Strategic Autonomy and Trade Resilience: A Joint Topic-Stance Framework for Mapping Causal Risk Propagation in European Union Trade Networks

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1. Abstract

The European Union's trade ecosystem is increasingly vulnerable to exogenous shocks—ranging from geopolitical conflicts to infrastructure failures—that are often documented in unstructured text long before manifesting in physical data. Current analytical pipelines typically isolate topic detection from sentiment analysis, resulting in fragmented signals that fail to capture the "Trigger-State" relationship of trade disruptions [Hassan et al., 2019]. This research proposes a unified Joint Topic–Stance (JTS) modeling framework to jointly infer (i) critical EU-relevant trade topics, such as commodity-specific corridors and export controls, and (ii) the "Stance Intensity" of the event (e.g., disruptive vs. stabilizing). By integrating Temporal Causality and Causal Discovery, the model moves beyond black-box sentiment scoring to provide interpretable "Nowcasts" of trade flow volatility. The research aims to demonstrate that text-derived causal features can quantify the propagation of risk across European Value Chains, offering a significant "Contribution to Knowledge" in both computational linguistics and macro-geopolitics by offering a novel tool for enhancing EU economic resilience.

Index Terms: Causal Discovery, Joint Topic–Stance Modeling (JTS), EU Strategic Autonomy, Global Value Chains (GVCs), Temporal Causality, Natural Language Processing (NLP), Geopolitical Risk (GPR), Nowcasting, European Value Chains, Stance Detection, Multi-task Learning.

2. Background

In an era of "Weaponized Interdependence," the European Union (EU) faces significant risks from external shocks to its supply chains [Farrell and Newman, 2019]. Events such as the Ukraine war or energy policy shifts act as primary drivers of volatility within the Eurozone. While financial NLP has traditionally focused on firm-level equity sentiment, a critical gap remains in modeling how linguistic signals in EU policy documents and international news precede structural shifts in trade flows [Kelly et al., 2021].

Existing research is hindered by pipeline fragmentation, where topic and sentiment are modeled independently. This ignores the intrinsic link between a Critical Topic (e.g., "Natural Gas Logistics") and its Stance Intensity (e.g., "Severe Disruption"), which dictates the causal impact on downstream sectors like EU manufacturing [Hoberg and Phillips, 2016]. Furthermore, the reliance on lagged customs data from sources like Eurostat creates a "blind spot" for policymakers. This research posits that text-based signals can serve as leading indicators for Nowcasting trade disruptions, using Causal Discovery to identify the temporal lead-lag relationship between a geopolitical stance shift and its physical outcome in European trade.

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3. Proposed Research

The proposed research develops a computational framework for **Event-Driven Structural Modeling** within the EU trade bloc. It utilizes a **Joint Topic–Stance (JTS)** encoder to process diverse text streams—ranging from European Commission press releases to global news—extracting signals that act as state variables for trade nodes.

The research formalizes the impact of an event as an interaction between a **Critical Topic** (f) and its **Stance Intensity** ($\mathcal{I}$):

$$x = f_{EU\_Topic} \times \mathcal{I}_{Stance}$$

formula 3.1: Formula to determine the impact of an event

where x represents the predicted delta in EU trade volume or sector-specific price indices. By bounding the dataset to EU-specific commodities (e.g., those listed in the EU Critical Raw Materials Act), the model minimizes noise and focuses on high-impact causal pathways. This model blends natural language processing, time-series econometrics, and causal inference, producing a forecasting pipeline that supports not just predictions but also interpretable "what-if" analyses for decision-makers.

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4. Research Questions (RQs) & Hypotheses

RQ1 (Joint Modeling): Can a unified JTS framework effectively decouple "Critical EU Trade Topics" from general market noise to produce calibrated disruption signals?

- **H1:** A joint architecture reduces semantic drift compared to pipeline-based models by enforcing shared latent representations between EU-specific commodities and their associated stance intensity.

RQ2 (State-Space Triggers): How do exogenous shocks to critical EU nodes (e.g., Suez Canal access or Ukraine Grain Corridor) function as state-variables in predicting Eurozone trade volatility?

- **H2:** Treating text-derived events as scalar "Triggers" within a state-space model provides higher precision in "Nowcasting" EU trade flows than traditional econometric indicators alone.

RQ3 (Temporal Causality): What is the lead-lag relationship between a shift in external geopolitical stance and the physical trade outcome at major EU entry points (e.g., Ports)?

