Tipping the Parliamentary Talk, 
Sprinting the Climate Policy Walk

A Computational Content Analysis based on Natural Language Processing
of the Swedish Parliamentary Climate Debate 2010-2021
and the Evidence for and Transformative Potential for Social Tipping

Petter Bjersér

Sustainability Science (Master’s Thesis)
Stockholm Resilience Centre, Department of Biology, Stockholm University
Supervisors: Gustav Engström, Juan Rocha, Thomas Hahn, Stefan Daume
Word count: 9941
Table word count: 1000
Figure Word Count: 202
Pages 41(64)
Acknowledgements

This thesis would never have been realised had I not been invited to stand on the shoulders of giants, to whom I convey my gratitude,

Gustav Engström, for being my guide in the universe of Natural Language Processing
Ingo Fetzer, for introducing me to Gunvor the Great, a faithful companion
Juan Rocha, for arguing with me on the ontological nature of social tipping
Stefan Daume, for becoming the supervisor I needed but did not deserve
Thomas Hahn, for motivating me to pursue a qualitative approach
Abstract

Social Tipping Processes as a theory of social change can help understand, identify, and trigger social tipping in the Swedish Parliamentary Debate on Climate Change. Social tipping can unlock transformative policy pathways for decarbonisation, as a form of abrupt self-reinforcing social change in parliamentary debate. This thesis aims to describe topics of the Swedish Parliamentary Debate on Climate Change 2010-2021, understand how political salience affects the structure of debate, and identify barriers and potential for social tipping. Accordingly, a mixed-methods approach based on computational content analysis is applied to study patterns emerging from two natural language processing models, a deep learning classifier and a Structural Topic Model. The evidence for social tipping is mixed, and the mechanisms are complex and context-dependent processes. The diversity of the climate debate increased continuously throughout the decade. Since 2018, the intensity of climate debate has doubled from 2.5% to 5% of parliamentary debate due to increased political contention between governing parties. Simultaneously, voter perceptions indicate that climate change is becoming an essential and polarised political issue. Increased political salience can reflect climate debate on potentially transformative policies or indicate political polarisation generating lock-in to unsustainable policy pathways. The Green Transition will contribute to Sweden’s goal of becoming a fossil-free welfare state. If this constitutes a social tipping point in climate policy, net-zero targets need to be more stringent, and green transition should be fair.
Contents

1. Introduction: Social Tipping in Political Debate in the Swedish Parliament .............................................. 5
   1.1. Problem Statement and Aim .................................................................................................................. 5
   1.2. Research Strategy, Previous Research, Contribution, and Research Questions .................................. 5
2. Theoretical Framework ................................................................................................................................. 6
   2.1. Social Tipping to Stabilise the Earth’s Climate .................................................................................... 6
   2.2. Social Tipping Processes as a Theory of Political Change ................................................................. 7
   2.3. Political Salience of Parliamentary Debate, Public Opinion, and Policy Processes ............................ 8
   2.4. Contagion and Feedbacks: Mechanisms of Social Tipping in Parliamentary Debate ..................... 9
   2.5. The Swedish Climate Political Context .............................................................................................. 10
3. Research Design ......................................................................................................................................... 11
   3.1. Analytical Framework ......................................................................................................................... 11
   3.2. Choice of Methods .............................................................................................................................. 11
   3.3. Natural Language Processing Approach ............................................................................................ 12
   3.3.1. The Original Text Corpus of Parliamentary Speeches .................................................................... 12
   3.3.2. Generating the Climate Text Corpus using a Deep Learning Classifier .......................................... 13
   3.3.3. Training A Deep Learning Classifier on the Original Climate Corpus .......................................... 13
   3.3.4. Using the Deep Learning Classifier to Create a Climate Text Corpus .......................................... 13
   3.3.5. Implementing a Structural Topic Model based on the Climate Text Corpus ................................. 14
   3.4. Hierarchical Clustering and Visualisation of the Structure of Debate ................................................. 17
   3.5. Computational Content Analysis ........................................................................................................ 17
   3.6. Limitation of Methods ......................................................................................................................... 18
4. Results ....................................................................................................................................................... 19
   4.1. The Intensity, Party Influence, and Priorities of Climate Debate ....................................................... 19
   4.2. Topics and Themes of Climate Debate ................................................................................................. 21
   4.3. Political Salience of Topics of Climate Debate ..................................................................................... 24
   4.4. Political Salience and Structure of Parliamentary Debate .................................................................. 24
   4.5. Dynamics of Political Salient Topics and Intensity of Parliamentary Debate ...................................... 27
   4.6. Dynamic Representation: Voter’s Perceptions of the Politics of Climate Change .............................. 28
   4.7. Case Studies: Climate Debate as a Social Tipping Processes in Climate Policy .............................. 29
   4.7.1. Climate Targets: Increased Political Salience and Political Consensus .......................................... 30
   4.7.2. The Swedish Energy System: Declining Political Saliency and Increased Political Contention ........... 32
5. Discussion ................................................................................................................................................ 36
   5.1. Three Periods of Parliamentary Debate on Climate Change ............................................................ 36
   5.2. Contention and Polarisation drive intensification and diversification post-Paris ............................... 36

3
5.4. Case Studies: Social Tipping of Parliamentary Debate and Policy Transformations .......... 37
5.4.1. The Transformative Potential of Net-Zero Targets .................................................. 38
5.4.2. The Green Industrial Transformation at a Critical Juncture .................................. 39
5.4.3. Discussion of Methods ......................................................................................... 40
6. Concluding Remarks ................................................................................................. 40
7. Appendix .................................................................................................................. 42
7.1. Code Availability .................................................................................................. 42
7.2. The Swedish Context ............................................................................................ 42
7.3. Table 4 Swedish Election Results 2002-2018 ...................................................... 44
7.4. Figure 9 Climate Score Kernel Density Plot ....................................................... 45
7.5. Table 5 Probability of Word Explaining the Topic Based on Highest Probability Words (Swedish) .................................................................................................................. 46
7.6. Figure 10 Model Diagnostics STMs Topics 10 - 100 Incremented by 10 ............... 47
7.7. Figure 11 Political Salience of Different Topics By Party ........................................ 48
7.8. Figure 12 Hierarchical Clustering of Standardized Political Salience By Parliamentary Year and Party .............................................................................................................. 49
7.9. Table 6 Description of Clusters of Politically Salient Topics of Debate by Different Parties and Years .............................................................................................................. 50
7.10. Ethics Review – Final Review ............................................................................... 50
8. Publication bibliography .......................................................................................... 51
1. Introduction: Social Tipping in Political Debate in the Swedish Parliament

Social tipping in parliamentary climate debate can enable transformative policy pathways for deep decarbonisation to stabilise the Earth System (David Tàbara et al. 2018; Lenton 2020; Otto et al. 2020; Winkelmann et al. 2022). Social tipping is a particular form of rapid abrupt self-reinforcing social change that can facilitate sustainability transformations to achieve a safe and just future for all (Farmer et al. 2019; Westley et al. 2011; Olsson et al. 2014; Milkoreit et al. 2018; Muller et al. 2021; Rockström et al. 2021; Centola et al. 2018a; Nyborg et al. 2016; Folke et al. 2005).

1.1. Problem Statement and Aim

Sweden is not on track to meet its climate goals of net-zero emissions by 2045. To close the policy gap, the annual reduction in territorial greenhouse gas emissions must be at least 6-10% (Naturvårdsverket 2022; Karlsson and Gilek 2020). Social tipping in parliamentary climate debate can enable tipping cascades in climate policy and unlock transformative pathways of deep decarbonisation across all sectors, particularly, hard to abate sectors of transportation and heavy industry, responsible for roughly two-thirds of Sweden’s territorial greenhouse gas emissions (Davies et al. 2021; Naturvårdsverket 2022; Stadelmann-Steffen et al. 2021; Roberts and Geels 2019; Lenton 2020; Strauch 2020a; Sharpe and Lenton 2021b). This thesis aims to describe the Swedish parliamentary Debate on Climate Change 2010-2021, understand how political salience affects the structure of debate, and identify the barriers and enablers for social tipping in climate debate to realise sustainability transformations.

1.2. Research Strategy, Previous Research, Contribution, and Research Questions

The research strategy applies a mixed-methods approach based on computational content analysis to study patterns emerging from two natural language processing models, a deep learning classifier and a Structural Topic Model (Edelmann et al. 2020; Grimmer et al. 2021; Isoaho et al. 2021). Previous research applying Natural Language Processing methods analyse parliamentary debate on coal phase-out in the German Bundestag (Müller-Hansen et al. 2021) and shifts in media framing regarding the Energiewende (Dehler-Holland et al. 2021). Analysis of political speech using Structural Topi Models has shown that Norwegian members of parliament from less-oil dependent constituencies are more prone to advance green policies following an oil-price bust than their peers (FINSEERAAS et al. 2020). Research on the Finnish parliamentary debate 2008-2020 illustrates how dynamics of political polarisation influence the energy transition (Repo et al. 2021).
This study is among the first to study the Swedish parliamentary debate on climate change using natural language processing methods, contributing to the emerging field of computational social science (Grimmer et al. 2021). First, it describes changes in the intensity of parliamentary climate debate based on the influence of political parties and party priorities. Second, it interprets politically salient topics and themes of climate debate over time. Third, it identifies three periods of the parliamentary climate debate, pre-Paris, Paris, and Post-Paris. This structure of parliamentary debate is analysed based on the analytical framework, outlining the interplay between the political salience of parliamentary debate, public opinion, and policy processes. Fourth, it outlines two case studies to analyse the mechanisms of and potential for social tipping in climate debate to advance transformative policy pathways for decarbonisation. In this pursuit, it set out to answer the research question(s):

*How has the Swedish Parliamentary Debate on Climate Change 2010-2021 changed over time and with different political parties, and how can social tipping in parliamentary debate contribute to transformative policy pathways for decarbonisation?*

a) *How do the intensity, party influence, and party priorities on climate change debate change over time?*

b) *What are politically salient topics and themes of climate debate over time and with different parties?*

c) *How do changes in the political salience of climate debate interact with public opinion and policy processes, and how does this affect the overall structure of climate debate?*

d) *How can changes in the parliamentary debate on climate debate manifest as social tipping and achieve sustainability transformations?*

2. Theoretical Framework

This section outlines the theoretical origins and definitions of social tipping, political salience, and mechanisms of social tipping as a process, political science, and public policy.

2.1. Social Tipping to Stabilise the Earth’s Climate

Current trajectories of planetary-scale environmental degradation and climate change, risk destabilising the biosphere with compounding threats to human lives, livelihoods, economies, ecosystems, and societies (IPCC 2021). Natural tipping points are instances of self-reinforcing abrupt change at global and regional scales of the climate system or the biosphere. At current emissions pathways, the risk of unleashing dominoes of tipping cascades across natural systems
cannot be disregarded (Lenton et al. 2008; Schellnhuber 2009; Steffen et al. 2018; Boers and Rypdal 2021; Wunderling et al. 2021; IPCC 2021; Juan Rocha et al. 2018).

Social Tipping is defined as “the point or threshold within a social-ecological system (SES) at which a small quantitative change inevitably triggers a non-linear change in the social component of the SES, driven by a self-reinforcing positive feedback mechanism, that inevitably and often irreversibly lead to a qualitatively different state of the social system” (Milkoreit et al. 2018).

