PERSPECTIVES

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TARIFFS, TRADE WAR & THE ECONOMY

VOLUME III

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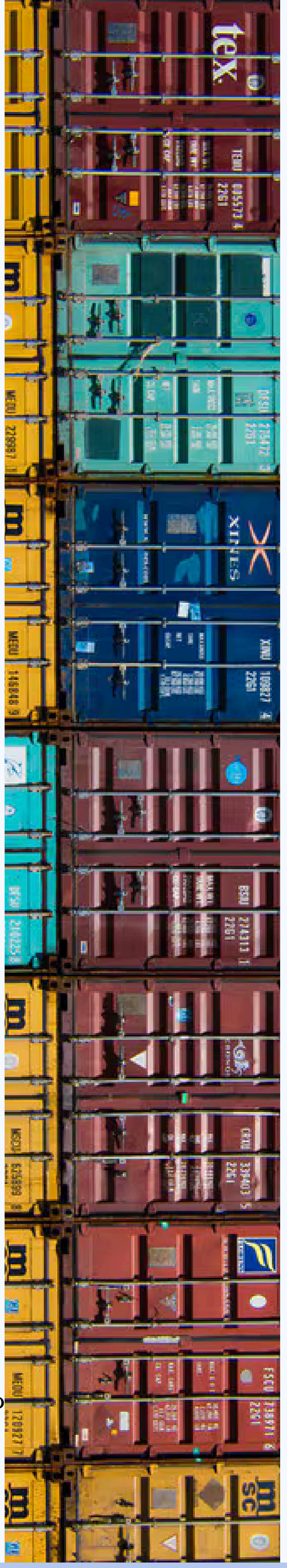

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2025-2026

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The entire editorial team would like to thank the Education Committee of KBS for their support in funding *Perspectives*, as this will ensure that the journal will have the resources needed to help support budding academics across King's Business School.

The team would also like to recognise the incredible support from the academic faculty. In particular, we would like to express our heartfelt gratitude to Vice Dean of Education Sally Everett for her commitment to supporting the journal, and for her steadfast belief in its stated purpose. We would like to thank Prof. Mary O'Mahony, as *Perspectives* is rooted in the economics department at KBS, for her contributions towards the original essay competition and for her support in turning the journal from an idea into a reality.

Finally, we would like to thank Dr. Canh Thien Dang for all his efforts as the first advocate for a KBS student journal. He provided tireless support in building up this first edition, and it is no exaggeration to say that without him, *Perspectives* would not exist.

PROFESSOR'S FOREWORD

It is with great pleasure that we present this special edition on *Tariffs, Trade Wars, and Their Broader Implications for Business and Society*. This collection brings together a remarkable range of winning essays and dissertations that showcase the depth, creativity, and analytical rigour of our students. From careful historical examinations to bold explorations of technology and policy, the works included here reflect not only academic excellence but also a keen awareness of the challenges facing our interconnected world.

The essays take us on a journey across centuries and disciplines. We revisit *The English East India Company and the Origins of the Modern Corporation*, uncovering how the structures of early trade and power continue to shape the institutions we know today. We encounter thought-provoking analyses such as *Borrowing Contest with Limited Liability: The Role of Risk Aversion in Rent-Seeking and Creation*, which shed light on the incentives underpinning modern markets.

Turning to the present, students grapple with urgent global questions: *Do Supply Chain Disruptions Contribute to Inflation?* and *The Semiconductor Supply Chain under the U.S.–China Trade War: A Comparative Analysis* offer sharp empirical insights into how geopolitical frictions translate into economic realities. *Branding Under Fire: The Impact of Tariffs and Trade Wars on Global Consumer Perception* demonstrates how business strategy and consumer psychology interact under pressure, while *Can Economic Nationalism Win in a Globalized World?* examines the broader political and economic stakes of tariff conflicts.