- **H3:** Causal discovery algorithms constrained by EU trade-ontology priors can identify stable, directional pathways that exceed the predictive power of standard correlative baselines.

RQ4 (Counterfactual Reasoning): To what extent can the framework simulate "What-if" scenarios for European supply chain resilience?

- **H4:** By intervening on text-derived causal features, the model can quantify the potential impact of hypothetical policy shifts (e.g., "What if a 10% tariff is applied to EU-bound steel?") on downstream industrial output.

5. Expected Impact

5.1. Academic Contribution (Contribution to Knowledge)

The primary academic impact lies in the synthesis of **Joint Topic-Stance (JTS) modeling** with **Structural Causal Discovery**. While existing literature in Financial NLP often treats sentiment as a monolithic variable [Araci, 2019], this research contributes a novel architecture that treats text as a **state-variable trigger** for economic systems. By bounding the study to the European Union, the research provides a new empirical benchmark for how geopolitical rhetoric propagates through specialized trade networks, moving the field of "Computational Macroeconomics" from correlative to causal methodologies.

5.2. Technical and Methodological Impact

This research will deliver a production-ready pipeline for **Trade Nowcasting**. Unlike traditional econometric models that suffer from the "reporting lag" of official statistics (e.g., Eurostat's monthly releases), the proposed framework demonstrates that high-frequency text signals can provide a real-time proxy for trade flow volatility. The engineering of a **Topic-Aware Gating Mechanism** will also offer a blueprint for reducing "semantic noise" in large-scale NLP tasks, a critical challenge in processing global news torrents.

5.3. Institutional and Policy Impact (The EU Lens)

At a policy level, the framework supports the **EU's Strategic Autonomy** agenda. By identifying the lead-lag relationship between external geopolitical shifts and internal supply chain disruptions, the research offers a quantitative tool for:

- **DG TRADE & European Commission:** Improving early-warning systems for critical raw material shortages (e.g., Lithium, Semiconductors).
- **Central Banks & Fiscal Authorities:** Providing "text-derived" leading indicators for inflation (HICP) driven by external supply shocks rather than internal demand.
- **Trade Resilience:** Quantifying the "What-if" impact of potential tariffs or logistical blockages (e.g., Suez Canal) on specific European industrial clusters.

5.4. Industrial Impact

For the private sector—particularly EU-based logistics and manufacturing firms—the research provides a framework for **Dynamic Risk Assessment**. By moving beyond generic "market sentiment," firms can identify specific causal risks to their "Critical Interests" (Steel, Oil, Food), allowing for more robust inventory management and supply chain hedging strategies in an era of global volatility.

- **Practical Application:** Provides real-time risk alerts, scenario-based forecasts, and robust tools for portfolio and risk management.

- **Societal/Economic Benefit:** Helps policymakers, regulators, and investors better anticipate and respond to systemic risks (e.g., supply-chain shocks, energy crises, geopolitical conflicts).

By moving beyond black-box prediction toward causal, interpretable forecasting, the project has the potential to set a new standard in financial text analysis.