Social tipping can facilitate cascades of cross-scale transformations (Watts 2011; Winkelmann et al. 2022; Otto et al. 2020; Simon Levin et al. 2018) through upward scaling of climate policy and technological diffusion across sectors (Sharpe and Lenton 2021a; Roberts and Geels 2019; Strauch 2020a; Halleck Vega and Mandel 2018; Miyamoto and Takeuchi 2019), policy-diffusion and feedbacks across sub-national, national, supra-national and international climate politics (Stadelmann-Steffen et al. 2021; Otto et al. 2020; Farmer et al. 2019; Davies et al. 2021; Strauch 2020b; Millar et al. 2021; Lockwood et al. 2017; Kammerer and Namhata 2018), and norm-diffusion across social networks such as public opinion, behaviour, institutions, and social movements (Jagers et al. 2020a; Chenoweth and Belgioioso 2019; Centola et al. 2018a; Termeer et al. 2017; Berger 2021).

2.2. Social Tipping Processes as a Theory of Political Change
Social Tipping Processes Winkelmann et al. 2022 can be applied as a theory of social change to understand, identify, and potentially navigate social tipping in parliamentary debate (Farmer et al. 2019; Winkelmann et al. 2022; Milkoreit et al. 2018; van Ginkel et al. 2020). This definitional framework analyses social tipping towards climate action within and across social-ecological networks. The parliamentary debate on climate change is a social network and a complex adaptive system conducive to social tipping (Holling 2001; Levin et al. 2013; Macy et al. 2021) Social tipping in the parliamentary debate occurs at a critical threshold, where a perturbation or intervention can transform a system into a qualitatively different, quasi-stable state, or onto an entirely novel pathway (Leonard et al. 2021; Winkelmann et al. 2022).

I draw on Winkelmann et al. 2022 to argue that social tipping is ontologically different from natural tipping as (i) agency is a primary social driver, (ii) social networks are both material and ideational (iii) change transpires across different spatial and temporal scales, and (iv)
processes are more complex and unpredictable (Song et al. 2005). Causation in the parliamentary debate is a complex adaptive systems phenomenon, and social change emerges from numerous, interacting, and distributed causes across scales (Preiser et al. 2018; Schlüter et al. 2019; Thurner et al. 2018). Social tipping in the climate debate must further ambitious climate action, occur within decades, or have impacts that are relevant to ethical considerations for centuries.

Concurrent with Winkelmann et al. 2022, I propose that the primary mechanisms of social tipping processes are contagion and feedback. Social change is conceived as cascading network effects, altering the structure of a social network according to a harmonising or polarising dynamic (Otto et al. 2020; Winkelmann et al. 2022). Social tipping in the parliamentary debate can manifest through the diffusion of consensus resulting in political harmonisation or contentious politics that drive polarisation, with profound context-specific impacts on transformative policy outcomes (Winkelmann et al. 2022; Vasconcelos et al. 2019; Kammerer et al. 2021; Leonard et al. 2021; Macy et al. 2021).

2.3. Political Salience of Parliamentary Debate, Public Opinion, and Policy Processes

Polarising and harmonising dynamics of climate politics influence the political salience of parliamentary debate on climate change (Axelrod et al. 2021; Leonard et al. 2021; Macy et al. 2021; Perrings et al. 2021; Vasconcelos et al. 2019). Political salience is the extent to which parliamentarians representing political parties cognitively and behaviourally engage with political issues on climate change at a particular point in time (Wlezien 2005; Wlezien and Moniz 2020).

The political salience of parliamentary climate debate results from an interplay between public opinion and policy processes (Wlezien 2017; Stimson et al. 1995b; Wlezien 2005; Sevenans 2021; Linde and Peters 2020; Page and Shapiro 1983). This interplay is impacting the political agendas of political parties (Greer 2015), outcomes from policy processes (Weible and Sabatier 2018) and the windows of opportunity that arise from socio-ecological and socio-political shocks (Herrfahrdt-Pähle et al. 2020; Folke et al. 2005; van Ginkel et al. 2020; Kopp et al. 2016). These dynamics are fundamental to identifying, understanding, and navigating the barriers or enablers of social tipping (Winkelmann et al. 2022) and the prospects to advance transformative policy pathways to decarbonise the Swedish economy and global climate action.
under the Paris Agreement (Bäckstrand et al. 2019; FALKNER 2016; Barrett 2016; Keohane and Victor 2016).

2.4. Contagion and Feedbacks: Mechanisms of Social Tipping in Parliamentary Debate

Contagion and feedback, the mechanisms of social tipping processes (Winkelmann et al. 2022; Otto et al. 2020), are closely related to mechanisms in political science and public policy that shape policy processes (Weible and Sabatier 2018) and policy agendas (Greer 2015). Feedbacks and contagion can accelerate and hinder the low-carbon transition (Rockström et al. 2017).

The Swedish Parliament is a social network nested within national party politics, interest groups, supra-national politics, and international markets. Social tipping can manifest in social networks by spreading social phenomena via simple contagion, propagation through pairwise interactions, or complex contagion, propagation that requires reinforcements from multiple interactions (Vasconcelos et al. 2019; Centola and Macy 2007). Simple and complex contagion of social phenomena such as norms, attitudes, behaviours, ideas, policies, and technologies, can diffuse within a population and reach a critical mass (Wiedermann et al. 2020; Centola and Macy 2007; Granovetter 1978, 1973; Schelling 1971), with the potential to instigate social tipping for transformation or support lock-in to the status quo (Otto et al. 2020; Nyborg et al. 2016; Berger 2021; Marquardt and Nasiritousi 2021; Seto et al. 2016; Vasconcelos et al. 2019).

Experimental evidence on social movements suggests that 25% of a population can represent a critical mass (Centola et al. 2018b), and others argue that a committed minority of 3.5% can instigate wide-ranging societal change (Chenoweth and Belgioioso 2019; Gladwell 2002; Rockström et al. 2017). Large-scale tipping points in collective action could enable sustained and effective cooperation to address climate change (Jagers et al. 2020a; Bak-Coleman et al. 2021; Granovetter 1978).

In representative democracies, policy outcomes should represent the public opinion (Dahl 1973; Pitkin 1972) as ensured through dynamic representation and reflected through feedbacks on policy processes and agendas (Greer 2015; Weible and Sabatier 2018; Stimson et al. 1995a).

Dynamic representation requires that officials are chosen in free and fair elections and that they are responsive to changes in public opinion (Stimson et al. 1995b; Page and Shapiro 1983). Policy feedbacks emerge as public opinion responds to policy decisions and implementation
Policy feedbacks can be self-reinforcing as successful policies strengthen public support for similar policies in the future or stabilising as policy implementation suffers from diminishing returns in public opinion (Pierson 1993). Policy feedbacks have the potential to create or support the political status quo (Pierson 1993) through path-dependency (Pierson 2000) or generate new pathways (Lockwood et al. 2017) enabling conditions for future sustainability transformation such as the low-carbon transition (Roberts and Geels 2019). Interest groups are an integral part of issue formulation in representative democracies. The political interest feedback emerges as specific policies give rise to powerful interest groups that advance climate policy through active advocacy, targeting decision-makers, competing interests, and influencing public opinion (Moore et al. 2022).

2.5. The Swedish Climate Political Context

For readers unfamiliar with the Swedish political system or Swedish climate politics, see background in the Appendix 7.1 The Swedish Context and Table 4 Swedish Election Results 2002-2018
3. Research Design
This section presents the research design based on the analytical framework, choice of methods and method limitations.

3.1. Analytical Framework

![Analytical Framework Diagram]

*Figure 1 Analytical Framework*

The Analytical Framework in Figure 1, outlines socio-ecological system interactions between public opinion and policy processes, representing the macro-level, parliamentary debate on the meso-level, and underlying mechanisms of social tipping processes, spanning the across levels and cross-scales.

3.2. Choice of Methods
The research strategy is four-fold and relies on computational content analysis to analyse patterns of parliamentary debate from two natural language processing models (Isoaho et al. 2021; Grimmer et al. 2021; Roberts et al. 2019). First, a deep learning classifier developed by Supervisor Gustav Engström is trained to identify parliamentary speech on climate change from transcripts of the Swedish Parliamentary Debate 2010-2021 to create a Climate Text Corpus (SpaCy 3.0 2022). Second, a Structural Topic Model (STM) is specified to generate word clusters from the Climate Text Corpus and interpret topics and themes based on climate debate (Roberts et al. 2019). Third, hierarchical clustering discerns the structure of parliamentary
debate based on clusters of politically salient topics for different parliamentary years. Fourth, the dynamics of two politically salient topics are analysed in qualitative case studies to evaluate the potential for social tipping, drawing on *social tipping as a process* (Winkelmann et al. 2022).

### 3.3. Natural Language Processing Approach

![Natural Language Processing Approach Diagram](image)

*Figure 2 Natural Language Processing Approach*

The Natural Language Processing approach has two steps. Initially, a deep-learning classifier is trained, and the data is described. Thereafter, a structural topic model is specified, evaluated, estimated, and interpreted, see Figure 2.

#### 3.3.1. The Original Text Corpus of Parliamentary Speeches

The Original Text Corpus contains transcripts of parliamentary speeches in the Swedish Riksdag 2010-2021, representing parliamentary debate. Table 1. Transcripts can be accessed through Riksdagens Open API and contain complete records of parliamentary speeches
(“änföranden”) and meta-data such as speech-id, day of the speech, parliamentarian, party affiliation, and title. Professional stenographers transcribe parliamentary speeches, each representing a unique address in parliament, and organise different topical segments of speech into paragraphs (Riksdagen 2022).

3.3.2. Generating the Climate Text Corpus using a Deep Learning Classifier

The Climate Text Corpus is generated using a supervised deep-learning classifier developed by Gustav Engström in Python module SpaCy 3.0 2022. The deep learning classifier utilises a Swedish transformer and attributes a climate score to each sentence of the Original Text Corpus (Huggingface.co 2022; KB.se 2022). Transformers are a family of neural networks used to recognise written text's meaning and semantic properties (Wolf et al. 2019). The deep learning classifier was trained and evaluated through a collaborative and iterative process.

The Climate Text Corpus is created based on climate paragraphs, paragraphs containing at least one sentence with a climate score > 0.99. Figure 9 in the Appendix shows a distribution of climate sentences in the Original Text Corpus. Climate paragraphs are parts of parliamentary speech that explicitly concern climate change with enough detail to capture the context of the debate. Manual inspection of the paragraphs indicates that the stenographer’s classification of paragraphs broadly aligns with natural speech and specific themes. Mistakes are rare and assumed not to affect the model's reliability.

3.3.3. Training A Deep Learning Classifier on the Original Climate Corpus

The deep learning classifier is trained on a sub-set of sentences identified using pattern matches and manual binary coding of paragraphs and sentences (N=25918) from the Original Text Corpus. The classifier’s ability to distinguish between climate and non-climate sentences is evaluated by Gustav Engström, using Area Under the Curve for the Receiver Operator Characteristic (AUC-ROC), plotting the probability curve of the true positive rate against the false-positive rate and estimating the area under the curve (Hanley and McNeil 1982; Bradley 1997; Melo 2013). The model is trained based on 25918 sentences and evaluated against 6480 sentences from the Original Text Corpus with a ROC AUC = 0.99. The deep learning classifier’s model score indicates a 99% chance of correctly classifying each sentence.