The collection does not stop at economics and business. Essays such as *Can Bots Govern the Commons? and Simulation of Ostromian Common Pool Resource Governance Using Generative AI Agents* push the boundaries of disciplinary thinking, merging political economy, governance theory, and artificial intelligence. Others, like the comparative study of German political discourse on X (formerly Twitter), remind us that trade wars are never purely economic—they are also deeply political, social, and cultural phenomena.

What unites these diverse contributions is a shared concern with the role of tariffs and trade wars in shaping not only businesses and economies, but also institutions, societies, and futures. The questions raised here—about resilience, adaptation, fairness, and innovation—speak to students' commitment to applying rigorous research and data analysis to some of the most pressing issues of our time.

This edition would not have been possible without the tireless work of our creative and dedicated editorial team led by our Editor in Chief Tanisha Sawa. We are especially grateful to our outgoing editors, led by Nicole Lim, for their excellent guidance, support, and meticulous editing. The section editors have tied together the wide-ranging essays with professionalism and flair, ensuring the final product is both coherent and engaging. Their collective effort has elevated this edition into a work of which we can all be proud—a publication that reflects the talent, energy, and intellectual ambition of King's Business School undergraduate students.

Dr. Canh Thien Dang
Program Director for Economics and Management,
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EDITOR'S FOREWORD

Welcome to *Perspectives*, King's Business School's first undergraduate research journal. We are delighted to present this third edition, centred on the pressing theme of Tariffs, Trade War, and the Economy. This issue brings together exceptional submissions from the King's Business School Essay Competition 2025, offering thoughtful explorations of how trade tensions, economic nationalism, and shifting global alliances are reshaping the world we live in.

Over the past decade, international trade has evolved from being a symbol of global cooperation to a field marked by uncertainty and strategic rivalry. The imposition of tariffs, the fragmentation of supply chains, and the rise of protectionist policies have redefined how nations compete and collaborate. From the U.S. – China trade dispute to the economic reverberations of Brexit, these developments have touched everything from corporate strategy to consumer welfare. The essays in this edition dive deep into these questions, examining how economic policy, politics, and human behaviour intertwine in a rapidly changing global order.

Beyond publishing research, *Perspectives* remains committed to nurturing intellectual curiosity across the King's community. This year, we introduced a new initiative —"The Freshers' Guide to Research"— designed to help first-year students take their first steps into the world of academic inquiry. The session covered everything from identifying credible data sources to developing strong research questions, helping new students gain confidence in expressing their ideas through evidence-based writing. The enthusiasm and engagement we witnessed reaffirmed our belief that research is not reserved for the few, but a journey open to every curious mind.

At its heart, *Perspectives* aims to build a community where ideas are challenged, curiosity is celebrated, and collaboration thrives. We hope this edition sparks meaningful conversations, broadens perspectives, and inspires students to explore how global trade continues to influence business, policy, and society. We hope you enjoy exploring this edition as much as we've enjoyed bringing it to life.

Tanisha Sawa

Perspectives Editor in Chief

TECHNOLOGY SECTION

INTRODUCTION

Welcome to the Technology Section of Perspectives, a forum for examining the intersections between technological innovation, global governance, and economic transformation. In this section, we seek to uncover how emerging technologies are reshaping international trade, cooperation, and sustainability — forces that increasingly define our collective future.

The semiconductor industry, the backbone of modern digital economies, illustrates how deeply technological infrastructure is entangled with geopolitics. The U.S.-China trade war exposed the vulnerabilities of a hyperconnected global supply chain, as tariffs, export bans, and subsidies reconfigured the strategic geography of chip production. These developments highlight the dual nature of technology: as both a driver of efficiency and growth, and as a geopolitical instrument through which nations pursue sovereignty, resilience, and dominance.

At the same time, artificial intelligence is not only transforming industries but also challenging fundamental assumptions about governance and cooperation. Recent research demonstrates that AI-powered agents, when placed in simulated decision-making environments, can replicate and even enhance the cooperative frameworks humans rely on to manage shared resources. This raises critical questions: Can non-human actors help overcome the tragedy of the commons? Might AI expand the scope of sustainable governance where human institutions falter?