6. Research Methodology

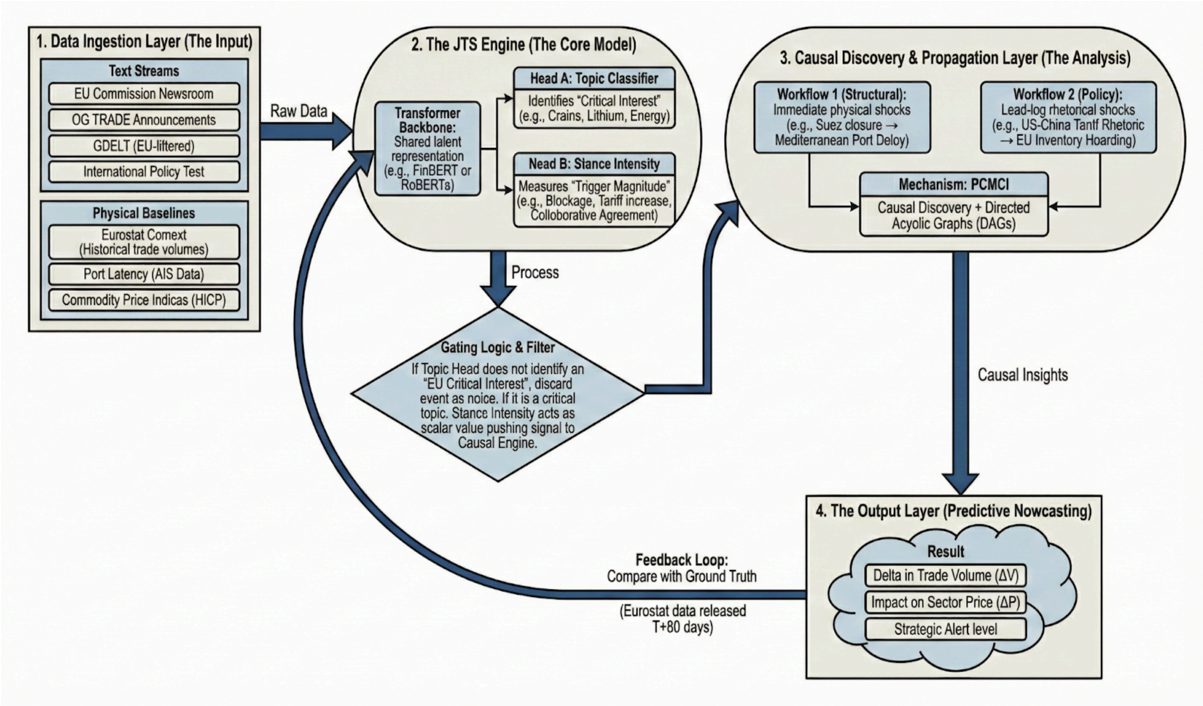

figure 6: Proposed Methodology

The proposed methodology follows a multi-stage pipeline designed to ingest unstructured text and output causal trade-disruption signals. The architecture is built on the principle of **"Topic-Aware Gating,"** ensuring the model focuses exclusively on critical EU trade nodes.

6.1. Data Acquisition and Focused Dataset Boundary

The system will integrate three primary data streams to establish both the "Signal" (Text) and the "Ground Truth" (Physical Outcome):

- **Textual Signal Layer:** Official European Commission press releases (EC Newsroom), DG TRADE policy announcements, and GDELT-filtered geopolitical news specifically tagged with EU-member state locations.
- **Physical Outcome Layer:** Monthly import/export volumes and unit values from **Eurostat (Comext)**, and high-frequency port latency data from major EU hubs (Rotterdam, Hamburg, Antwerp).
- **Focused Ontology:** To prevent "Boiling the Ocean," the dataset is bounded by the **EU Critical Raw Materials Act** list (e.g., Lithium, Cobalt, Magnesium) and essential commodities (Energy, Grains).

6.2. Joint Topic–Stance (JTS) Modeling (RQ1)

Instead of sequential processing, the research proposes a **Multi-task Learning (MTL)** architecture based on a transformer backbone (e.g., RoBERTa or Longformer).

- **Shared Encoder:** Learns the general semantic representations of trade discourse.
- **Topic Head:** Classifies text into specific EU trade sectors or HS-code categories.
- **Stance Head:** Determines the "Intensity" of the event—ranging from *Highly Stabilizing* to *Highly Disruptive*.

This joint approach ensures that the "Stance" is contextually anchored. For example, the word "restriction" has a different "Stance Intensity" when applied to "Fishing quotas" versus "Russian Gas Pipeline" access.

6.3. Temporal Causal Engine (RQ2 & RQ3)

Once the JTS model identifies an event trigger, the system maps the propagation of that signal using **Causal Discovery** algorithms such as **PCMCI** or **Causal Graphs (DAGs)**.

- **Workflow 1 (Structural):** Captures immediate logistical shocks (e.g., Suez Canal blockage ➔ Port Latency ➔ EU Commodity Price).
- **Workflow 2 (Policy):** Captures the lead-lag of rhetoric (e.g., Trade War rhetoric ➔ Inventory Hoarding ➔ Volume Drop).

6.4. Implementation Stack (The Engineer's Lens)

- **Orchestration:** Prefect or Dagster for ETL pipelines.
- **NLP:** PyTorch/HuggingFace for JTS model training.
- **Causal Inference:** Tigramite or DoWhy libraries for causal discovery and counterfactual estimation.
- **Database:** Neo4j for mapping the relationships between EU industrial clusters and external trade partners.