3.3.4. Using the Deep Learning Classifier to Create a Climate Text Corpus

The Climate Text Corpus is made from climate paragraphs (N=49622) containing at least one sentence with a climate score > 0.99 (N=75724), see Table 1. Climate sentences (N=75724)
represent 40% of all sentences in the Climate Text Corpus (N=187857) and 6.41% of the total number of sentences in the Original Text Corpus (N=2931641). Climate paragraphs represent 5.56% of all paragraphs (N=891755). Parliamentary speeches mentioning climate change (N=18964) represent 14.07% of all speeches in parliament (N=134766).

**Table 1 Original and Climate Text Corpus**

<table>
<thead>
<tr>
<th>Text</th>
<th>Climate Text Corpus</th>
<th>Original Text Corpus</th>
<th>Share of Original Text Corpus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Sentences</td>
<td>75724</td>
<td>75724</td>
<td>100%</td>
</tr>
<tr>
<td>Sentences</td>
<td>187857</td>
<td>2931641</td>
<td>6.41%</td>
</tr>
<tr>
<td>Paragraphs</td>
<td>49622</td>
<td>891755</td>
<td>5.56%</td>
</tr>
<tr>
<td>Speeches</td>
<td>18964</td>
<td>134766</td>
<td>14.07%</td>
</tr>
</tbody>
</table>

The Climate Text Corpus in Table 1 is used to describe the parliamentary debate on climate change based on intensity, the average share of climate paragraphs out of all paragraphs, party influence, the average share of climate paragraphs by each party out of all paragraphs and party priorities, the average share of climate paragraphs by each party out of paragraphs for each party.

3.3.5. Implementing a Structural Topic Model based on the Climate Text Corpus

Structural Topic Models (STMs) are semi-supervised machine learning models that build on previous generative word count models such as the LDA (Blei et al. 2003) through the inclusion of metadata to generate topics in the form of word clusters (Roberts et al. 2019). The Structural Topic Model is fit using climate paragraphs (N=49622) from the Climate Text Corpus as documents. Climate paragraphs are used to capture enough context, whereas sentences lack enough detail, and complete parliamentary speeches often concern many different subjects. Moreover, the model fitting includes co-variates of party affiliation and days from the opening of parliament in 2010 to capture changes in political salience in time.

The STM attributes a probability of each climate paragraph (document) belonging to a latent number of topics belonging to a latent number of topics (Grimmer et al. 2021). Topics of the climate debate represent an admixture of word clusters “where each word has a probability of belonging to a topic”, and each climate paragraph (document) “is a mixture over topics” and has a probability of explaining a topic (Gamma value). Both “word probabilities for a given
topic” and “topic proportions across all topics” for a climate paragraph sum to one (Roberts et al. 2019; Grimmer et al. 2021).

The Structural Topic Model is specified through an iterative process based on model diagnostics and interpretation to motivate the use of a specific number of topics to represent the climate debate. Pre-processing removes stop words based on a Swedish stop word vocabulary, custom stop words from a political-speech vocabulary, and specific stop words with names of parliamentarians’ names and words of general parliamentary speech.

3.3.6. Structural Topic Model Interpretation and Estimation

Structural Topic Models generate topics by different word clusters based on words that are the highest probability of belonging to a topic (prob), frequent and exclusive to a topic (FREX), and log frequency with a topic compared to other topics (score) (Roberts et al. 2019). Topics generated by the STM are interpreted inductively, focusing on word clusters’ highest probability, FREX, and score. Topics represent different parliamentary debates on climate change and are categorised into overarching themes (Lucas et al. 2015; Edelmann et al. 2020; Carlsen and Ralund 2022; Isoaho et al. 2021; Nelson 2020; FINSEERAAS et al. 2020; Müller-Hansen et al. 2021; Roberts et al. 2019). The political salience of climate topics is operationalised based on expected topics proportions, the expected share of the Climate Text Corpus that belongs to a topic relative to other topics for each party at a point in time (Roberts et al. 2019). The Structural Topic Model is evaluated based on model diagnostics, optimising topic quality, maximising for high semantic coherence and exclusivity, and model fit, maximising for high held-out likelihood and small residuals (Roberts et al. 2019).

3.3.7. Structural Topic Model Specification and Selection

Specifying an appropriate number of topics for the Structural Topic Model is an iterative and interpretative process. First, the STMs are specified based on a broad number of topics (K=10-100, incremented by 5) to evaluate model diagnostics of STMs with few and many topics, see Figure 10 in Appendix. The second round of model specification increased granularity and narrowed the set of topics (K=25-65, incremented by 1), see Figure 3. Based on model diagnostics, Figure 3 shows two alternatives for STM estimation, a model with fewer topics (K=30) or one with more topics (K=53). The STM with fewer topics (K=30) performs well in terms of topic quality as it preserves semantic coherence at relatively high levels of exclusivity,
and *model fit* maximises held out likelihood at the cost of larger residuals. The STM with a greater number of topics (K=53) optimises *topic quality* for exclusivity, achieving relatively small gains at the cost of deteriorating semantic coherence. *Model fit* improves in terms of smaller residual but at the cost of held-out likelihood.

The smaller model (K=30) is chosen for the STM estimation, maximising held-out likelihood, maintaining semantic coherence at a higher level, and achieving high levels of exclusivity. The smaller model comes at the cost of larger residuals. Higher residuals are not a great concern as the interpretation of the larger model showed that it included many topics of everyday parliamentary debate that are not of interest to the analysis.

---

*Figure 3 Model Diagnostics STMs (K =25-65, incremented by 1) Exclusivity increases until K=53, Held-Out Likelihood decreases from K=30, Residuals decreases from K =24, and Semantic Coherence is decreasing dramatically from K=30 before stabilising.*
3.4. Hierarchical Clustering and Visualisation of the Structure of Debate

The structure of parliamentary debate is visualised using hierarchical clustering with Euclidean distance. Expected topic proportions are aggregated by parliamentary year and standardised using min-max normalisation. This represents the aggregated political salience of topics of climate debate for each parliamentary year and party, respectively. The data is visualised using r-Package pHeatmap based on a two-dimensional dendrogram of co-occurrence of topics that are politically salient within and across parliamentary years (RDocumentation.org 2022). The number of column breaks representing topic clusters, and row breaks, representing clusters based on year, party, or party and year, are determined iteratively to best represent the patterns that emerge from the data.

3.5. Computational Content Analysis

Patterns emerging from Natural Language Processing methods of deep learning and machine learning are analysed using interpretive computational content analysis and qualitative case studies. This computational social science approach is applied to discover and measure new concepts (Edelmann et al. 2020) emerging from the analysis of big-text data transcripts of the Swedish Parliamentary Debate 2010-2021 (Grimmer et al. 2021; Isoaho et al. 2021).

Interpretive computational content analysis is applied to the patterns emerging from the Structural Topic Model to suggest climate debate topics and themes based on word clusters (Drisko and Maschi 2016; Rocha and Daume 2021). Interpretation and categorisation of word clusters are inspired by the pattern detection and refinement steps from computational grounded theory (Nelson 2020; Carlsen and Ralund 2022). The interpretive content analysis utilises word clusters as connotative codes “based not on explicit words but the overall or symbolic meaning of phrases or passages” to suggest topics and categorise these into themes and topic clusters to create perceivable concepts reflective of the Swedish Parliamentary Climate Debate (Isoaho et al. 2021; Drisko and Maschi 2016).

The structure of the climate debate is interpreted from the results of hierarchical clustering and the analytical framework. This outlines politically salient clusters of debate over time and with political parties. Qualitative case study analysis is applied to two parliamentary debate topics with rapidly increasing or decreasing levels of political salience. Case studies are informed by segments of parliamentary speech with a high gamma-value, the probability of a paragraph being explained by a topic (Roberts et al. 2019). The two case studies draw on the analytical
framework and social tipping as a process to evaluate the potential for social tipping, or risk of lock, in debate and prospective transformative policy pathways (Engel et al. 2021; Drisko and Maschi 2016; Grimmer et al. 2021; Hyett et al. 2014; Flick 2022).

This process is informed by a constructivist epistemological approach to qualitative text analysis by Schreier 2012 and Schreier 2014, that seeks to expand and enlarge the original text data by including latent content to explicate meaning and nuance, to generate claims about the transformative potential of climate debates beyond the original data (Drisko and Maschi 2016; Flick 2022).

3.6. Limitation of Methods
Computational Content Analysis captures coarse-grained patterns of parliamentary debate. The deep learning classifier is based on manual coding and a subjective understanding of what constitutes climate sentences and paragraphs. A conservative interpretation of climate speech reduces the model's noise, implicating the generation of the Climate Text Corpus. The Structural Topic Model represents climate debates as static word clusters that are insensitive to natural speech variations over time (Roberts et al. 2019; Blei et al. 2003). For more extended time series, state-of-the-art natural language processing methods such as Dynamic Embedded Topic Models have been applied to capture continuous features of vocabulary terms and topics (Dieng et al. 2019).

The Political Salience of climate debate topics from the Structural Topic Model does not uncover party positions, dynamics of contention or consensus, or policy outcomes. Interpretive content analysis and qualitative case study analysis introduce bias, subjectivity, and the researcher's positionality at the heart of the analysis. Connotative coding could benefit from expert solicitation and collaboration with researchers to improve the “identification of latent information” and ensure a more replicable process (Drisko and Maschi 2016).
4. Results
This section presents the results from computational content analysis and Natural Language Processing Models based on parliamentary transcripts. First, it describes changes in the intensity of parliamentary climate debate due to the influence of political parties and party priorities. Second, it identifies politically salient topics and themes of climate debate over time. Third, it identifies three periods of the climate debate, pre-Paris, Paris, and Post-Paris, contextualised with the analytical framework. Fourth, two case studies analyse the mechanisms of and potential for social tipping in the parliamentary debate to advance transformative policy.

4.1. The Intensity, Party Influence, and Priorities of Climate Debate,
Figure 4 shows the intensity of the Climate Debate between 2010-2021 and political events.

![Figure 4 Intensity of Climate Debate (Rolling 90-day average share of climate paragraphs out of all paragraphs) Highlighting Important Political Events from 2011-04-01 to 2021-01-01]
Following the failure in Copenhagen in 2009, the debate intensified, leading to the 2012 decision at COP17 in Durban to start negotiations on a new international climate agreement (Maizland 2019). In late 2013 just before COP18 in Doha, the intensity of debate peaked at 4%. During the electoral campaign and the first two years of the new Social Democratic and Green Party Government, Löfven I, the debate stabilised at around 3% - 3.5%. The Paris Agreement seems to have depoliticised the issue, as debate declined to its lowest point after COP22 in Marrakesh in November 2016.

It was not until one year later, subsequent COP23 in Bonn/Fiji, the entry into the force of the Swedish Climate Law on January 1st, 2018, and during the 2018 electoral campaign, that intensity of debate increased from around 2.5% to 3.8%. After a summer of serve forest fires, Greta Thunberg’s School strikes, an ambiguous election outcome, protracted government negotiations, and the formation of Löfven II based on the centrist January Agreement, intensity peaked above 5% just before COP25 in Madrid. In early 2020, debate stabilised below 4% and picked up again around the time of the WHO declaring COVID-19 a global pandemic.