By drawing together these perspectives, we situate technology at the interplay of power, sustainability, and social organisation. Whether in semiconductor supply chains or AI-driven governance systems, we are reminded that technological progress is never neutral; it is embedded in institutions, politics, and human values.

In the articles that follow, we invite readers to reflect on how technologies not only solve immediate economic challenges but also reconfigure the long-term architecture of global cooperation and competition. Through rigorous analysis and innovative inquiry, this section endeavours to illuminate how technology is shaping the landscape of our future.

Piriyanga Sivagajan

Perspectives Technology Section Editor

Can Bots Govern The Commons: Simulation of Ostromian Common Pool Resource Governance Using Generative AI Agents

Duru Karadeniz

Introduction

Governing the commons has long been an engaging subject within academia. Sustainable governance of multi-user resources that are prone to exploitation and depletion has captured the attention of scholars as an issue with intertwined political, economic, and philosophical dimensions. Prior to its popularity as a field of research, natural resource depletion appears to date back centuries as a documented worry. Archival evidence of this concern goes way back to 360 BCE with Plato's (as cited in Goldin, 1997, p.77-78) Critias, and can more recently be found in an emotional call-to-action piece for forest preservation by George B. Dorr (1913). These examples highlight the human inclination to anxiously reflect on the eventual overuse and depletion of the commons.

In the past several decades, this worry has given way to a promising field in the intersection of political economy and socio-ecological governance. One of its pioneers and a Nobel Prize winner, Elinor Ostrom, studied various real common pool resource governance systems in her book Governing the Commons (1990) and derived from these a list of design principles for cooperatively and sustainably governing similar resources. Joint users of a commons cooperate by expending time and resources to establish, follow, and monitor each other's compliance with these principles (Ostrom, 2009, p.2). Moreover, later experimental evidence suggests the source of this cooperation to be inherently 'human' (Bowles & Gintis, 2011, p.3). With this in mind, and considering the currently emerging transformative Artificial Intelligence (AI) technology, the question around the ability of non-human entities to provide commons governance remains unanswered. Can bots govern the commons?

The aim of this research is to study the integrability of AI agents into devising commons governance systems. To do so, this study uses the principles from Governing the Commons (Ostrom, 1990) as a guide. AI output is produced using Microsoft's AutoGen and analysed using qualitative content analysis. This research is theoretically situated within the fields of Ostromian socioecological governance and game theory, and practically operates using AI-powered interactive human simulacra. First, a literature review and a brief theoretical framework are provided. A section on methodology and terminology ensues. Results and a discussion thereof follow, before finally concluding that AI-powered agents are appropriately trained to autonomously devise a common pool resource governance system that not only complies with the Ostromian design principles but also considers additional contemporary concerns.

Literature Review

Common pool resources (CPRs) and their appropriate governance are prevalent issues in academia, and research in this field is abundant. CPRs are characterised by their semi-excludability and rivalry, and so, they require governance systems that prevent overuse and free riding. Semi-excludability means that these resources are large enough to warrant the definition of official users and the exclusion of others (Ostrom, 2008, p.11), due to, for instance, their geographical distance from the resource. Rivalry points to the fact that one individual's use of the resource negatively affects that of another (ibid.). Examples of CPRs are often found in nature, such as grazing meadows, forests, common lands, and rivers (Ostrom, 1990, Chapter 3). Others can be man-made, such as irrigation systems (Ostrom, 2008, p.11).

Due to being semi-excludable and rivalrous, CPRs are vulnerable to overuse and free riding. This is most famously discussed by Garett Hardin (1968) in his article 'The Tragedy of the Commons', wherein he proposes that each homo economicus herder jointly using a meadow will choose to overgraze as the benefits belong entirely to him, while any costs are borne by the community as a whole (ibid.). Thus, allowing freedom to overuse results in the ultimate depletion, or tragedy, of the commons. To avoid it, CPR governance is crucial. Hardin (1968, p.1245) proposes government intervention or private property rights as solutions.

