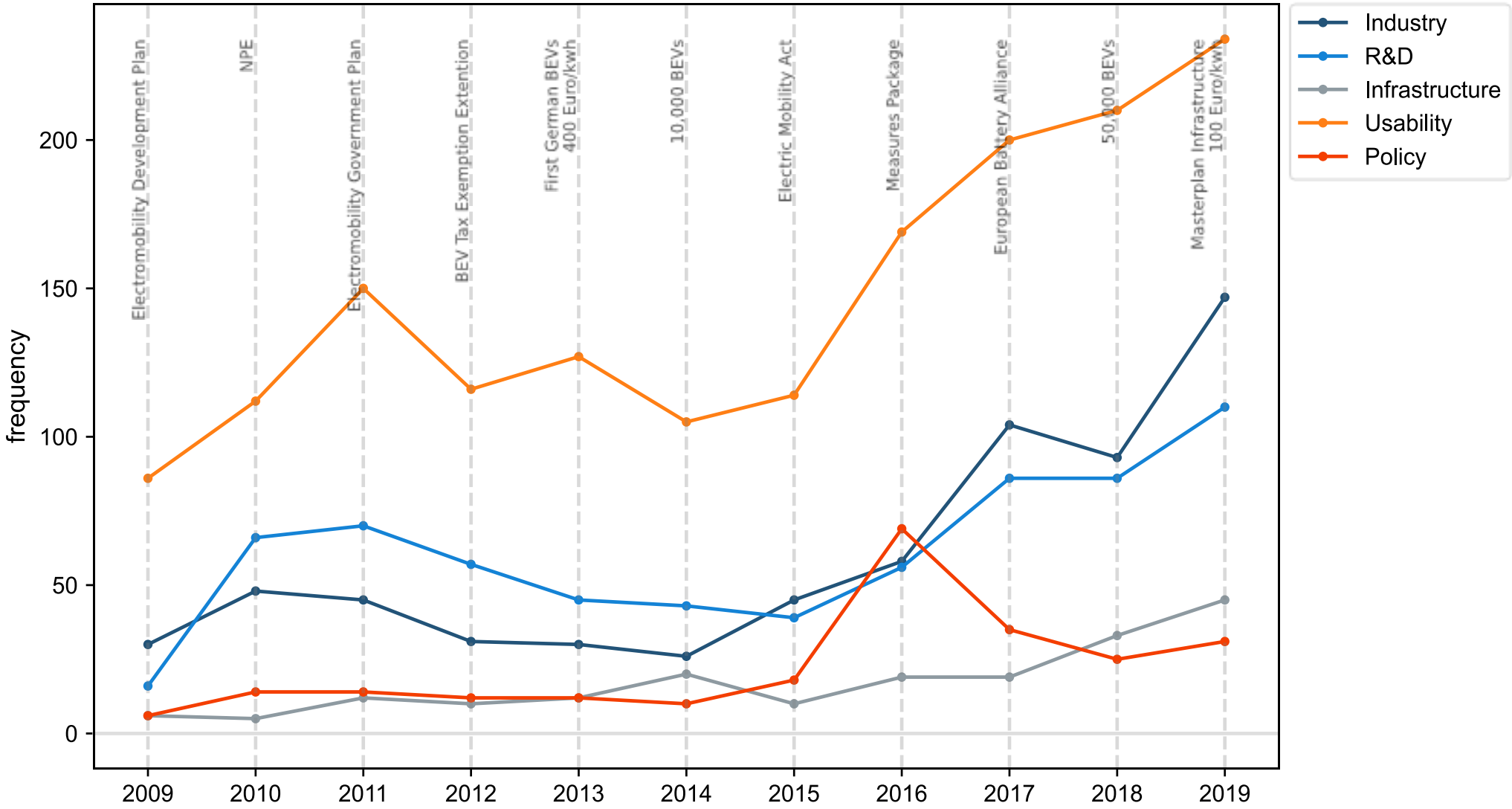
Processing pipeline



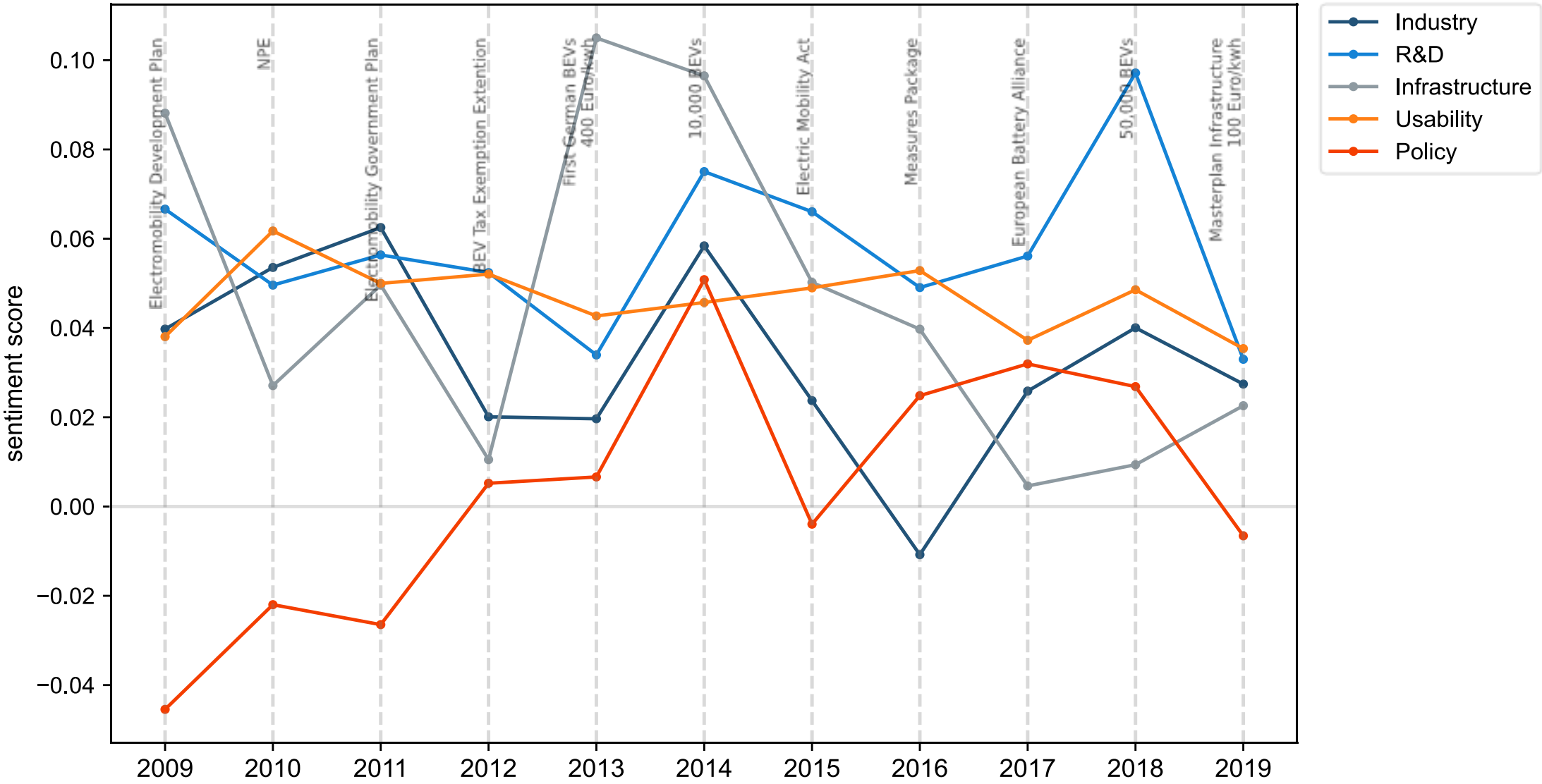
LDA topic keywords and probabilities for BEV