Figure 5 shows each party’s engagement in parliamentary debate from 2011 to 2021 as (1) the influence of a party in the debate and (2) the degree to which parties prioritise climate debate. Before the 2014 elections, the Centre Party, and the Green Party, were most influential in the debate, followed by Moderates, the Social Democrats, and the Left Party. The Green Party has the most considerable focus on climate issues, followed by the Centre Party and the Left Party. Interestingly, the Moderates and Social Democrats are influential in the debate due to their overall influence in parliamentary debate, without prioritising the issue. Throughout the Löfven I government, the coalition partners are most influential in the debate. The Green Party extended its priorities beyond climate issues as the share of climate debate fell to around 10%. The Moderates, the Centre Party, and the Left Party become less influential in the debate, as they appear to be shifting focus towards other issues.

In early 2018, the Green Party strengthened its priority on climate issues, as the share increased to 15% by the time of the elections and gained increased influence in the climate debate together with the Left Party. As the January Agreement resolved the government stalemate in early 2019, most parties increased their priority on climate issues, resulting in more diverse engagement throughout parliament. The Social Democrats and the Moderates achieved additional influence,
indicating renewed engagement from the political opposition, and the Green Party and the Left Party became less influential despite increasing their prioritisation on the issues.

![Figure 5](image)

*Figure 5 - Party (Influence) on Climate Debate (* of climate paragraphs by each party out of all paragraphs) & Party (Priority) of Climate Debate (* of climate paragraphs by each party out of paragraphs for each party) Rolling 90-Day Average Share* from 2011-04-01 to 2021-01-01

4.2. Topics and Themes of Climate Debate

Six overarching themes of climate policy debate are induced using the STM with few topics (K=30), see A Table 5 and Table 2. Swedish Climate Politics (1,4,5,8,13,16,17,27) captures parliamentary debate on the political dimensions of climate change on the domestic level. Swedish Climate Policy (7,9,10,11,12) covers topics of climate policy debate that are too few to form separate themes. The Economy and Economics of Climate Change (14,24,25,29)
captures debate related to economic policies, the economics of climate change, and budget matters, Energy (19,22,28) captures debate on the energy and electricity system, Transport (6,15, 20,21,23) relates to the transport system, and International Climate Policy and Politics (1,2,3,18,26) concern international climate policy debate. Topic 30 captures general parliamentary debate and is not considered.
<table>
<thead>
<tr>
<th>Topic #</th>
<th>Theme</th>
<th>Topic Name</th>
<th>Highest Probability Words</th>
<th>Frequent and Exclusive Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Swedish Climate Politics</td>
<td>Effects of Climate Change</td>
<td>climate change, people, measure, world, effects of climate change, global challenges</td>
<td>climate change, the threat, threat, natural disaster, threat, conflicts, IPCC</td>
</tr>
<tr>
<td>2</td>
<td>International Climate Policy and Politics</td>
<td>EU Directives and Regulations</td>
<td>should, EU's, consider, commission, a, rules, regulations, power</td>
<td>the directive, June, green book, missing, implement, legislation, the green book</td>
</tr>
<tr>
<td>3</td>
<td>International Climate Policy and Politics</td>
<td>European &amp; Nordic Cooperation</td>
<td>European, cooperation, arctic, council, Nordic, areas, Sweden</td>
<td>Nordic, arctic, Nordic countries, cooperation, Nordic, short-lived</td>
</tr>
<tr>
<td>4</td>
<td>Swedish Climate Politics</td>
<td>Climate Change, Politics, and Parties</td>
<td>climate, responsibility, the climate change issue, political, seriousness, read, parties</td>
<td>the climate change issue, politicians, serious, Greta, political, affid, engagement</td>
</tr>
<tr>
<td>5</td>
<td>Swedish Climate Politics</td>
<td>Government Proposals and Regulations</td>
<td>government, proposal, response, regulation, government's, parliament, concrete</td>
<td>take (action), asked, concrete, intention, begin, response, supporting materials</td>
</tr>
<tr>
<td>6</td>
<td>Transport</td>
<td>Private Cars and Low-Emissions Vehicles (Subsidies)</td>
<td>cars, increase, car, buy, instead, wrong, car</td>
<td>cars, reality, buy, bonus-malus system, car, cars, people</td>
</tr>
<tr>
<td>7</td>
<td>Swedish Climate Policy</td>
<td>Forests, Carbon Taxes, Market Economy</td>
<td>stand, own, understand, difficult, think, forests, back</td>
<td>stand, carbon taxes, own, market-economy, ideas, either want</td>
</tr>
<tr>
<td>8</td>
<td>Swedish Climate Politics</td>
<td>Questions to Government Representatives</td>
<td>ask, think, environment, climate, want, government, minister</td>
<td>minister, ask, climate minister, the climate minister, minister, answer, hear</td>
</tr>
<tr>
<td>9</td>
<td>Swedish Climate Policy</td>
<td>Industry, Infrastructure, and Cities</td>
<td>industry, Stockholm, report, economical, smart, Gothenburg, fast</td>
<td>beltray, smart, socio-economic, environment, highway, double, co2-emissions</td>
</tr>
<tr>
<td>10</td>
<td>Swedish Climate Policy</td>
<td>Green Transition and Rural Politics</td>
<td>green, jobs, transition, Sweden, create, Swedish, business</td>
<td>enterprises, enterprise, green, countryside, the countryside, create, jobs</td>
</tr>
<tr>
<td>11</td>
<td>Swedish Climate Policy</td>
<td>Environment Management</td>
<td>make, demands, makes, change, environmental, requirements, manage, situation</td>
<td>belong, think, require, make, California, change, models</td>
</tr>
<tr>
<td>12</td>
<td>Swedish Climate Policy</td>
<td>Oceans, Biodiversity, Water, and Air</td>
<td>problems, water, biological, diversity, clean, ocean, people</td>
<td>problem, ocean, water, lakes, air, freshwater, Vättern (lake)</td>
</tr>
<tr>
<td>13</td>
<td>Swedish Climate Politics</td>
<td>Climate Impact, Buildings, Parliamentary Debate</td>
<td>climate impact, concern, the report, reservation, decreased, the report, acclamation</td>
<td>acclamation, demand, demand, reservation, buildings, reservations, the report</td>
</tr>
<tr>
<td>14</td>
<td>The Economy and Economics of Climate Change</td>
<td>Funding for Climate and Environment</td>
<td>money, billions, climate politics, SEK, budget, politics, propose</td>
<td>climate aid, additional, additionality, money, foreign aid budget, climate efforts, environmental budget</td>
</tr>
<tr>
<td>15</td>
<td>Transport</td>
<td>Fossil Fuels and Biofuels</td>
<td>Renewable, fossil fuels, ethanol, fuel, bio fuels, energy sources,</td>
<td>fuel, fuels, fossil, ethanol, fuels, fuels, energy sources</td>
</tr>
<tr>
<td>16</td>
<td>Swedish Climate Politics</td>
<td>Climate Targets</td>
<td>Sweden, Sweden's, goal, the goal, climate goal, transportation sector, achieve</td>
<td>parliament, welfare state, Sweden, climate law, steel, climate goals, net-zero emissions</td>
</tr>
<tr>
<td>17</td>
<td>Swedish Climate Politics</td>
<td>Sweden as a Climate Leader</td>
<td>Sweden, countries, the world, country, growth, technology, Europe</td>
<td>help, helping, technology, green tech, leading country, wealth</td>
</tr>
<tr>
<td>18</td>
<td>International Climate Policy and Politics</td>
<td>Sustainable Development and Human Rights</td>
<td>development, sustainable, environment, climate, contribute, work, rights</td>
<td>rights, equality, sustainable, human, social, women, sustainability</td>
</tr>
<tr>
<td>19</td>
<td>Energy</td>
<td>State Owned Utility Vattenfall</td>
<td>Vattenfall, Germany, government, coal power, Vattenfall's, company, sell</td>
<td>lignite business, Nuo, Vattenfall, lignite business, lignite, German</td>
</tr>
<tr>
<td>20</td>
<td>Swedish Climate Policy</td>
<td>Subsidies (Charging infrastructure, industry, and municipalities)</td>
<td>support, millions, government, SEK, Climate Leap, investment,</td>
<td>Climate Leap, charging stations, charging infrastructure, Industry Leap, city environment, Regions, investment</td>
</tr>
<tr>
<td>21</td>
<td>Transport</td>
<td>Mode-shift and Alternative Transport</td>
<td>need, is needed, transportation, build, investment, rail,</td>
<td>biking, rail, rail freight, freight, rail, sea transport, high speed rail</td>
</tr>
<tr>
<td>22</td>
<td>Energy</td>
<td>Energy Politics</td>
<td>energy, renewable, Sweden, nuclear power, renewable energy, nuclear power, energy efficiency,</td>
<td>energy, energy system, Energy Agreement, renewable, energy politics, energy politics, energy supply</td>
</tr>
<tr>
<td>23</td>
<td>Transport</td>
<td>Aviation and Bio Fuels</td>
<td>aviation, aviation's, flight, flight tax, bio fuels, climate impact, Sweden</td>
<td>aviation, to fly, airport, aviation, electric airplanes, Arlanda (airport), airport</td>
</tr>
<tr>
<td>24</td>
<td>The Economy and Economics of Climate Change</td>
<td>Green Tax Reform</td>
<td>green, taxes, transition, taxes, tax, politics, reduce</td>
<td>tax reform, green taxes, taxes, taxes, tax increase, green, reduce</td>
</tr>
<tr>
<td>25</td>
<td>The Economy and Economics of Climate Change</td>
<td>Circular Economy (Forestry, Agriculture, Recycling, Biodiversity)</td>
<td>forest, economy, production, products, diversity, agriculture, biodiversity</td>
<td>fertiliser, textiles, recycle, circular, material recycling, circular, cycle</td>
</tr>
<tr>
<td>26</td>
<td>International Climate Policy and Politics</td>
<td>International Climate Conferences</td>
<td>internationella, globala, Sweden, global, countries, Paris agreement, EU's,</td>
<td>Paris, climate summit, climate agreement, the climate agreement, climate summit, climate negotiations, COP</td>
</tr>
<tr>
<td>27</td>
<td>Swedish Climate Politics</td>
<td>Emissions Reductions</td>
<td>emissions, emissions, reduce, declining, carbon dioxide, declined, tonnes</td>
<td>emissions, declined, emissions, tonnes, greenhouse gases, reduced, grams</td>
</tr>
<tr>
<td>28</td>
<td>Energy</td>
<td>Electrification (Electricity Certificates, Energy production)</td>
<td>system, the system, system of electricity certificates, hydropower, terawatt hours, Norway, wind power</td>
<td>electricity certificates, system of electricity certificates, the electricity certificates, hydropower, effect reserve, power type, power production</td>
</tr>
<tr>
<td>29</td>
<td>The Economy and Economics of Climate Change</td>
<td>Emissions Trading</td>
<td>question, government, emissions certificates, against, EU's, fossil fuel independence, believe</td>
<td>environmentally dangerous, emissions certificates, emissions trading system, fossil fuel independence, emissions trading system, the emissions trading system, emissions trading</td>
</tr>
</tbody>
</table>

Table 2 Themes and Topics of Climate Debate
4.3. Political Salience of Topics of Climate Debate

The Structural Topic Model estimates the expected topic proportion for different parliamentary debate topics by political parties between 2010 to 2021, see Figure 6. Expected topic proportions represent the political salience of climate topics, indicative of how much each party prioritises a topic relative to other topics at a particular point in time (Wlezien 2005; Wlezien and Moniz 2020).