Several decades later, while acknowledging that these may be suitable for governing certain open access commons (Ostrom, 2008, p.11), Elinor Ostrom emphasises the importance of self-governance by users as an effective solution for governing other CPRs. In Governing the Commons, Ostrom (1990, p.90) devises a set of design principles inspired by real and long enduring examples of successful CPR governance by user groups. If exercised properly, these principles can facilitate cooperation among joint users of a commons.

Firstly, boundaries of the CPR and everyone's usage thereof must be clearly defined (Ostrom, 1990, p.90), prohibiting access by 'outsiders' (ibid., p.91; Pennington, 2012, p.26). Secondly, appropriation rules tailored to the CPR and its contextual features must be established (Ostrom, 1990, p92). Thirdly, users must be able to participate in devising and amending these rules (ibid., 93; Pennington, 2012, p.28). Fourthly and fifthly, monitoring and gradual sanctioning mechanisms must be established (Ostrom, 1990, p.94) to help ensure conditional cooperation (Levi as cited in ibid., p.95; Rustagi et al., 2010, p.964). Sixthly, a quick and cost-effective conflict resolution mechanism is needed (Ostrom, 1990, p.100) to secure accessible dispute resolution arenas. Penultimately, users must have an externally recognised right to self-govern (ibid., p.101) to ensure that governmental authorities acknowledge their self-governance as legit, thus facilitating internal rule enforcement. Finally, all mechanisms need to be nested (ibid.), meaning devised at the local level and simultaneously integrated into wider institutional structures. Together, these Ostromian principles challenge the idea that commons governance can only be resolved through governmental intervention or privatisation, proposing instead that users can cooperate to self-govern.

Indeed, experimental evidence shows that individuals can, and do, cooperate to collectively govern the commons. Both laboratory and field experiments (Fehr & Fischbacher, 2003; DeCaro et al., 2021; Rustagi et al., 2010; Cardenas & Ostrom, 2004; Ghate et al., 2013; Cardenas, 2003; Bochet et al., 2006) suggest that CPR users will not always act to maximise their self-interest and will instead choose to cooperate, sometimes at their own expense (Fehr & Fischbacher, 2003, p.785-786).

Often, this cooperation is facilitated by establishing one, or more, of the Ostromian design principles outlined above. For instance, Devesh Rustagi et al. (2010, p.962) find that monitoring forest maintenance results in better commons management outcomes. Ernst Fehr and Urs Fischbacher (2003, p.786) run a third-party punishment game in which participants repeatedly punish defectors they perceive as behaving unfairly, suggesting that a sanctioning mechanism can indeed deter free riding.

Experimental findings challenge the classic self-interest assumption in various other ways. Literature suggests other reasons why people might cooperate, including a sense of moral satisfaction (Pennington, 2012, p.27), kin-driven altruism, displeasure with unfair outcomes (Bowles & Gintis, 2011, p.19; Fehr & Fischbacher, 2003, p.785), a desire to build a favourable reputation (ibid., p.787), varying belief of others' cooperation, subjective evaluation or perception of economic payoffs, a dopamine release (ibid, p.788), or even the biological evolution of social preference norms (Bowles & Gintis, 2011, p.93). These explanations all share a common feature: They are, arguably, examples of social, biological, relational, evolutionary, and ultimately inherent, human behaviour.

In the age of artificial intelligence, this naturally raises the question of how competent AI can be in simulating human behaviour within the context of cooperation. With a lack of inherent human characteristics that facilitate cooperation, and possession of an immense amount of knowledge, the ability of AI agents to behave cooperatively when governing the commons remains uncertain. Following AI's impressive ascent to a central role in daily life, research around how generative AI (GenAI) agents can cooperate like humans in other contexts has emerged. For example, Qiaozhu Mei et al. (2024) conduct a Turing test on GenAI chatbots to assess how similar their levels of cooperation, fairness-preference, and risk-aversion among others are to those of humans. They have the bots play six games including a finitely repeated Prisoner's Dilemma (PD). Mei et al. (2024) find that AI behaviour and traits are markedly similar to those of humans most of the time, and when not, they deviate in a more cooperative direction.

