Methodological Framework for the Border Neighbours Threat Index (BNTI): A Computational Approach to Geopolitical Risk Quantification

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Abstract

This paper presents the methodology behind the Border Neighbours Threat Index (BNTI), a computational system designed to quantify geopolitical instability among neighboring states. By synthesizing the Goldstein Scale for event intensity with modern Zero-Shot Classification techniques, BNTI offers a nuanced, real-time assessment of regional security threats. We discuss the theoretical underpinnings of our weighting system, the integration of institutional stability factors derived from Democratic Peace Theory, and the logarithmic normalization process used to produce a standardized risk index.

1 Introduction

Quantifying political risk has traditionally relied on manual expert analysis or coarse-grained sentiment analysis. The BNTI seeks to bridge the gap between qualitative political science theory and quantitative natural language processing (NLP). By analyzing real-time RSS feeds from strategic border nations, the system constructs a dynamic threat index that reflects not just the volume of negative news, but the specific *intensity* of conflict events.

2 Theoretical Framework

2.1 The Modified Goldstein Scale

The core scoring logic of BNTI is adapted from the Goldstein Scale [2], originally developed for the World Event/Interaction Survey (WEIS). Goldstein proposed a continuous scale ranging from -10 (extreme conflict) to +10 (extreme cooperation) to code political events.

For the purpose of conflict early-warning, we adhere to the intensity hierarchy established by Goldstein but invert the polarity to produce a positive "Threat Score." As noted by Leetaru and Schrodt [3] in their work on GDELT, differentiating between material and verbal conflict is crucial for accurate risk assessment. Our weighting system (Table 1) reflects this distinction.

2.2 Institutional Stability Factors

Raw event counts often fail to account for the stabilizing effect of international institutions. Drawing on Democratic Peace Theory and the broader literature on institutional liberalism [5], we posit that conflict dyads embedded in robust security architectures (e.g., NATO) possess higher thresholds for escalation.

Consequently, BNTI applies a dampening coefficient ($\delta = 0.6$) to threat scores emerging from NATO-allied neighbors (e.g., Greece). This adjustment reflects the lower probability of militarized dispute escalation compared to non-integrated neighbors.

Table 1: BNTI Event Weighting System

Category	**Description**	**Weight** (W_c)
Military Conflict	Kinetic engagement (e.g., artillery, border clashes)	10.0
Terrorist Act	High-intensity asymmetric violence	9.0
Violent Protest	Civil instability and breakdown of order	7.0
Political Crisis	Diplomatic rupture, regime instability	6.0
Economic Crisis	Structural economic stress (recession, currency)	4.0
Peaceful Diplomacy	Stabilizing diplomatic statements or treaties	-2.0
Neutral News	General reporting without security implications	0.0

3 Methodology

3.1 System Architecture Overview

Figure 1 summarizes the end-to-end BNTI pipeline from data ingestion to index publication.

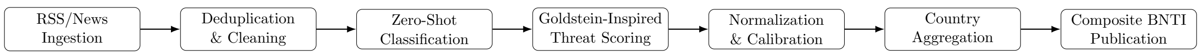

Figure 1: Schematic overview of the BNTI processing pipeline.

3.2 Zero-Shot Classification

Unlike traditional sentiment analysis which offers a binary positive/negative output, BNTI utilizes a BART-large-mnli model for Zero-Shot Classification [6]. This allows the system to semantically map news headlines to specific conflict categories (e.g., "Military Conflict" vs. "Political Crisis") without task-specific fine-tuning.

The raw threat contribution (C_i) for a news item i is calculated as:

$$C_i = \begin{cases} W_c \times S_{conf} & \text{if } S_{conf} \geq \tau \\ 0 & \text{if } S_{conf} < \tau \end{cases} \tag{1}$$

where W_c is the category weight, S_{conf} is the model's confidence score, and $\tau = 0.4$ is the noise filtration threshold.

3.2.1 Decision Logic and Thresholding

To promote interpretability, the classification stage may be viewed as a two-step decision scheme: (i) semantic assignment to a category c and (ii) acceptance/rejection under a confidence gate τ. Figure 2 illustrates this logic.

Following Caldara and Iacoviello's GPR Index methodology [1], we normalize by article volume to obtain the average threat intensity per country:

$$\bar{T}_k = \frac{1}{N_k} \sum_{i=1}^{N_k} C_i \tag{2}$$

where N_k is the number of articles analyzed for country k.

3.3 Saturating Exponential Normalization

To prevent volume-driven inflation observed in simple logarithmic scaling, we apply a saturating exponential function. Unlike the logarithmic approach, this produces a natural asymptote that distributes scores across the full 1–10 range:

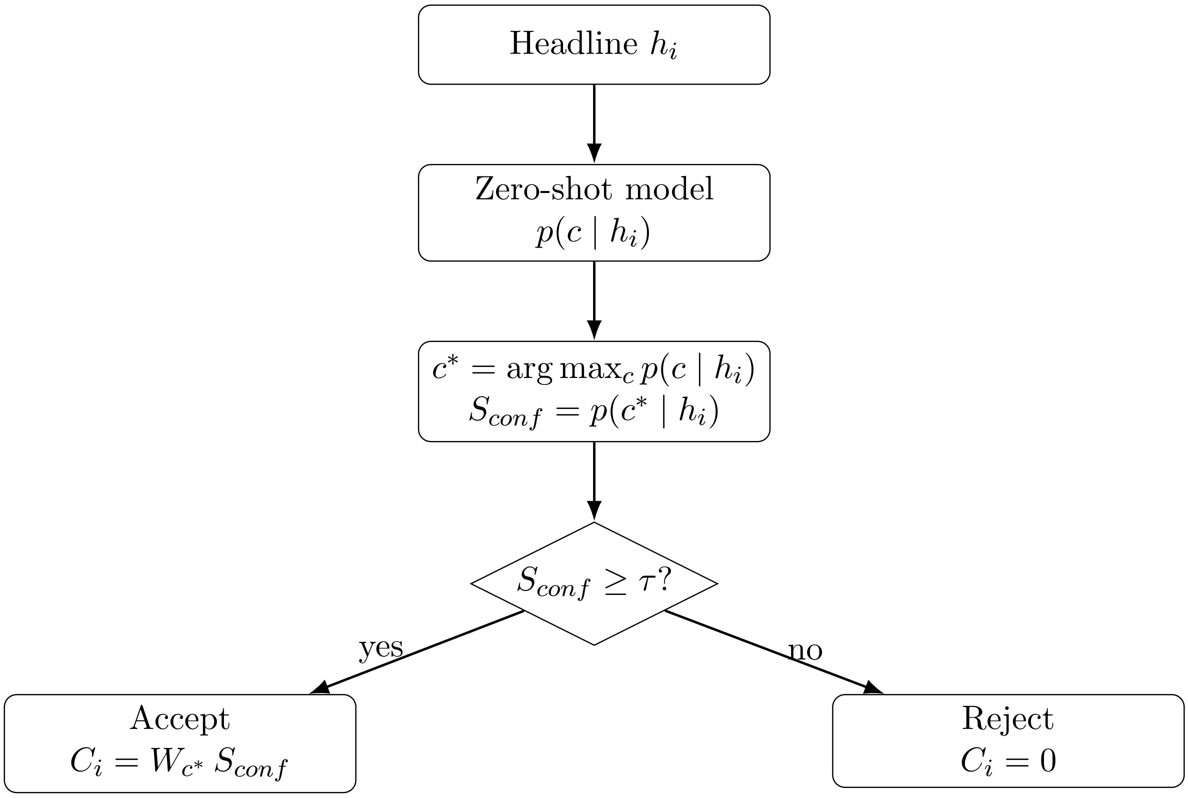

Figure 2: Decision scheme for category assignment and confidence-gated scoring.

The per-country index (I_k) is derived as:

$$I_k = 1 + 9 \cdot \left(1 - e^{-\frac{\bar{T}_k}{5} \cdot 1.2}\right) \tag{3}$$

3.3.1 Calibration Interpretation

Let $\kappa = 1.2/5$ denote the effective curvature parameter. Then

$$I_k = 1 + 9\left(1 - e^{-\kappa \bar{T}_k}\right), \tag{4}$$

which maps $\bar{T}_k \in [0, \infty)$ to $I_k \in [1, 10)$, with diminishing marginal increases $\partial I_k / \partial \bar{T}_k = 9\kappa e^{-\kappa \bar{T}_k}$.

3.4 Composite Index via Weighted Averaging

Drawing on the Fragile States Index (FSI) methodology [4], the composite BNTI is computed as a weighted average of per-country indices rather than a sum, preventing any single country from dominating the index:

$$I_{\text{BNTI}} = \frac{\sum_k w_k \cdot I_k}{\sum_k w_k} \tag{5}$$

where w_k reflects the geopolitical importance weight of country k (e.g., $w_{\text{Syria}} = 1.5$ for active conflict zones, $w_{\text{Greece}} = 0.6$ for NATO-integrated allies).

3.5 Reproducibility and Implementation Notes

For computational reproducibility, the pipeline is parameterized by $(\tau, \delta, \kappa, \{W_c\}, \{w_k\})$ and can be fully specified in an experiment manifest (e.g., a YAML configuration) capturing model version identifiers, label set, and preprocessing rules.

3.6 Reference Pseudocode

Algorithm 1 BNTI Computation (Per Day)

Input: headlines $\{h_i, \text{country}(i)\}_{i=1}^{M}$, weights $\{W_c\}$, τ, dampening map $\delta(\cdot)$, geo-weights $\{w_k\}$
for $i = 1$ to M **do**
  compute $p(c \mid h_i)$ over categories c
  $c^* \leftarrow \arg\max_c p(c \mid h_i)$; $S_{conf} \leftarrow p(c^* \mid h_i)$
  if $S_{conf} \geq \tau$ **then**
    $C_i \leftarrow W_{c^*} \cdot S_{conf}$
  else
    $C_i \leftarrow 0$
  end if
end for
for all countries k **do**
  $\bar{T}_k \leftarrow \frac{1}{N_k} \sum_{i:\, \text{country}(i)=k} C_i$
  $I_k \leftarrow 1 + 9 \cdot \left(1 - e^{-\kappa \bar{T}_k}\right)$
  $I_k \leftarrow \delta(k) \cdot I_k$ ▷ optional institutional dampening
end for
$I_{\text{BNTI}} \leftarrow \frac{\sum_k w_k I_k}{\sum_k w_k}$
Output: $\{I_k\}$ and I_{BNTI}

4 Conclusion

The BNTI represents an advancement in automated threat perception, moving beyond simple sentiment analysis to a theoretically grounded, event-intensity model. By combining the Goldstein Scale, GPR-style volume normalization, and FSI-inspired weighted averaging within a modern NLP pipeline, we provide a robust tool for real-time geopolitical monitoring that distributes risk assessments across the full analytical scale.

References

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