![Figure 6 Political Salience of Climate Debate with Political Parties 2010-2021, Expected Topic Proportion by Topics of Climate Debate](image)

4.4. Political Salience and Structure of Parliamentary Debate

There are different ways of discerning the structure of parliamentary debate based on intensity, influence, and party priorities (Figure 4, Figure 5), political salience (Figure 6) of topics by parliamentary year (Figure 7), by different parties (Appendix Figure 11), or political salience
for parties and parliamentary year (Appendix Figure 12 and interpreted in Table 6). The temporal structure is induced from Hierarchical Clustering of politically salient climate topics across parliamentary sessions (Figure 7). Structural shifts in political salience of clusters of the climate debate co-occur with parliamentary elections in 2014 and 2018. Accordingly, three temporal periods are identified, the Pre-Paris period (2010/11-2013/14), the Paris Period (2014/15-2016/17), and the Post-Paris Period (2017/18-2020/21).

Figure 7 Hierarchical Clustering, Standardized Sum of Climate Topics Political Salience by Year

Drawing on Hierarchical Clustering in Figure 7, eight column-wise clusters of climate topics are induced and interpreted as clusters of politically salient debates, see Table 3.
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Name</th>
<th>Topics</th>
<th>Politically Salient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Climate Politics and Funding</td>
<td>Climate Change, Politics, and Parties (4), Funding for Climate and Environment (14), Emissions Reductions (27)</td>
<td>2010/11-2020/21</td>
</tr>
<tr>
<td>2</td>
<td>Energy and Climate</td>
<td>Questions to Government Representatives (8), Energy Politics (22)</td>
<td>2010/11-2020/21</td>
</tr>
<tr>
<td>3</td>
<td>Hard to Abate Sectors</td>
<td>Aviation and Biofuels (23), Private Cars and Low-Emissions Vehicles (Subsidies) (6), Subsidies (Charging Infrastructure, Industry, and Municipalities) (20)</td>
<td>2016/17-2021/20</td>
</tr>
<tr>
<td>4</td>
<td>Green Transition</td>
<td>Mode-Shift and Alternative Transport (21), Climate Targets (16), Circular Economy (25), Green Tax Reform (24), Effects of Climate Change (1), Green Transition and Rural politics (10)</td>
<td>2013/14-2020/21</td>
</tr>
<tr>
<td>5</td>
<td>Industry, Infrastructure, and Regulations</td>
<td>Industry, Infrastructure, and Cities (9), Environmental Management (11)</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Misc</td>
<td>EU Directives and Regulations (2), Oceans, Biodiversity, Water, and Air (12), European and Nordic Cooperation (3), Forests, Carbon Taxes, Market Economy (7), Climate Impact, Buildings, and Parliamentary Debate (13)</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Paris Agreement and Vattenfall</td>
<td>State-owned energy utility Vattenfall (19), International Climate Conferences (26)</td>
<td>2013/14-2016/2017</td>
</tr>
<tr>
<td>8</td>
<td>Emissions Trading, Sustainable Development, and International Politics</td>
<td>Emissions Trading (29), Fossil Fuels and Biofuels (15), Sustainable Development and Human rights (18), Government Proposals and Regulations (5), Sweden as a Climate Leader (17), Electrification (28)</td>
<td>2010/11-2017/18</td>
</tr>
</tbody>
</table>

The Pre-Paris period (2010/11-2013/14) is a homogenous phase where established political parties debated similar topics (Appendix Figure 12 and Table 6). Debate is relatively intense (Figure 4), and debate is salient with Climate Politics and Funding (Cluster 1), Energy and Climate (Cluster 2), and Emissions Trading, Sustainable Development, and International Politics (Cluster 8). Ahead of the 2014 elections, political salience increased across Paris Agreement and Vattenfall (Cluster 7) and the Green Transition (Cluster 4), particularly with climate topics Climate Targets (4), Effects of Climate Change (1), and Green Transition and Rural Politics (11) (Figure 7).

In the Paris Period (2014/15-2016/17), debate decreased in intensity partly as the Centre Party and Moderates de-prioritised the issue (Figure 5). The debate diversified as parties began formulating individual climate agendas other than Energy Politics (22) (Appendix Figure 12
and Table 6). Salience increased with clusters Paris Agreement and Vattenfall (Cluster 7) and Green Transition (Cluster 4), particularly on topics of Green Tax Reform (24), Green Transition and Rural Politics (10), and in 2016/17, political salience increases with topics Mode-Shift and Alternative Transport (21), and Climate Targets (16).

Simultaneously, salience increased within Hard to Abate Sectors (Cluster 3), particularly Aviation and Biofuels (23), consequent to increased political contention as the government pursued an aviation ticket tax (SOU 2016). However, there are worrying signs that voters’ perceptions of the impacts of flying are polarised according to ideology and political affiliation, where left-voters are more likely to overstate, and right-wing voters underestimate the climate impacts (Weissenbilder and Lundmark 2020).

The Post-Paris period (2017/18-2020/21) is characterised by intensifying debate and increased political contention. Most parties strengthened their priority and influence on the climate debate. The Green party re-emphasized its focus on climate issues. However, the Social Democrats advanced its climate agenda and became influential in the climate debate in 2019 (Figure 5). The climate debate diversified further as parties’ climate agendas aligned with political divides (Figure 6 and Appendix Figure 12 and Table 6), and voters across all parties attributed the climate and environmental politics greater importance (Figure 8).

The parliamentary debate is focused on four clusters, as Hard to Abate Sectors (Cluster 3) and Green Transition (Cluster 4) (Table 3) emerged alongside previously established debates on Climate Politics and Funding (Cluster 1) and Energy and Climate (Cluster 2). Parliamentary consensus contributed to decreased salience with Paris Agreement and Vattenfall (Cluster 7) and Emissions Trading, Sustainable Development, and International Politics (Cluster 8).

4.5. Dynamics of Political Salient Topics and Intensity of Parliamentary Debate

Increased intensity of political debate around the post-Paris period co-evolved with increased political salience with climate topics (2, 4, 10, 16, 20, 21, 23, 25) and decreased salience with topics (19, 22, 24, 26). The dynamics of political salience varied with different topics. Some topics increased incrementally (10, 20, 25) or rapidly (2, 4, 16, 21, 23), whereas other topics decreased incrementally (24), rapidly (22, 26), or even abruptly (19), see Figure 6 (and Appendix Figure 12 and Table 6).
Since Löfven I, the Social Democrats and Centre Party, and more recently the Moderates, have engaged in continuous debate on the Green Transition and Rural Politics (10). The Social Democrats and the Green Party advocated for Climate Targets (16). The Centre Party and the Christian Democrats prioritised the Circular Economy (25), and unlike the debate on Climate Targets (16), salience increased even after the Covid-19 pandemic. The Green Party and Christian Democrats engaged in debate on Subsidies (20), and there was a comprehensive debate on Mode-Shift and Alternative Transport (21) between (S, V, Mp, C, Kd, L), and Aviation and Biofuels (23) (M, C, S, Kd, L).

Climate change issues, politics, and parties (4) increased in salience simultaneous to Greta’s School Strikes. As “Greta” is among the FREX words defining this topic, and there was a clear burst in political salience with several parties (V, Mp, S, C, L, M), this could indicate a positive “Greta-effect” on Swedish Climate Politics. Moreover, the “Greta-effect” might have contributed to shifting parties’ climate agendas, affecting political salience with several topics of the climate debate due to dynamic representation, diffusion, policy- and interest feedback.

Some topics decreased in political salience with reduced impact on the intensity of debate. Debate on Green Tax Reform (24) started trending downwards around 2019, simultaneous to the Social Democrats and Moderates strengthening their influence in the climate debate. This trend is partly explained by dynamic representation, as voters with the Left Party, Liberals, and the Green Party are more pro carbon taxes, and the Social Democratic, Moderates, and Christian Democratic voters, are more against, as compared to Centre Party Voters (Jagers et al. 2020b).

4.6. Dynamic Representation: Voter’s Perceptions of the Politics of Climate Change

Figure 8 shows that environmental politics was an important issue among voters from most parties at the beginning of the decade, as illustrated by 10% of Moderate, 8% of Social Democratic, and more than 30% of Green Party voters. Following the Copenhagen Summit and the Euro-crisis, the importance of the environment started to decline. This trend was reversed in 2017, as environmental politics grew in importance with various parties (V, Mp, S, L, Sd), and climate change emerged among the most critical issues among voters of the Green and Left Party.
In 2018, the climate issue picked up as Social Democratic, Centre Party, and Liberal voters increasingly believed that climate was an important issue, and in 2019, the issue gained importance with voters from all parties. Voter’s beliefs are also reflected in the 2018 elections, as environmental issues were the fourth most common reason for voters casting their vote for a particular party in the election (Valforskningsprogrammet 2020).

4.7. Case Studies: Climate Debate as a Social Tipping Processes in Climate Policy
Two qualitative case study analyses on climate debates, *Climate Targets* (16) and *Energy politics* (22), are informed by influential segments of parliamentary speech, Figure 6.
4.7.1. Climate Targets: Increased Political Salience and Political Consensus

“The Government’s energy and climate politics is an aggressive expansion of renewable energy and investment in energy efficiency. The starting point is that market-based policies, a carbon tax, is the most effective way to increase the share of renewable energies and reduce greenhouse gases…” – Centre Party Minister 2011-06-10 (Gamma = 0.73, rank = 34, party rank = 8)

Climate Targets (16) have been subject to political debate before the liberal-conservative Reinfeldt Coalition Government (2006-2014) of the Moderates, Christian Democrats, Liberals, and Centre Party. The Reinfeldt government was committed to advancing a domestic Climate and Energy Policy as part of the EU strategy (Climate Action 2022a; Regeringskansliet 2022g). During the Reinfeldt government’s second term, political salience increased as the political opposition called for more ambitious climate politics, including short-term and long-term targets (Miljöpartiet 2014; Socialdemokraterna 2014).

After Löfven I won the 2014 elections, salience of debate on Climate Targets (16) decreased slightly, even though the EU adopted its 2030 Climate and Energy Framework as a show of ambition on the road to the Paris Climate Conference (Climate Action 2022b). In 2015, ahead of the Paris Agreement, Löfven I announced its goal of becoming one of the first fossil-free welfare states and updated climate targets, boosting political salience until the 2018 elections (Regeringskansliet 2022f).

International climate conferences and agreements have failed to limit global warming to 2°C aiming for 1.5°C (UNFCC 2021). The Paris Agreement is considered a catalyst for cross-scale and cross-sectoral climate action originating from domestic climate politics (FALKNER 2016; Barrett 2016; Bäckstrand et al. 2019) Still, it was not until the establishment of the Swedish Climate Policy Framework, as of January 1st, 2018 (Karlsson 2021), that the downward trending intensity of climate debate was reversed and gained momentum leading up to the elections, particularly with the Social Democrats and the Green Party, see Figure 4.