Topic	Distribution of the most important topic keywords
Industry	0.005*"milliarde" + 0.004*"bus" + 0.003*"konzern" + 0.003*"produktion" + 0.003*"kamenz" + 0.003*"mitarbeiter" + 0.003*"elektrobus" + 0.003*"produzieren" + 0.002*"projekt" + 0.002*"verkaufen" + 0.002*"batteriezelle" + 0.002*"branche" + 0.002*"elektromotor" + 0.002*"werk" + 0.002*"bereich" + 0.002*"industrie" + 0.002*"zulieferer" + 0.002*"firma" + 0.002*"investieren" + 0.002*"geschäft"
R&D	0.004*"e-bike" + 0.003*"team" + 0.003*"projekt" + 0.003*"firma" + 0.003*"motor" + 0.003*"idee" + 0.003*"einsatz" + 0.003*"professor" + 0.003*"technologie" + 0.003*"akku" + 0.003*"rennen" + 0.002*"material" + 0.002*"thema" + 0.002*"meter" + 0.002*"welt" + 0.002*"institut" + 0.002*"mobilität" + 0.002*"lithium" + 0.002*"hochschule" + 0.002*"fahrrad"
Infrastructure	0.005*"ladestation" + 0.005*"stadtwerke" + 0.004*"standort" + 0.004*"ladesäule" + 0.003*"akku" + 0.003*"station" + 0.003*"wagen" + 0.003*"laden" + 0.003*"tesla" + 0.003*"meter" + 0.003*"anlage" + 0.003*"netz" + 0.003*"minute" + 0.003*"fahrer" + 0.003*"steckdose" + 0.003*"fahrt" + 0.003*"dauern" + 0.002*"kilometerprostunde" + 0.002*"leistung" + 0.002*"monat"
Usability	0.006*"tesla" + 0.004*"wagen" + 0.003*"ampera" + 0.003*"akku" + 0.003*"idrei" + 0.003*"leaf" + 0.003*"sekunde" + 0.003*"model" + 0.003*"fahrer" + 0.003*"steckdose" + 0.003*"laden" + 0.002*"dollar" + 0.002*"ladestation" + 0.002*"haus" + 0.002*"pferdestärke" + 0.002*"meter" + 0.002*"netz" + 0.002*"stromer" + 0.002*"hören" + 0.002*"technik"
Policy	0.006*"prämie" + 0.005*"antrag" + 0.005*"kaufprämie" + 0.004*"zelle" + 0.004*"diesel" + 0.004*"kaufen" + 0.003*"staat" + 0.003*"bund" + 0.003*"beantragen" + 0.003*"verein" + 0.003*"verbrennungsmotor" + 0.003*"förderung" + 0.003*"milliarde" + 0.003*"wirtschaft" + 0.003*"bundesregierung" + 0.003*"firma" + 0.003*"bundesamt" + 0.003*"regierung" + 0.003*"rechnen" + 0.003*"verbraucher"

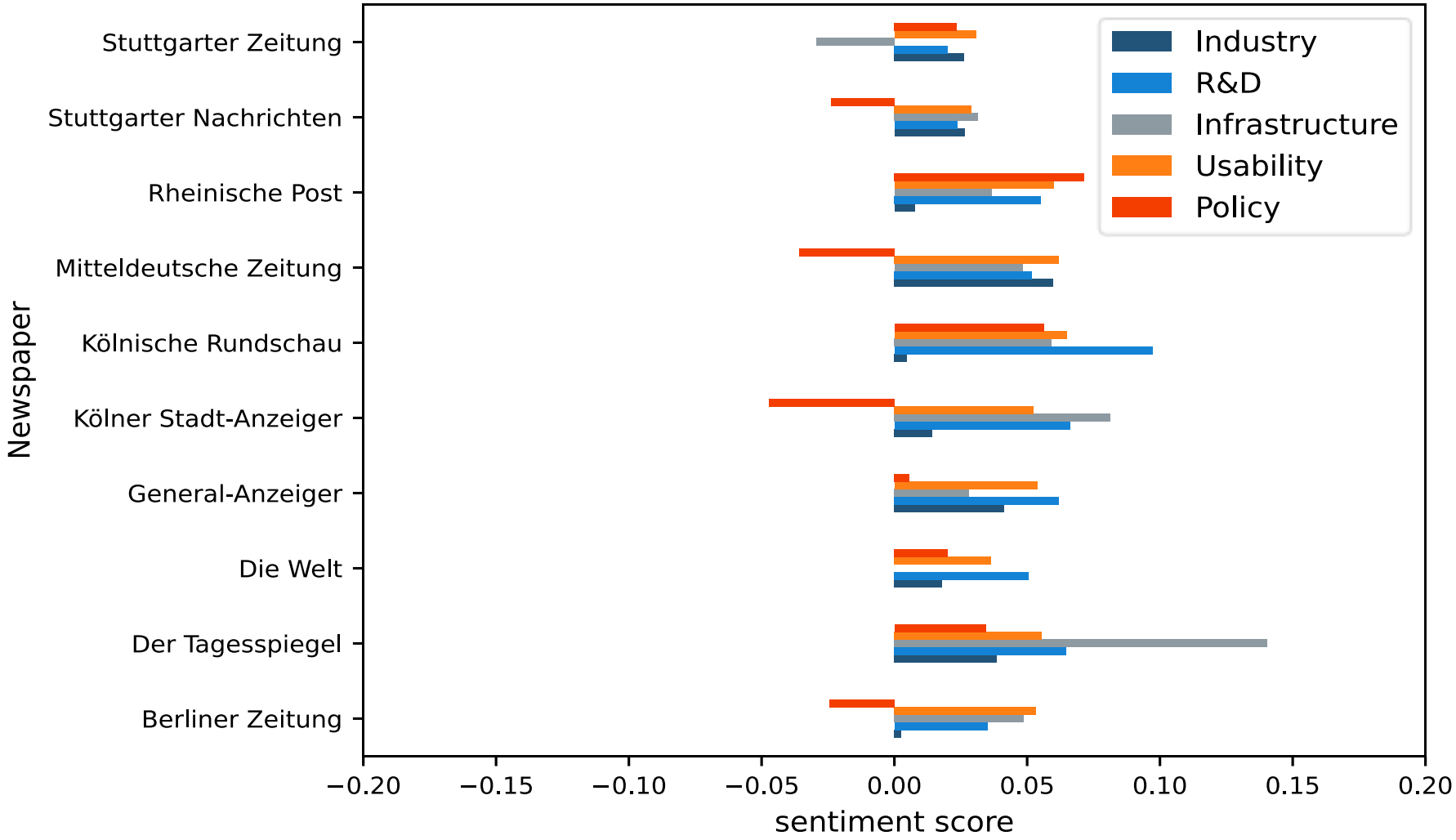
Media attention per topic for BEVs in Germany