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7. Evaluation and Validation

To ensure the framework's academic and practical validity, three evaluation metrics will be utilized:

1. **Macro-F1 & Calibration:** Measuring the JTS model's ability to accurately identify topics and predict stance intensity compared to human-annotated EU policy briefs.
2. **Causal Precision:** Evaluating the stability of discovered causal pathways across different time windows (e.g., Pre- vs. Post-Ukraine conflict).
3. **Nowcasting Accuracy (RMSE):** Comparing the model's "Predicted Trade Flow" against actual Eurostat data released 60 days later. A successful model will minimize the error in this "reporting gap."

8. Timeline

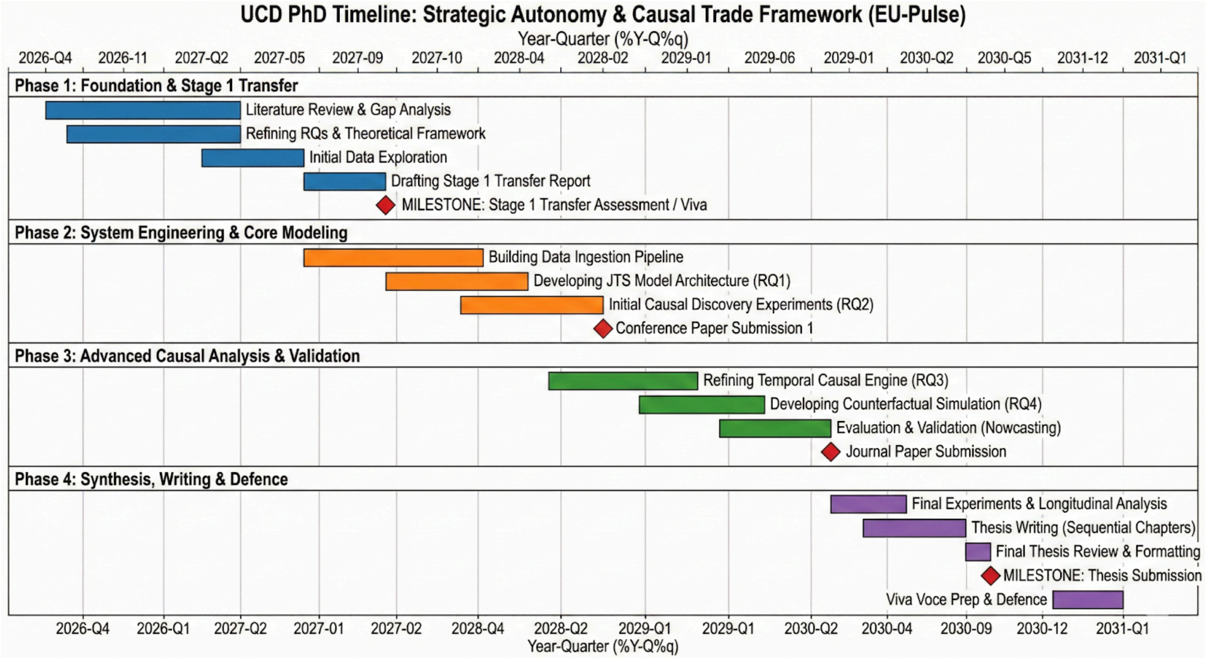

Fig 8: PHD Timeline

Phase 1: Foundation & Stage 1 Transfer (Q4 2026 – Q4 2027)

The initial year focuses on grounding the research. Key activities include a comprehensive literature review, the refinement of Research Questions (RQs), and initial data exploration.

- Milestone: The Stage 1 Transfer Assessment/Viva in late 2027, which marks the formal transition to advanced doctoral candidacy.

Phase 2: System Engineering & Core Modeling (Q4 2027 – Q2 2029)

This phase shifts toward technical implementation. It involves building the data ingestion pipeline and developing the Joint Time Series (JTS) Model Architecture to address RQ1.

- Milestone: Conference Paper Submission 1, following initial causal discovery experiments (RQ2).

Phase 3: Advanced Causal Analysis & Validation (Q2 2028 – Q2 2030)

The core of the innovative work occurs here, specifically refining the Temporal Causal Engine (RQ3) and developing Counterfactual Simulations (RQ4). The phase concludes with the evaluation of nowcasting capabilities.

- Milestone: Journal Paper Submission in mid-2030, ensuring the research undergoes peer review before the final synthesis.

Phase 4: Synthesis, Writing & Defence (Q2 2030 – Q1 2031)

The final stage focuses on longitudinal analysis and the sequential drafting of the thesis.

- Completion: The process culminates in Thesis Submission in late 2030, followed by the Viva Voce Prep & Defence in early 2031.

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