“...The task of evaluating if the Government’s targets are sufficient to reach the targets is already dealt with by the Environmental Protection Agency. Therefore the climate policy council is not needed...” – Swedish Democratic MSP 2017-06-14 (Gamma = 0.73, rank = 38, party rank = 2)
The Swedish Climate Policy Framework resulted from a multi-year process of the All-Party Committee on Environmental Objectives, supported by all parties but the Swedish democrats (Karlsson 2021). The Climate Policy Framework (CPF) outline new Climate Goals, the Swedish Climate Change Act (CCA), and the Swedish Climate Policy Council (CPC) (Karlsson 2021; Regeringskansliet 2021). The process promoted deliberation and fostered political consensus through a science-based understanding of climate policy, highlighting the economic co-benefits of climate action and the costs of inaction, demonstrating consistency with the constitution and policy tradition, and the benefits of cross party-bloc collaborations on climate change (Karlsson 2021). Moreover, the CPF mandates the presiding Government to present a comprehensive strategy to address climate change. Interviews with experts indicate a strong belief that the CPF has contributed to parties prioritising improved climate policy outcomes (Karlsson 2021; Matti et al. 2021).

The Swedish Climate Change Act is inspired by the UK’s 2008 Climate Act, which has contributed to the diffusion of similar laws across political systems (Karlsson 2021). Climate Laws have the potential to unlock new climate policy trajectories, promote stability in the policymaking process, and contribute to the formulation of long-term emissions reduction targets (Fankhauser et al. 2015; Nash and Steurer 2019). Unlike the UK’s climate targets, the Swedish climate goals are not legally binding. The goal of climate neutrality by 2045 is related to the framing of Sweden as a Climate Leader (17), and the inclusion of a net-zero target stems from policy diffusion from the Paris Agreement (Matti et al. 2021). The Climate Policy Council has consistently reiterated the gap between policy measures and policy goals (Climate Policy Council 2020), representing a political interest feedback.

“The purpose of the bonus-malus system is to incentivise car purchases of more climate and environmentally friendly alternatives. To achieve net-zero emissions and reduce emissions from transportation, we need a larger share of the car fleet to run on green fuels or electricity...” – Social Democratic Minister 2021-04-20 (Gamma=0.801, party rank = 2, rank = 12)

The political salience of debate on Climate Targets (16) stabilised leading up to the entry into force of the Climate Policy Framework. The debate shifted focus from goal formulation to policy implementation. Parliamentarians noted the policy gap to achieve net-zero across domestic and international jurisdictions. Salience increased as the Social Democrats, and the Green Party formed the Löfven II government. This new government ruled on basis of the
January Agreement, negotiated with the Centre Party, and the Liberals, and with tacit approval from the the Left-Party (Lindvall et al. 2020). The Fridays for Future movement gained momentum in Europe, the Election of a new President of the EU Commission, and consequently, the announcement of the European Green Deal in December 2019 (Gunningham 2019; Comm/dg/unit 2019).

“...is the government willing to vote no to the proposal [by the EU Commission] if fossil-free energy production and Swedish forestry are to be considered unsustainable in the future? We know that it is needed for the climate transition.” – Moderate MSP 2020-11-26 (Gamma = 0.85, rank = 3, party rank = 1)

Despite the socio-political shock of the COVID-19 pandemic, debate stabilised in intensity. While political salience decreased slightly, the debate remained focused on the policy gap to reach net-zero, plausibly due to the EU promoting the Green Recovery (Bruegel, 2022; (Comm/dg/unit 2020). Sweden’s climate agenda was further aligned with supra-national and international processes through the submission of an EU-wide long-term strategy and nationally determined contributions to the Paris agreement (Council of the European Union and 2020; European Commission 2020) In 2021, Sweden contributed to the formulation of an EU Climate Law and updated ambitious Climate Targets while defending its national interests such as forestry and biofuels (Regeringskansliet 2022c, 2022b).

4.7.2. The Swedish Energy System: Declining Political Saliency and Increased Political Contention

“Let me also state that there is a thirst for energy in the world, not the least from China. They turn towards fossil fuels. We shall act in a manner where renewable alternatives grow while ensuring that nuclear power can be used in a secure way.” – Moderate Member of Government 2012-04-26 (Gamma = 0.83, rank = 18 party rank = 2).

Parliamentary debate on Energy Politics (22) precedes the climate change debate and focuses mainly on nuclear power's role in the Swedish electricity system, one of the most protracted conflicts in Swedish politics. The 2011 Fukushima Nuclear disaster shifted public opinion in support of dismantling existing ageing nuclear power stations (Holmberg 2020). Energy Politics (22) was one of the most salient debates on climate change before the 2014 elections.
Political divides aligned with the Alliansen era, as the Centre Party had softened its traditional resistance to nuclear power (Holmberg 2020).

“Maybe the greatest challenge in the energy transition to weather-dependent renewable energy such as solar and wind is the so-called electrical load issue... ...The role of politics is to ensure that new solutions can emerge when the demand for load management occurs. That the transition to 100% renewable energy will come with costs is self-evident.” – Green Party Member of Swedish Parliament (MSP) 2018-06-15 (Gamma = 0.88, rank =2, party rank = 1)”

To become the world’s first fossil-free welfare state, Löfven I pursued broad parliamentary support (Mp, S, C, M, Kd) for the 2016 Energy Agreement on a 100% renewable electricity system by 2040. The agreement entailed decommissioning existing nuclear power at the end of their service life and lowering the level of political contention, as reflected in decreasing political salience (Holmberg 2020).

“Our common enemy should be coal and oil, and the ambition must be to phase out fossil fuels in a responsible manner” – Christian Democratic MSP 2020-12-09 (Gamma= 0.87, rank = 6, party rank = 2)

In December of 2019, the political landscape rearranged again with historical dividing lines of the debate on nuclear power. The Christian Democrats and Moderates left the agreement and endorsed nuclear power as a solution to achieve 100% fossil-free electricity, together with the Swedish Democrats and Liberals. In 2019, the pro-nuclear coalition swayed public opinion, and a small pro-nuclear majority emerged. Interestingly, these efforts appear to have been mustered outside of parliamentary debate (Holmberg 2020) as the salience of Energy Politics (22) stabilised at lower levels.

“...It is not transportation that we want to stop, rather, it is the emissions from transportation that should be stopped. Here I want to reiterate what [Moderate MSP] said, that there is an ideological divide between the left parties and the Alliance. The Left Party’s focus is too often on transportation itself rather than the emissions” – Centre Party MSP 2017-04-19 (Gamma = 0.88, rank = 3, party rank = 1).
There is a vivid debate on future pathways of the Swedish energy system in *Energy Politics* (22), and policies to decarbonise industry and transportation through electrification, and other policies. That is reflected across emerging debates in the post-Paris Period within clusters of Hard to Abate Sectors (C3) and the Green Transition (C4), see Figure 7 and Table 3. The debate on *Energy Politics* (22) also concerns the relatively high electricity prices in Sweden’s southern price areas and the consequences for businesses and households.

The Government’s 2020 Climate Policy Strategy identifies transportation and industry, currently responsible for two-thirds of territorial emissions, as fundamental to achieving the climate goals (Miljödepartementet 2020). National strategies emphasise that rapid electrification of the energy system is needed to decarbonise these hard-to-abate-sectors (Kvarnström 2022), based on different scenarios. Existing high electrification scenarios have been criticised for inadequate ambition (Material Economics 2021b) and for lacking integrated avoid-shift-improve perspectives that prioritise end-use of different scarce energy sources such as biofuels (Material Economics 2021a). Accordingly, this sufficiency-centred perspective promotes demand management to achieve deep decarbonisation for net-zero emissions (IPCC 2022).

“HYBRIT is another example. A project where SSAB, LKAB, and Vattenfall are developing steel without coal. The Government’s investment in the Industry Leap has been an enabler”. – Social Democratic MSP 2018-05-29 (Gamma =0.899, rank =1).

Public and private initiatives to decarbonise the steel sector, HYBRIT (Hydrogen Breakthrough Ironmaking Technology), and H2 Green Steel have the potential to reduce Sweden’s territorial emissions substantially and transform global supply chains (Ryman 2020; LKAB 2022). Private company Northvolt is expanding sustainable battery production to electrify transportation as part of the European Battery Alliance, supporting the EU’s green transition (European Commission 7/29/2020; European Battery Alliance 2022). Green industries are attracted to northern Sweden, partly because of access to cheap and clean electricity. HYBRIT alone estimates its electricity demand to 55TWh. In 2021 Sweden used 140TWh (Ryman 2020; LKAB 2022; Bäcklin 2021). These initiatives inspire large-scale societal transformations and represent a solid political interest feedback supporting investment in electrification, primarily from wind power, the grid, and energy carriers, mainly green hydrogen.
“...We are a country where we have an Energy Agreement based on broad political consensus, and we say: Let the market decide! The market invests in wind, solar, hydropower, and other energy sources – and efficiency. This explains why Sweden currently exports more electricity than what is required to electrify the entire transport sector.” Social Democratic Minister 2021-01-12 (Gamma = 0.803, rank =60, party rank=10)

There is broad political support for climate targets (16), including net-zero targets, the green industrial transition, and fossil-free transportation. Nonetheless, the policy gap remains, particularly in industry and transportation. Electrification pathways are contested, as the future of renewable energy and nuclear power in the electricity system is polarised according to ideological divides (Hedberg 2019; Holmberg 2020; Naturvårdsverket 2022; Karlsson and Gilek 2020).
5. Discussion

5.1. Three Periods of Parliamentary Debate on Climate Change

There are different ways to analyse the structure of the parliamentary debate. Three periods of parliamentary debate on climate change are identified based on clusters of politically salient topics, the Pre-Paris period (2010/11-2013/14), the Paris period (2014/15-2016/17), and the post-Paris period (2018/19-2020/21). The intensity of the climate debate was stable in the pre-Paris period, whereas it declined in the Paris period and increased again in the post-Paris period. The diversity of debate increased continuously throughout the decade.

Intensification and diversification of debate could indicate a social tipping point in the structure of parliamentary debate (Winkelmann et al. 2022). In the post-Paris period, Parliamentary debate on climate change doubled in intensity from 2.5% of parliamentary debate after COP22 in Marrakesh to 5% before COP25 in Madrid. As of the Covid-19 pandemic, debate declined and stabilised at a previously high level, as the EU commission supported the EU Green Recovery.

Changes in parliamentary climate debate's intensity and the political salience of topics can reflect both harmonising and polarising dynamics, with highly context-dependent outcomes on transformative climate policy. Accordingly, the discussion focuses on the mechanisms of contagion and feedback as enablers and barriers of social tipping in parliamentary debate.

5.2. Contention and Polarisation drive intensification and diversification post-Paris

During the post-Paris period, numerous socio-ecological processes contributed to the increase in intensity and diversity of the climate debate. This includes, among other events, the entry into force of the Climate Policy Framework, the 2018 elections, national forest fires, the Fridays for Future Movement, international climate conferences, the January Agreement, and the EU Green Deal. Debate on climate change has evolved from an issue of concern only to issue-oriented parties, the Green Party, the Centre Party, or the Left Party, to an issue of more significant concern for the governing parties, the Social Democrats and the Moderate Party, as they have emerged as substantially more influential in the debate, signifying increased political contention across ideological divides.

A growing share of voters considered climate politics an important political issue, and parties have formulated niche climate agendas reflective of dynamic representation, policy feedback, and diffusion (Andersson et al. 2020; Jagers et al. 2020c). Somewhat worryingly, voters’
perceptions of climate change and climate policies are increasingly polarised according to traditional (Jönsson 2022; Weissenbilder and Lundmark 2020; Holmberg 2020) and emerging political divides (Jagers et al. 2020b).