Media sentiment per topic for BEVs in Germany



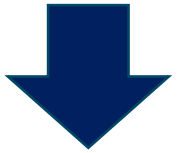
Differences across regional newspapers



A MEDIA-BASED INNOVATION INDICATOR: EXAMINING DECLINING TECHNOLOGICAL INNOVATION SYSTEMS (WEISS AND NEMECZEK 2022)

Measuring the decline of a technology

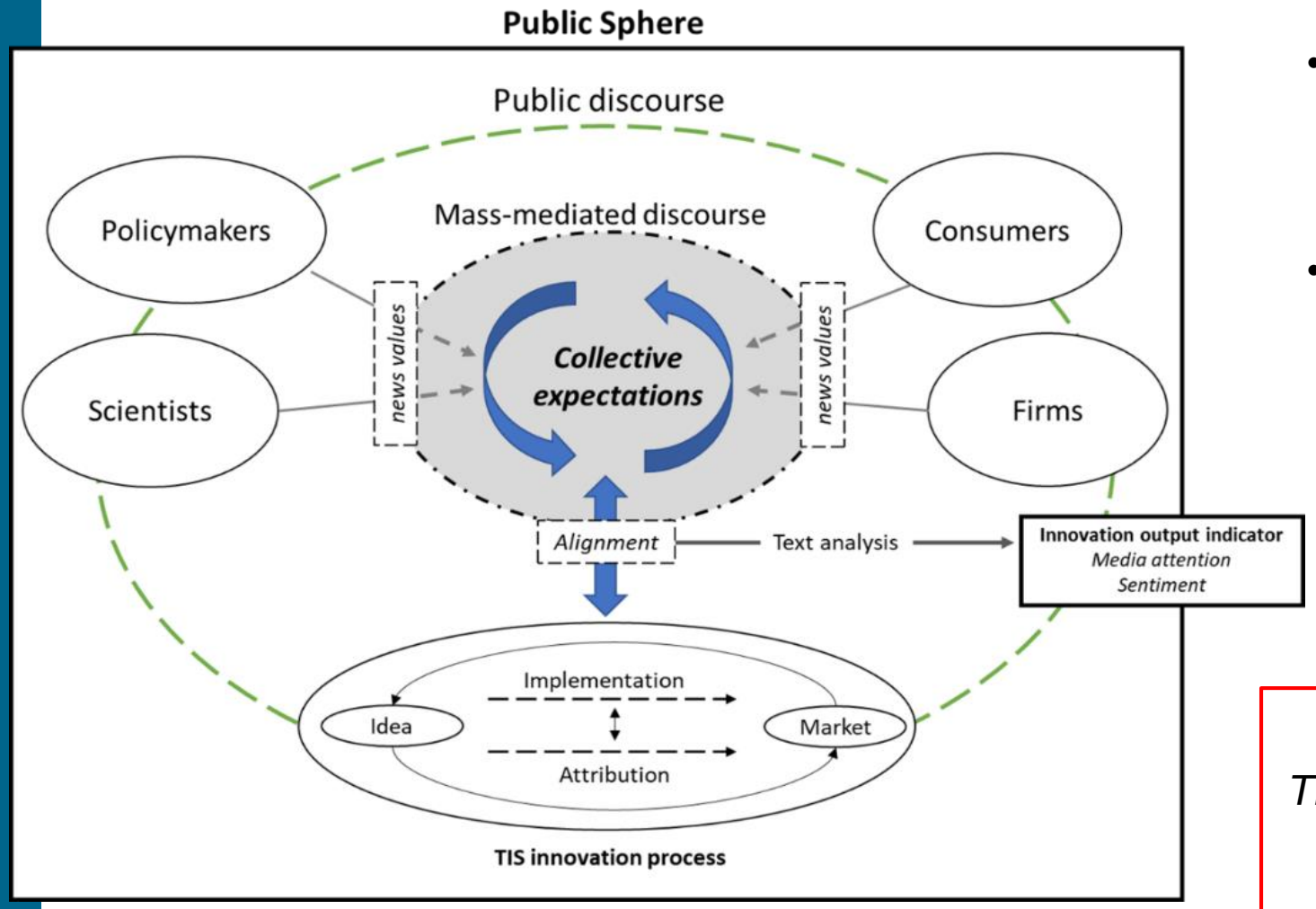
- Shortcomings of current technology decline indicators such as production, sales and patent data (Isoaho and Markard 2020, Markard et al. 2020, Weiss and Scherer 2021)
    - Delayed and missing granularity (Kinne and Axenbeck 2020)
    - Limitations of patent data (Eggink 2012)
    - Neglecting collective expectations and preferences (van Lente and Rip 1998, Brown and Michael 2003, Borup et al. 2006)



➢ Novel mass-media-based innovation output indicator illustrated with ICE

➢ Methodological framework based on NLP (Bellstam et al. 2021, Weiss and Nemeczek 2021)