In the United States, voter polarisation drives unpredictable critical thresholds reinforcing lock-in of the climate policy debate (Winkelmann et al. 2022; Axelrod et al. 2021), that are accelerated under socio-political shocks (Macy et al. 2021). Polarisation of political elites appears to be self-reinforcing and accelerates close to a critical threshold, as mediated by the mass polarisation of public opinion (Leonard et al. 2021). Issue polarisation can be prevented through non-polarised belief exchange (Guilbeault et al. 2018), reduced exposure between polarised groups, or directed policy interventions striving for compromise (Axelrod et al. 2021).

5.3. Greta-Effects in Public Opinion and Parliamentary Debate in the post-Paris Period
In the post-Paris Period, voters’ perceptions of climate politics as an important issue (Figure 8) have co-evolved with increased intensity, influence, and party priorities regarding the general climate debate (Figure 4) and increased political salience across topics of climate debate. Indicative of dynamic representation of voters in an election year, policy feedback from the Climate Policy Framework, and diffusion of pro-climate action norms in the form of a “Greta-effect”.

Previous research argues that there is a “Greta-effect” in public opinion, as the importance of environmental and climate issues increased from 15% in 2019 to 24% in 2019 (Jagers et al. 2020c), with voters from all parties (Figure 8). However, there are no observable changes in climate change concerns, behaviours, pro-environmental attitudes, demonstrations, or involvement in civil society organisations (Jagers et al. 2020c; Andersson et al. 2020). Moreover, unlike the European experience, there are no apparent changes in public support for the Swedish Green Party (Winkelmann et al. 2022), potentially as all parties articulated climate agendas. Arguably, increased intensity and political salience across topics such as climate change issues, politics, and parties (4) illustrate the interplay of public opinion and parliamentary debate and support a “Greta effect” in Swedish parliamentary debate.

5.4. Case Studies: Social Tipping of Parliamentary Debate and Policy Transformations
Two case studies were outlined to study mechanisms and context-specific outcomes enabling or preventing social tipping in the parliamentary debate to access transformative pathways.
5.4.1. The Transformative Potential of Net-Zero Targets

Political salience on Climate Targets (16) increased incrementally over ten years. The debate is characterised by political consensus on goal, and political contention on the policies to address the policy gap. The Climate Policy Framework and goal of net-zero emissions by 2045 signifies Sweden’s political culture of agreement and the transformative potential of consensus in the Swedish context.

The Swedish experience is part of and has contributed to a process of rapid cross-scale policy diffusion promoting the adoption of net-zero goals (Karlsson and Gilek 2020) (Karlsson 2021). Net-zero emissions are necessary to limit global warming at any level and limiting climate change to 1.5°C or 2°C requires deep, rapid, and sustained emissions reductions. Carbon Dioxide Removal is indispensable to reducing residual emissions achieve net-zero emissions in hard-to-abate sectors (IPCC 2022). If net-zero targets endorse large-scale reliance on complementary measures, CDR, or carbon credits, there is a greater risk of entrenching fossil fuel infrastructure and technology while supporting carbon-intensive behaviours, and institutions (Seto et al. 2016; IPCC 2022, 2018).

More than a hundred countries have adopted net-zero targets in the seven years since the Paris Agreement representing 90% of the world economy, 85% of the population, and 88% of global emissions (Climate Action Tracker 2022; Net Zero Climate 2021). Net-zero targets are dependent on large-scale carbon dioxide removal (CDR) or accounting for emissions reductions through carbon credits. Sweden’s net-zero targets allow for 15% of emissions reductions through complementary measures. This is largely aligned with the sustainability (P2) pathway for 1.5°C (IPCC 2018) requiring shifts toward sustainable consumption, low-carbon technology innovation, well-managed land systems, and limited applications of Bio-energy CCS (BECCS). The CPC proposes specific targets for these complementary measures and promotes BECCS, carbon storage in forestry and land use, and verified emissions reductions abroad (Climate Policy Council 2020).

The inability of Swedish politicians to endorse truly transformative low-energy demand scenarios represents an imaginary lock-in, defined as an inability to “envision a decarbonized future beyond the status quo” and previously identified with all parties except the Left and the Green party (Moore and Milkoreit 2020; Marquardt and Nasiritousi 2021; IPCC 2018). Globally, net-zero targets vary significantly in their design. For the proliferation of such targets
to represent social tipping with transformative potential for decarbonisation, there needs to be greater stringency regarding the reliance on complementary measures proposed by the Swedish Climate Policy Council.

5.4.2. The Green Industrial Transformation at a Critical Juncture

The debate on *Energy Politics* (22) stands out in a political culture dominated by deliberation, as politics are antagonistic toward or against nuclear power (Holmberg 2020), and more recently, there has been an emerging ideological polarisation of wind power (Hedberg 2019). The political salience of debate decreased abruptly following the 2016 Energy Agreement. However, as the Moderates and Christian democrats left the agreement, the debate was re-policised (Holmberg 2020).

Electrification enables multiple pathways for social tipping, directly through decarbonisation of transportation, industrial processes, and the emergence of fossil-free supply chains (Sharpe and Lenton 2021b), and indirectly through reform of the EU-ETS, the introduction of carbon levies (van der Ploeg and Rezai 2020; van der Ploeg and Zeeuw 2018) or ideational transformations inspired by the green transition (Moore and Milkoreit 2020). Emerging green industries and international capital represent an important political interest feedback promoting electrification of transportation and industry.

The green transition requires increased availability of resources and electricity, related to land-use and resource conflicts. Successful management of electrification and sustainable resource use can facilitate social tipping in climate policies (Devine-Wright 2011; Loorbach 2010; Strauch 2020a; Olsson et al. 2014) through managing trade-offs between regulatory requirements, public acceptability (NIMBYism), distributional effects, local politics, and national interests (Devine-Wright 2011; Dorband et al. 2019; Jamasb et al. 2021, 2021), while achieving synergies between economic prosperity and climate impacts, and safeguarding environmental concerns, and indigenous people’s rights (UNEP 2021; SEI 2020)

The government’s policy response to higher and more unstable electricity and energy prices across European markets in the winter of 2021/2022 and following Russia’s war of aggression in Ukraine is beyond the scope of the Original Text Corpus on the parliamentary debate (Bruegel 2022). These events are likely to increase the political salience of *energy politics* (22) and its importance for voter’s, a head of the 2022 elections. Concurrent to the analysis of
(Holmberg 2020) regarding public opinion, parliamentary debate indicates that the future of the Swedish energy system is at a crossroads and that the upcoming election can potentially shape future pathways of the energy system.

5.4.3. Discussion of Methods

Preliminary limitations of computational content analysis is discussed in (3.6 Limitation of Methods). The appropriateness of the method to study social tipping phenomena can be questioned based on naturalistic and interpretivist perspectives. Naturalistic critiques might suggest modeling approaches such as Agent-Based Models, or social network analysis, to study social tipping dynamics based on numerical representations of parliamentary debates rather than interpretation (Leonard et al. 2021; Macy et al. 2021; Axelrod et al. 2021). Qualitative or interpretivist critiques might question the validity of natural language processing methods to infer meaning and suggest an interpretive analysis of full parliamentary debates (Drisko and Maschi 2016; Rocha and Daume 2021).

6. Concluding Remarks

As Sweden aims to become among the world’s first fossil-free welfare states, the policy gap in transportation and industry needs to be addressed. Since 2018, socio-political processes and shocks have contributed to diversifying and intensifying the climate debate. Political parties have articulated individual climate policy agendas, signifying increased political contention and competition for voters. This has not yet resulted in a self-reinforcing process where political parties ratchet up climate ambitions, transcend a critical threshold of parliamentary debate and facilitate transformative change across scales.

Nonetheless, the cross-scale diffusion of net-zero targets could represent a global tipping point in climate action. This would require greater stringency on complementary measures proposed by the Climate Policy Council. Here, Sweden should advance a stringent framework, nationally and supra-nationally. In this regard, the green transition of hard-to-abate-sectors presents opportunities for social tipping to bridge the policy gap and achieve net-zero goals.

Nonetheless, heightened political contention and voter polarisation could emerge as barriers to social tipping. In the Swedish context consensus appears to be conducive to policy transformation. If parliamentary climate debate and voter perceptions become further polarised,
there are substantial risks of lock-ins to policy pathways with greater dependence on carbon dioxide removal technologies or exacerbated resource conflicts to achieve net-zero goals.

To navigate social tipping requires transformational governance of energy systems to un-lock emissions reductions across all sectors. This could align with high-electrification scenarios and avoid-shift-improve measures. More importantly, the green transition should not only be a strategy for decarbonising the economy. For the transition to be sustainable in the long term, transformational pathways need to consider sustainability in a broader socio-ecological sense. This is the stuff of politics, and parliamentarians should strive to inspire societal tipping to sustainable futures by transcending imaginary lock-ins of the parliamentary climate debate.
7. Appendix

7.1. Code Availability

The code is available
https://github.com/petterbjerser/TippingAndSprinting/

Contact Gustav Engström for details on the deep learning classifier
gustav.engstrom@beijer.kva.se

7.2. The Swedish Context

Sweden is a small parliamentary democracy in Northern Europe with a tradition of minority
government because of negative parliamentarism and proportional representation. Negative
Parliamentarism indicate that a majority of parliament tolerates a government and that a 50% majoriti
majority of parliamentarians are required to vote no in a vote of confidence to unseat the
government. Elections occur every four years, and since the 2010 elections, the 349
parliamentary seats have been split between eight political parties. Parliamentarians are
representatives of their respective political parties and political agendas, as agreed in the
internal democratic processes of each party (Lindvall et al. 2020).

The contemporary political landscape is characterised by the left-right power struggle between
the Social Democrats “S” and the Moderates “M” and their respective political coalitions (A
Table 4). The centre-right coalition “Alliansen” won the 2006 elections, and the Moderates
formed the Reinfeldt Government (2006-2014) with the Centre Party “C”, Liberals “L”, and
Christian Democrats “Kd” (Lindvall et al. 2020). In their second term, the Reinfeldt’s
government faced criticism for its management of state-owned energy utility Vattenfall,
regarding the acquisition of Dutch energy company Nuon and ownership of lignite coal in
Germany (SvD.se 2022; Cederblad 2016)

The Government emphasised its commitment to addressing climate change through ambitious
environmental and climate objectives and strategies, an ambition to decouple emissions from
economic growth in transportation, housing, and industry (Regeringskansliet 2022e). The
Government presided as President of the Council of the European Union leading up to the 2009
Copenhagen negotiations (Government Offices of Sweden 2009). During this period, the
Government emphasised Sweden’s role as a climate leader and aligned its climate and energy
policy with the EU’s 2020 Climate and Energy targets. The domestic climate and energy
strategy included targets and strategies for emissions reductions, renewable energy, energy
efficiency for 2020, and a goal of a fossil-fuel independent transport sector by 2030 (Climate Action 2022a; Regeringskansliet 2022g). In their second term, the Reinfeldt government faced criticism for its management of state-owned energy utility Vattenfall, regarding the acquisition of Dutch energy company Nuon and ownership of lignite coal in Germany (Cederblad 2016; SvD.se 2022, 2022).