Conceptional foundations



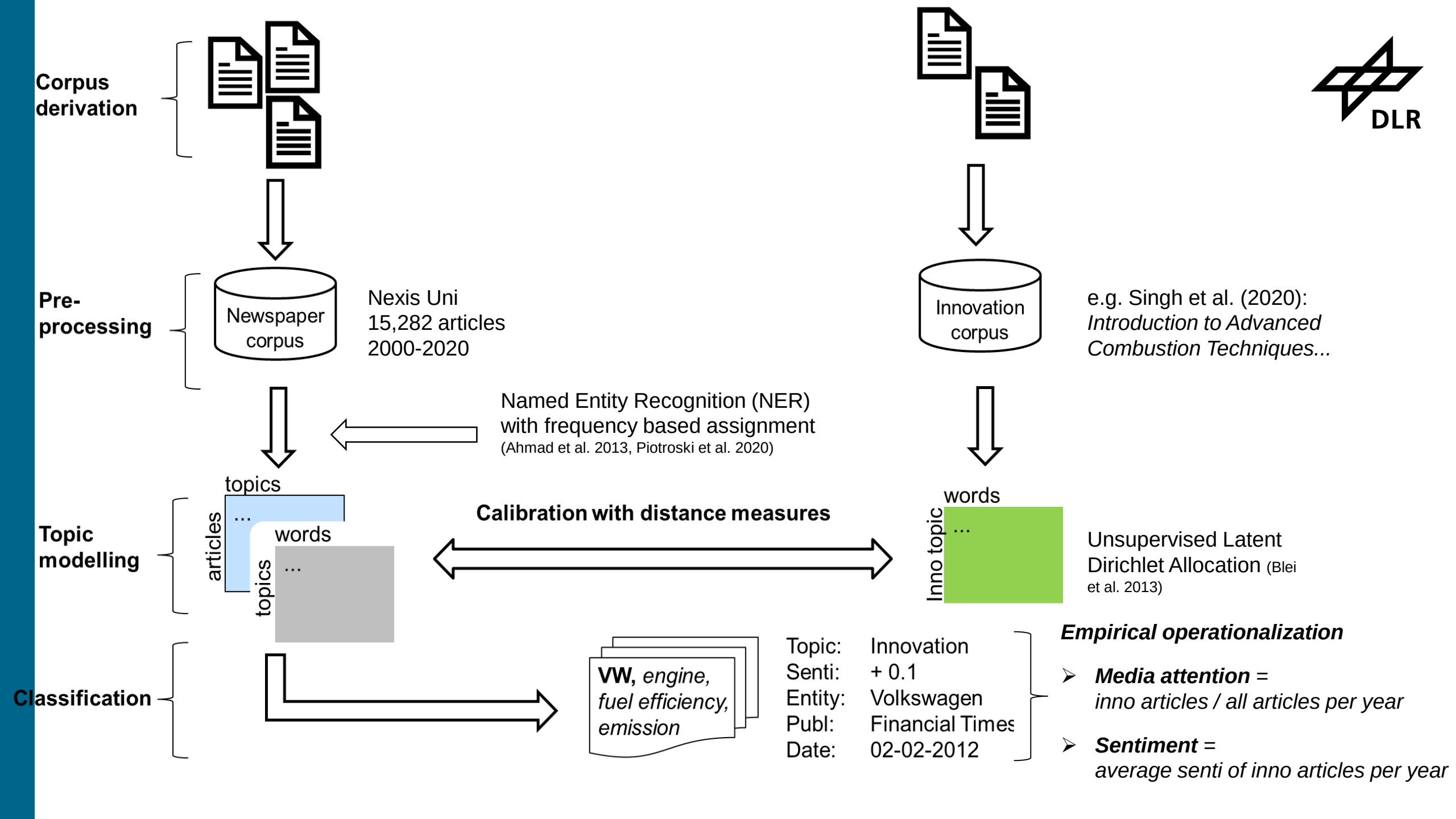
Source: own depiction with reference to Waldherr (2008, 2012)

- Aggregated mass-mediated discourse as a proxy of collective expectations and preferences (Konrad et al. 2012, Waldherr 2012, Dehler-Holland et al. 2021, Weiss and Nemeczek 2021)
- Technology-specific news values guide media attention for innovations (Waldherr 2008, 2012)
  - ➢ Relevance, timeliness, and relatedness to prevailing societal problems

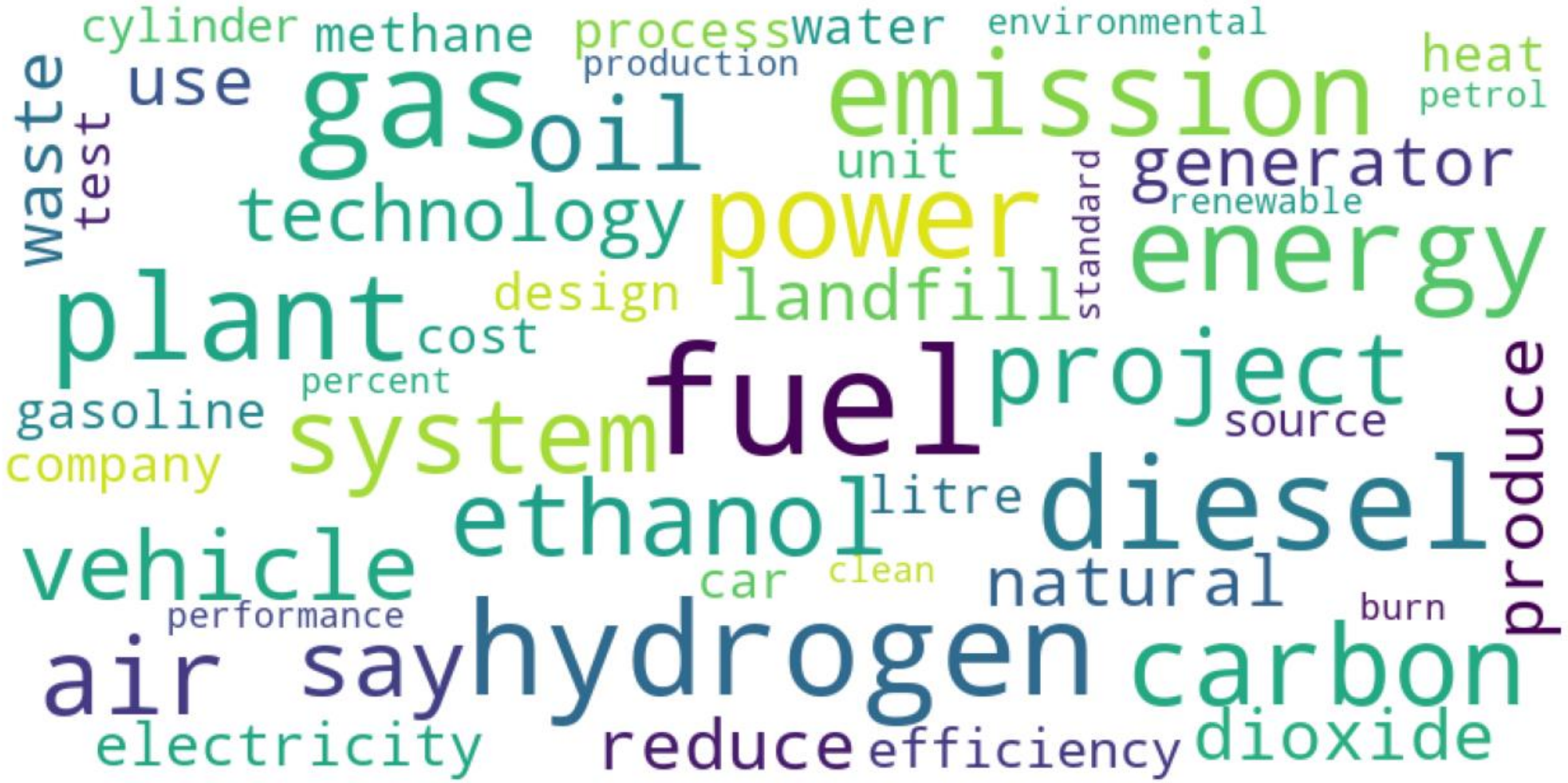
Assumption:

The media reports on innovations that are aligned with collective expectations and preferences

Media attention + sentiment indicates demand and support for the innovation

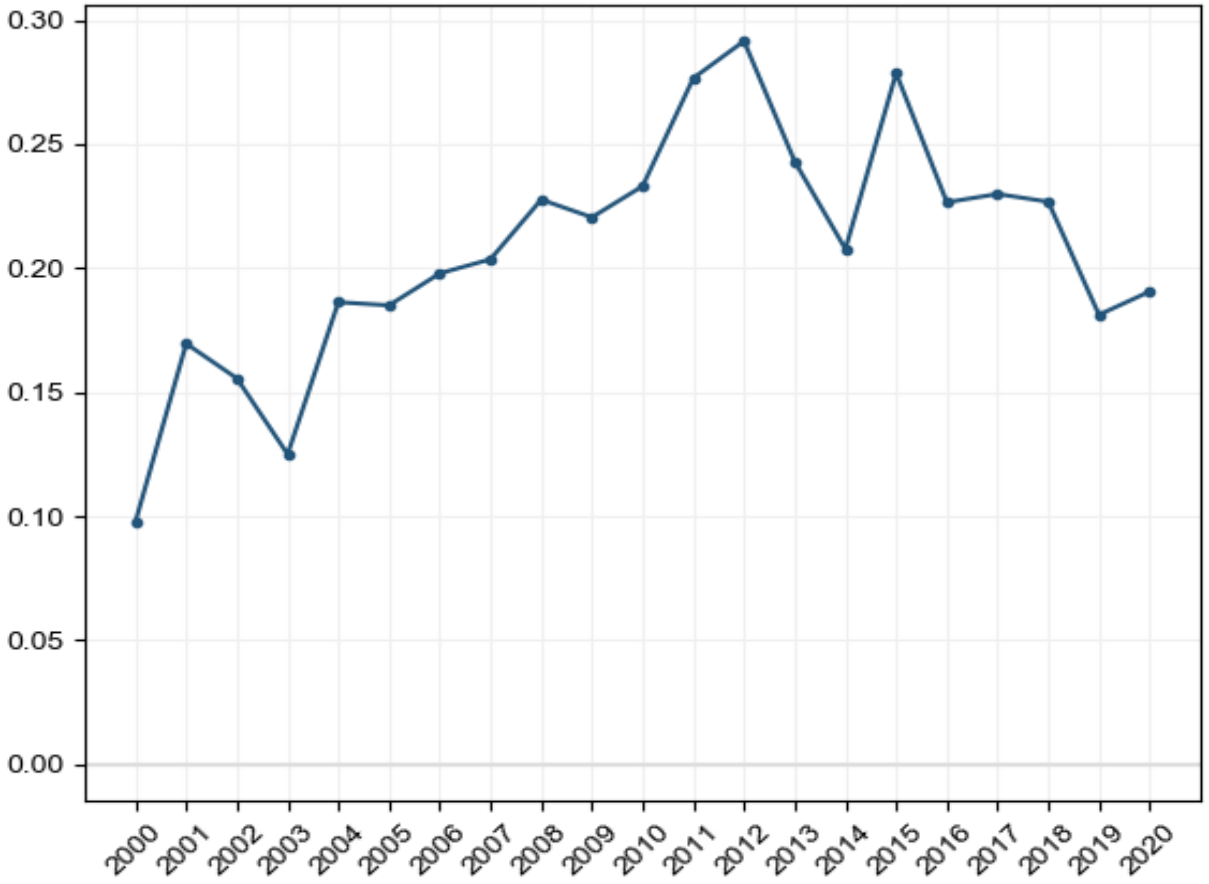

Corpus derivation
Pre-processing
Newspaper corpus
Nexis Uni
15,282 articles
2000-2020
Innovation corpus
e.g. Singh et al. (2020): Introduction to Advanced Combustion Techniques...
Named Entity Recognition (NER) with frequency based assignment
(Ahmad et al. 2013, Piotroski et al. 2020)
Topic modelling
topics
articles
...
words
...
topics
Calibration with distance measures
words
Inno topic
...
Unsupervised Latent Dirichlet Allocation (Blei et al. 2013)
Classification
VW, engine, fuel efficiency, emission
Topic: Innovation
Senti: + 0.1
Entity: Volkswagen
Publ: Financial Times
Date: 02-02-2012
Empirical operationalization
Media attention = inno articles / all articles per year
Sentiment = average senti of inno articles per year

Word cloud ICE innovation

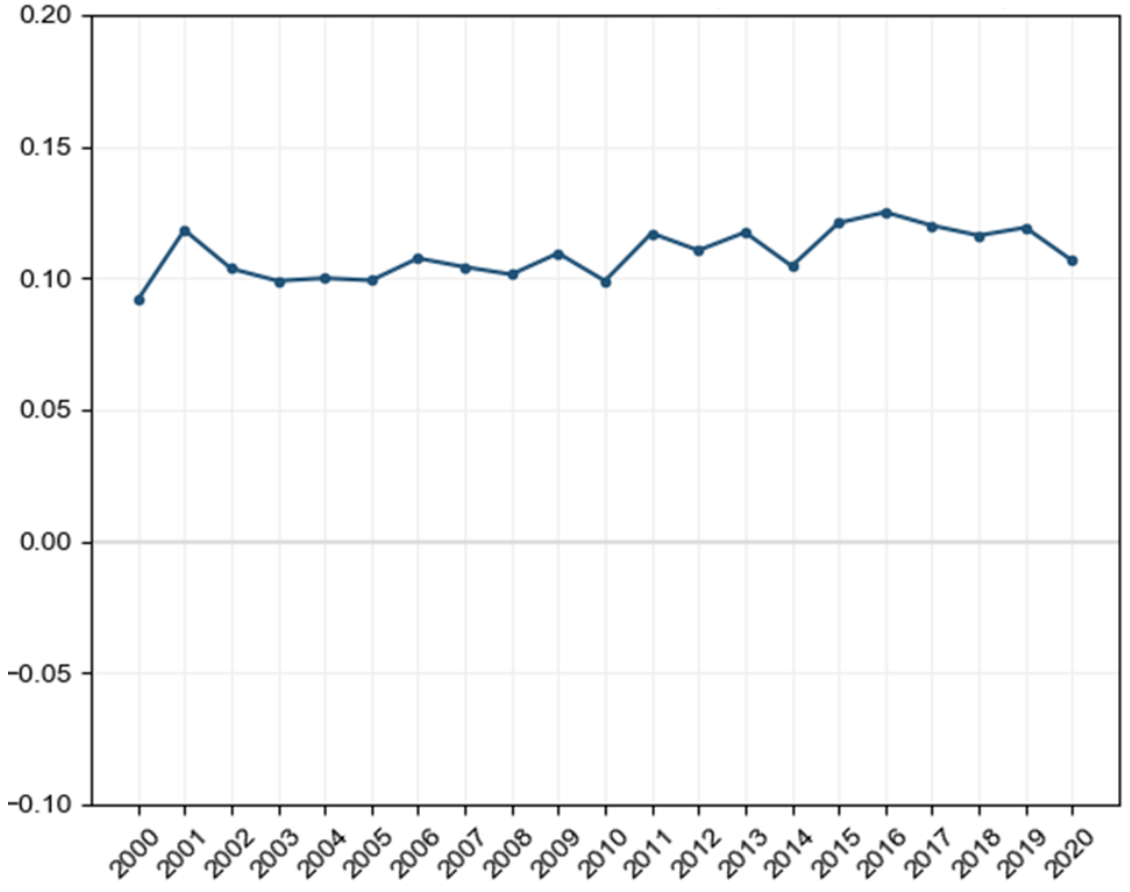


Indicator results for ICE, English newspapers 2000-2020

Share of innovation articles



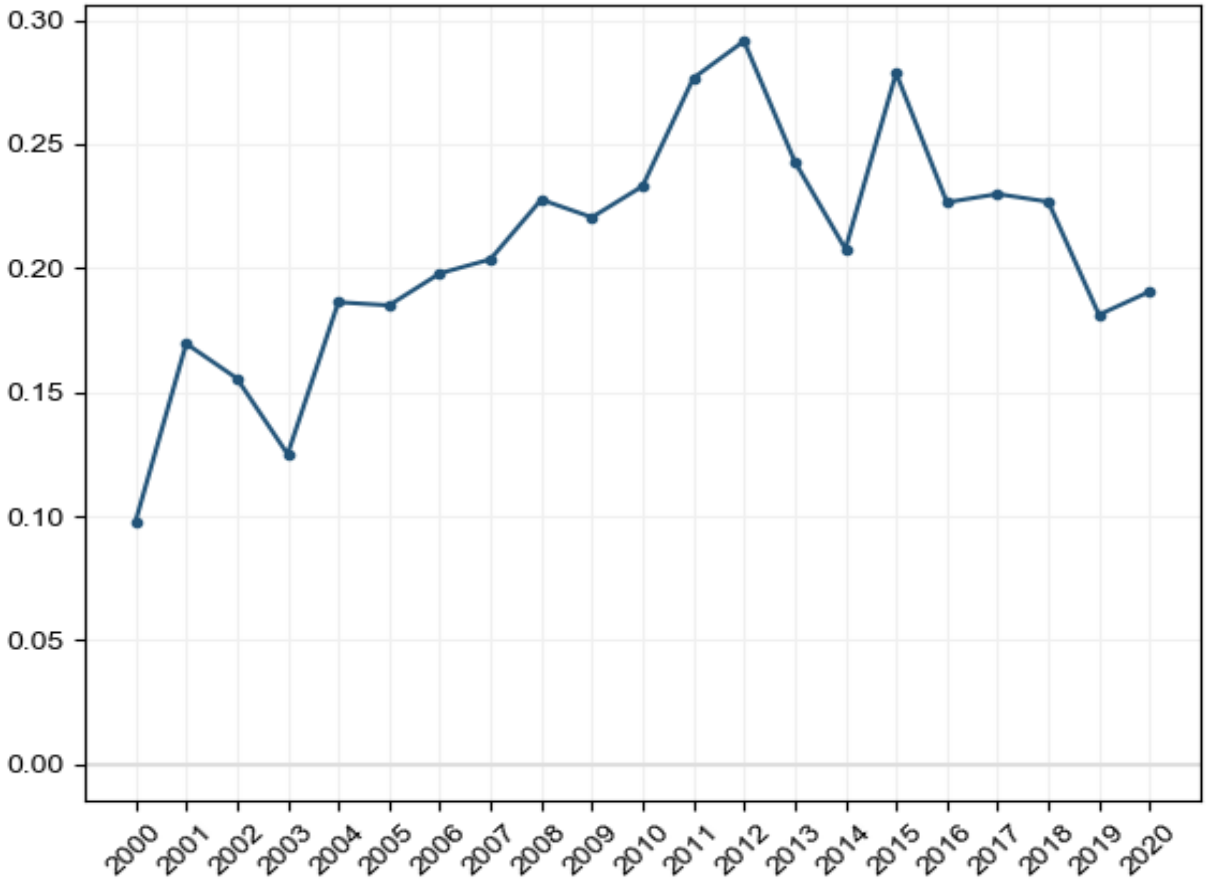
Sentiment

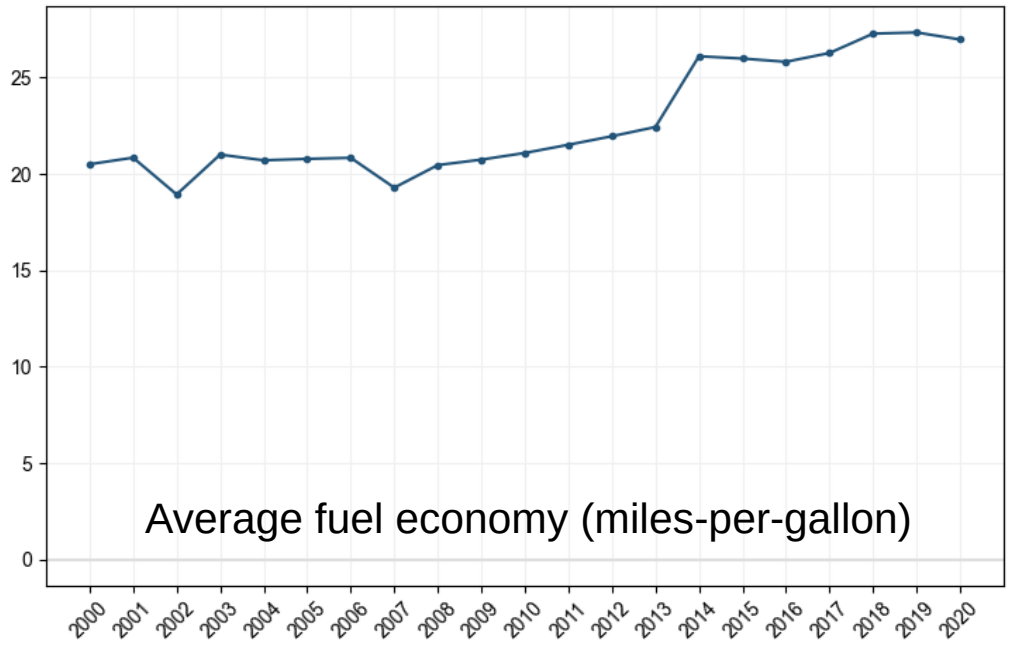


- **Decreasing trend after 2015, although positive sentiment.** Robust results.