The 2014 elections saw the Social Democrats form a minority government with the Green Party and with the support of the Left Party, Löfven I (2014-2018) (Lindvall et al. 2020). Löfven I, emphasised climate change as a decisive issue of our time and focused on Sweden’s role in international climate politics, the climate transition, and the green economy as an engine for jobs and welfare (Regeringskansliet 2022d). Ahead of the Paris Summit, the government announced its goal of becoming one of the world’s first fossil-free welfare states (Regeringskansliet 2022f). In June 2017, the Swedish Climate Policy Framework (CPF) was agreed in parliament with substantial political agreement. The CPF established new climate targets, a Climate Policy Council to evaluate governments’ climate policies, and a Climate Change Act requiring the government to draw up a climate policy action plan and an annual climate report (Karlsson 2021; Regeringskansliet 2021).

The 2018 elections altered political relations as the Social Democrats formed a centrist government, Löfven II, together with the Green Party and with the support of the Liberals and Centre Party, based on the January Agreement. The agreement aimed to ensure parliamentary support for the national budget, keep the far-right Swedish Democrats away from government, and reduce the political influence of the Left party (Lindvall et al. 2020).

The January Agreement outlines a climate agenda focusing on market-based approaches and a green economy as the primary means to achieve climate targets, fossil-free transport, sustainable cities, an EU Climate Law, biodiversity protection, and reduction of microplastics (Januariavtalet 2019). In December 2019, the government formalised its climate agenda in the first Climate Policy Strategy, a 132-action program to reduce emissions, as mandated by the Climate Policy Framework (Regeringskansliet 2022a).
### Table 4 Swedish Election Results 2002-2018

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>8.40%</td>
<td>5.90%</td>
<td>5.60%</td>
<td>5.70%</td>
<td>8.00%</td>
</tr>
<tr>
<td><strong>Green Party “Mp” (Miljöpartiet)</strong></td>
<td><strong>Role</strong></td>
<td>Supporting Persson</td>
<td>Opposition</td>
<td>Opposition</td>
<td>Löfven I</td>
<td>Löfven II</td>
</tr>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>4.70%</td>
<td>5.20%</td>
<td>7.30%</td>
<td>6.90%</td>
<td>4.40%</td>
</tr>
<tr>
<td><strong>Social Democrats “S” (Socialdemokraterna)</strong></td>
<td><strong>Role</strong></td>
<td>Persson (S)</td>
<td>Opposition</td>
<td>Opposition</td>
<td>Löfven I (S)</td>
<td>Löfven II (S)</td>
</tr>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>39.90%</td>
<td>35.00%</td>
<td>30.70%</td>
<td>31.00%</td>
<td>28.30%</td>
</tr>
<tr>
<td><strong>Centre Party “C” (Centerpartiet)</strong></td>
<td><strong>Role</strong></td>
<td>Opposition</td>
<td>Reinfeldt</td>
<td>Reinfeldt</td>
<td>Opposition</td>
<td>Supp. Löfven II</td>
</tr>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>6.20%</td>
<td>7.90%</td>
<td>6.60%</td>
<td>6.10%</td>
<td>8.60%</td>
</tr>
<tr>
<td><strong>Liberals “L” (Liberalerna)</strong></td>
<td><strong>Role</strong></td>
<td>Opposition</td>
<td>Reinfeldt</td>
<td>Reinfeldt</td>
<td>Opposition</td>
<td>Supp. Löfven II</td>
</tr>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>13.40%</td>
<td>7.50%</td>
<td>7.10%</td>
<td>5.40%</td>
<td>5.50%</td>
</tr>
<tr>
<td><strong>Moderates “M” (Moderaterna)</strong></td>
<td><strong>Role</strong></td>
<td>Opposition</td>
<td>Reinfeldt</td>
<td>Reinfeldt</td>
<td>Opposition</td>
<td>Supp. Löfven II</td>
</tr>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>15.30%</td>
<td>26.20%</td>
<td>30.10%</td>
<td>23.30%</td>
<td>19.80%</td>
</tr>
<tr>
<td><strong>Christian Democrats “Kd” (Kristdemokraterna)</strong></td>
<td><strong>Role</strong></td>
<td>Opposition</td>
<td>Reinfeldt</td>
<td>Reinfeldt</td>
<td>Opposition</td>
<td>Opposition</td>
</tr>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>9.10%</td>
<td>6.60%</td>
<td>5.60%</td>
<td>4.60%</td>
<td>6.30%</td>
</tr>
<tr>
<td><strong>Swedish Democrats “Sd” (Sverigedemokraterna)</strong></td>
<td><strong>Role</strong></td>
<td>Not in parliament</td>
<td>Not in Parliament</td>
<td>Opposition</td>
<td>Opposition</td>
<td>Opposition</td>
</tr>
<tr>
<td></td>
<td><strong>Vote %</strong></td>
<td>1.40%</td>
<td>2.90%</td>
<td>5.70%</td>
<td>12.90%</td>
<td>17.50%</td>
</tr>
</tbody>
</table>
The Kernel Density Plot shows that a climate score of 0.99% captures 75724 sentences in the Climate Text Corpus out of 2931641 in the Original Text Corpus.
7.5. Tabell 5: Sannolikheten för ord att förklara temaet baserat på högsta sannolikhet av ord (svenska)

<table>
<thead>
<tr>
<th>Word ranking</th>
<th>Probability of word explaining the topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>klimalöjda, mån, måne, månlig, månesver</td>
</tr>
</tbody>
</table>
Exclusivity increases rapidly until K = 30, Held Out Likelihood Declines from K=25, Residuals improve until K=70, and Semantic Coherence deteriorates from K=20 before stabilising at K=50.
7.7. Figure 11 Political Salience of Different Topics By Party
Figure 12 Hierarchical Clustering of Standardized Political Salience By Parliamentary Year and Party
### 7.9. Table 6 Description of Clusters of Politically Salient Topics of Debate by Different Parties and Years

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Name</th>
<th>Topics</th>
<th>Politically Salient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>Sd</td>
<td>Fossil Fuels (15), Electrification (28), Energy Politics (22), Emissions Reductions (27), Funding for Climate and Environment (14), State-owned energy utility Vattenfall (19),</td>
<td>2010/11-2020/21</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>Questions to Government Representatives (8), Funding for Climate and Environment (14), Emissions Reductions (27)</td>
<td>2010/11-2016/17</td>
</tr>
<tr>
<td>5</td>
<td>L</td>
<td>Energy Politics (22), Mode-Shift and Alternative Transport (22), Climate politics (4), Green Tax Reform (24)</td>
<td>2018/19</td>
</tr>
<tr>
<td>6</td>
<td>V</td>
<td>Questions to Government Representatives (8), Funding for Climate and Environment (14), Emissions Reductions (27), Mode-Shift and Alternative Transport (21), Climate Politics (4), Climate Change (1), Flights, Airports and Biofuels (23)</td>
<td>2017/18-2020/21</td>
</tr>
<tr>
<td>6</td>
<td>Mp</td>
<td>Mode-Shift and Alternative Transport (21), Climate Targets (16), Climate Change (1), Climate Politics (4), Subsidies for Charging Infrastructure, Industry, and Municipalities (20),</td>
<td>2013/14-2020/21</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>Questions to Government Representatives (8), Private Cars and Low-Emissions Vehicles (6), Funding for Climate and Environment (14), Flights, Airports and Biofuels (23), Green Tax Reform (24), Green Transition and Rural Politics (10),</td>
<td>2014/15-2020/21</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>Green Transition and Rural Politics (10), Green Tax Reform (24), Fossil Fuels and Biofuels (15), Circular Economy (25), Mode-Shift and Alternative Transport (21),</td>
<td>2014/15-2020/21</td>
</tr>
<tr>
<td>9</td>
<td>S</td>
<td>Green Transition and Rural Politics (10), Mode-Shift and Alternative Transport (21), Climate Targets (16), Sustainable Development and Human rights (18), Aviation and Biofuels (23),</td>
<td>2016/17-2020/21</td>
</tr>
<tr>
<td>10</td>
<td>Kd</td>
<td>Mode-Shift and Alternative Transport (21), Emissions Reductions (27), Subsidies (Charging infrastructure, industry, and municipalities) (20), Energy Politics (22)</td>
<td>2015/16-2016/17</td>
</tr>
<tr>
<td>10</td>
<td>L</td>
<td>Climate Politics (4), Mode-Shift and Alternative Transport (22), Aviation and Biofuels (23),</td>
<td>2017/18, 2019/20, 2020/21</td>
</tr>
<tr>
<td>10</td>
<td>Kd</td>
<td>Energy Politics (22), Aviation and Biofuels (23), Circular Economy (25), EU Directives and Regulations (2)</td>
<td>2017/18-2020/21</td>
</tr>
</tbody>
</table>

### 7.10. Ethics Review – Final Review

This thesis relied on openly accessible data of parliamentary transcripts. These contain information on the speaker, political affiliation, and any information this person discloses during the statement. The NLP analysis converts this data into numerical representations of parliamentary debate. The main consideration that emerged was to anonymise any reference to individuals in parliamentary speeches that were used for analysis.
8. Publication bibliography

Andersson, Ulrika; Carlander, Anders; Öhberg, Patrik (2020): Regntunga skyar Ulrika Andersson, Anders Carlander & Patrik Öhberg (red). In Regntunga skyar.


Boers, Niklas; Rypdal, Martin (2021): Critical slowing down suggests that the western Greenland Ice Sheet is close to a tipping point. In Proceedings of the National Academy of Sciences of the United States of America 118 (21). DOI: 10.1073/pnas.2024192118.


Juan Rocha; Garry D. Peterson; Örjan Bodin; Simon Levin (2018): Cascading regime shifts within and across scales.


Levin, Simon; Xepapadeas, Tasos; Crépin, Anne-Sophie; Norberg, Jon; Zeeuw, Aart de; Folke, Carl et al. (2013): Social-ecological systems as complex adaptive systems: modeling and policy implications. In Envir. Dev. Econ. 18 (2), pp. 111–132. DOI: 10.1017/S1355770X12000460.


Nyborg, Karine; Anderies, John M.; Dannenberg, Astrid; Lindahl, Therese; Schill, Caroline; Schlüter, Maja et al. (2016): Social norms as solutions. In *Science (New York, N.Y.)* 354 (6308), pp. 42–43. DOI: 10.1126/science.aaf8317.


Rockström, Johan; Gupta, Joyeeta; Lenton, Timothy M.; Qin, Dahe; Lade, Steven J.; Abrams, Jesse F. et al. (2021): Identifying a Safe and Just Corridor for People and the Planet. In *Earth's Future* 9 (4). DOI: 10.1029/2020EF001866.

Ryman, Christer (2020): HYBRIT Pilot plant - Pre-Feasibility Study.


Simon Levin; Rocha, Juan; Peterson, Gary D.; Bodin, Örjan; Levin, Simon (2018): Cascading regime shifts within and across scales.


Steffen, Will; Rockström, Johan; Richardson, Katherine; Lenton, Timothy M.; Folke, Carl; Liverman, Diana et al. (2018): Trajectories of the Earth System in the Anthropocene. In *Proceedings of the National Academy of Sciences of the United States of America* 115 (33), pp. 8252–8259. DOI: 10.1073/pnas.1810141115.


Termeer, Catrien J.A.M.; Dewulf, Art; Biesbroek, G. Robbert (2017): Transformational change: governance interventions for climate change adaptation from a continuous change perspective. In