Indicator results for ICE, English newspapers 2000-2020

Share of innovation articles



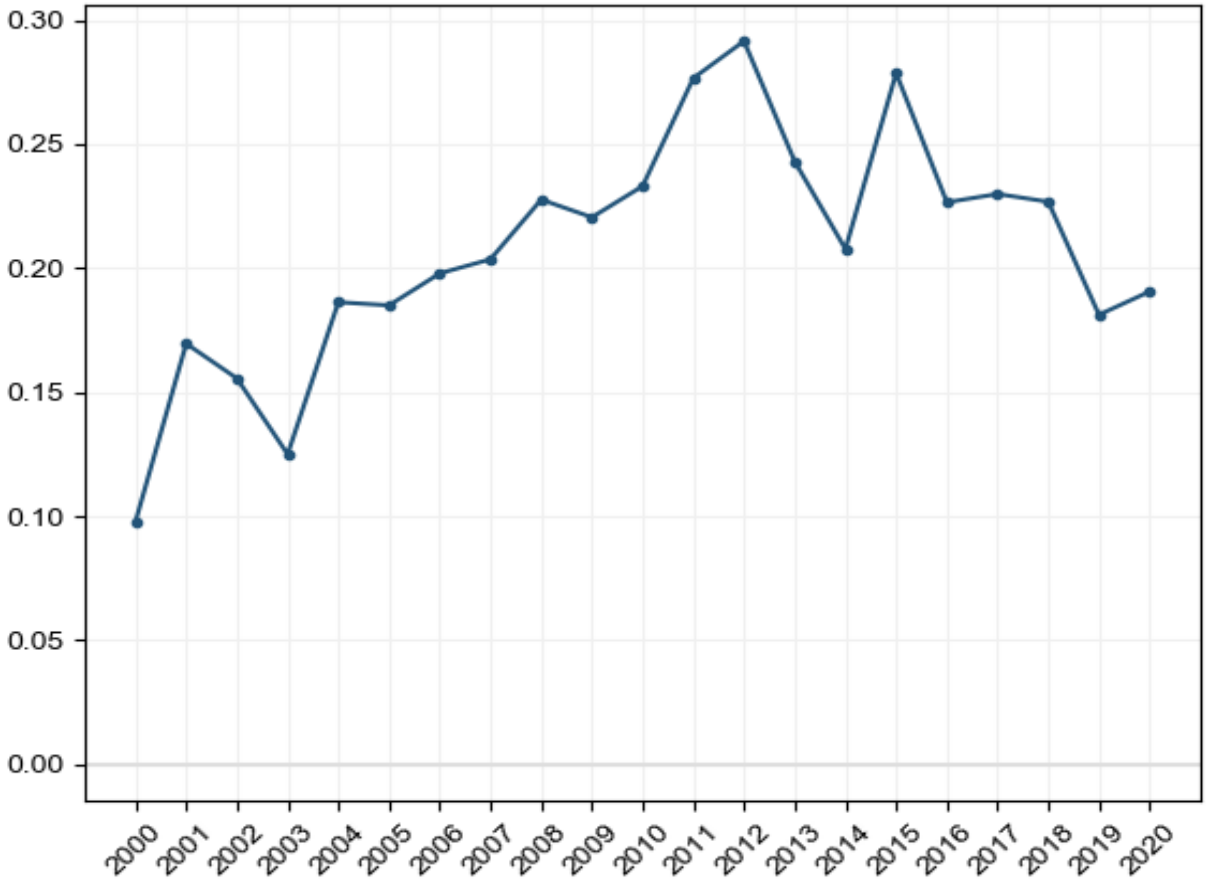


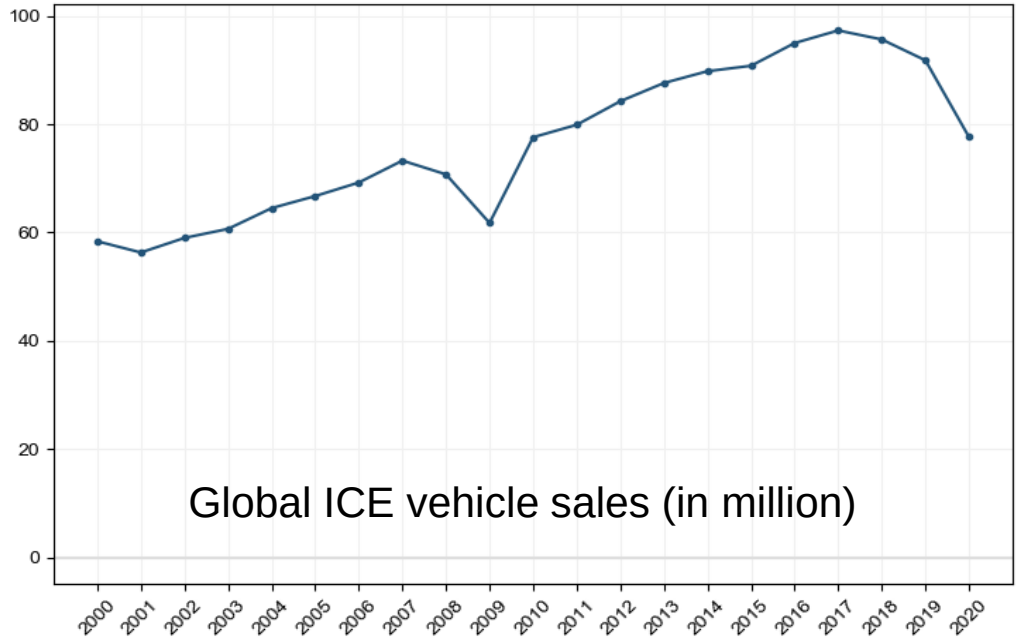
Source: EPA 2020 (filtered by cylinder count, model year average)

- **Decreasing trend after 2015, although positive sentiment.** Robust results.

Indicator results for ICE, English newspapers 2000-2020

Share of innovation articles





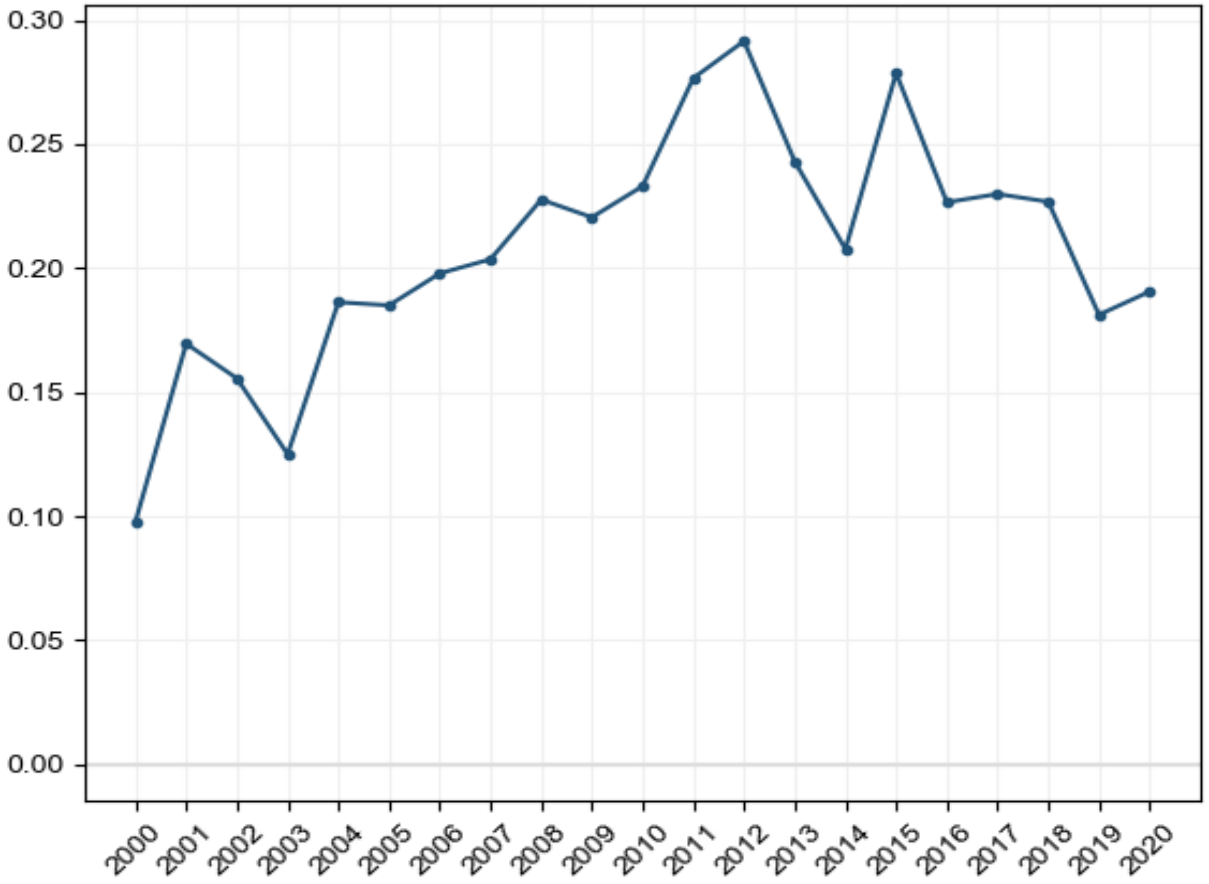
Global ICE vehicle sales (in million)

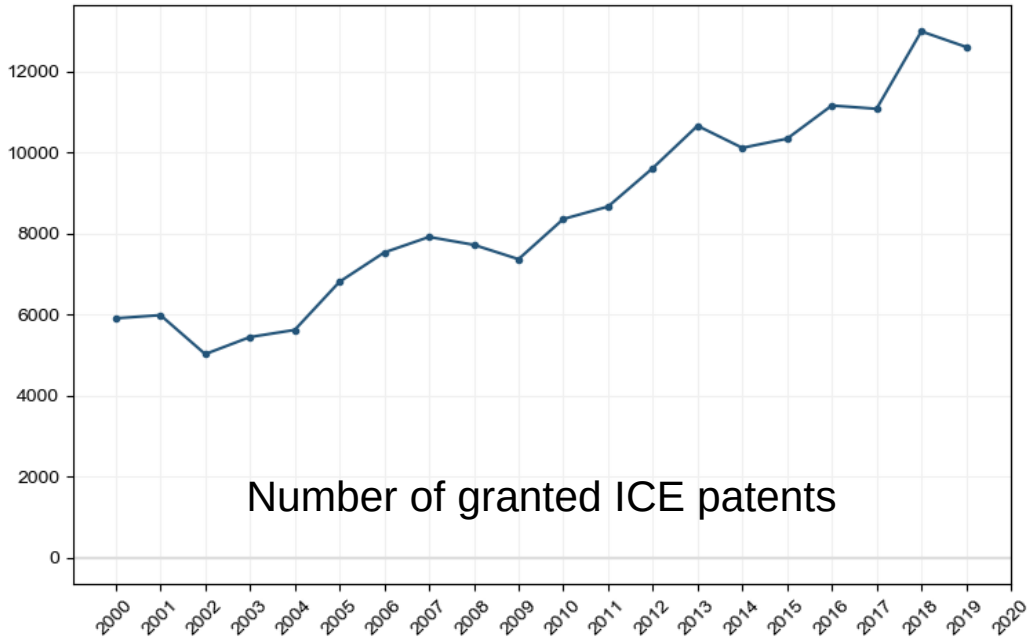
Source: IEA 2021

- **Decreasing trend after 2015, although positive sentiment.** Robust results.

Indicator results for ICE, English newspapers 2000-2020

Share of innovation articles





Number of granted ICE patents

Source: EPO (with IPC codes from Aghion et al. (2016))

- **Decreasing trend after 2015, although positive sentiment.** Robust results.

Indicator results for ICE, English newspapers 2000-2020

Firm	Total number of innovation articles	Average sentiment
Mazda	53	0,17
Bmw	50	0,16
Daimler	33	0,17
Wartsila	29	0,14
Honda	28	0,16
Infiniti	28	0,21
Ford	26	0,22
Peugeot	19	0,21
Achates	17	0,15
Hyundai	16	0,17

DISCUSSION & OUTLOOK

Discussion

➢Cost-efficient analysis, offering unique insights for decision-making

But:

- Still depended on ‚hands-on'-analysis
- How to expand to more ‚abstract' innovations - e.g., social innovations
- Integration with other methods and forward looking approaches needed (Weiss 2023)

Outlook – LLMs?

- Advanced NLP-tasks
  - Q&A
  - Chatbots
  - Text understanding?

- But trade-offs to traditional NLP-methods, e.g., blackboxing

- **Substitute to innovation researchers?**

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THANK YOU!

Dr. rer. pol. Daniel Weiss

Research group leader
„Market analysis, -design and innovation strategies“ (MGI)

Daniel.weiss@dlr.de
www.dlr.de/vf