Considering this, this study aims to contribute insight into GenAI agent behaviour when faced with an infinitely repeated PD, such as the governance of a CPR.

In this aim, this study employs AI-powered interactive simulation of human behaviour. This novel method uses AI to mimic human thinking, communication, and decision-making. Inspired by the work of Joon Sung Park et al. (2023) where they simulate emergent social behaviour using a sandbox environment with GenAI agents, this study applies a similar methodology to observe the simulated deliberation of CPR governance. Park et al. (2023) assemble twenty-five GenAI-powered agents, represented by an avatar and an identity, in a virtual village. Agents move and interact freely, communicate in natural language, diffuse information, remember interactions, and take initiative to action plans they devise such as a Valentine's Day party (ibid., p.7). In a similar spirit, this study utilises GenAI-powered simulation to examine the emergent CPR governance behaviour when agents can interact and converse freely and fully autonomously.

Theoretical Framework

Some theoretical assumptions need to be explored to understand governance structures within the context of this study. Ostrom's seminal work on CPR governance has firmly positioned the Ostromian school of thought within the rational choice tradition (Pennington, 2012, p.22) and the subsumed behavioural rational choice framework which considers social preferences, norm-compliance, and willingness to sanction (McGinnis, 2020, p.5). Individuals are assumed to be rational actors (ibid., pp.11-12, p.26), however, they are constrained by bounded rationality, incomplete information, and limited cognitive ability (ibid., p.26). They trust and reciprocate (ibid., p.16). These assumptions are understood to be closely linked to how individuals make decisions within institutional settings.

The eight Ostromian design principles in Governing the Commons (1990) are also grounded in such behaviourally rational decision-making assumptions. In addition to her pioneering work in this book, Ostrom formally developed the Institutional Analysis and Development (IAD) Framework with colleagues from the Ostrom Workshop about fifteen years later (Indiana University, n.d.). In this, institutions are understood as comprising the rules, norms, and common understandings that compile and structure recurring social interactions (McGinnis, 2020, p.4). It should be noted that, although she does not overtly attempt to develop nor implement the IAD Framework in Governing the Commons (1990), Ostrom nonetheless appears to include some early glimpses into its key concepts in this book, including monitoring and sanctioning mechanisms and nested polycentric governance structures.

For this study, a clear definition of governance is imperative. Once more, this research adopts this concept as defined by the Ostrom Workshop. Governance encompasses the processes by which groups deliberate on, make, enact, and refine collective decisions (McGinnus, 2020, p.6). These processes can be influenced by a wide range of actors beyond the members of the collective (ibid.). It does not necessarily entail the existence of a formal government body, nor a monopoly of power (ibid.). Rather, it is understood as the joint efforts of citizens to collectively overcome problems that affect the community, such as the tragedy of the commons. Within the context of this study, governance is understood as polycentric (ibid., p.7). Thus, AI agents are expected to devise governance structures that compose of various interdependent bodies working simultaneously and collaboratively during the simulations conducted in this study.

Methodology and Terminology

Bots rely on AI when engaging in human-like communication. Large language models (LLMs) have emerged, which are advanced AI models that analyse colossal amounts of text data from a multitude of web sources to learn human language and its subtleties (Raiaan et al., 2024).

This information is presented as an open-source dataset, often composed of public webpages and occasionally of other resources like books (Lee, n.d.). This text is pre-processed to clean noisy data, disable outliers, process linguistic features, and remove missing data (ibid.). The LLM then trains itself using this dataset (Raiaan et al., 2024). Once trained, AI can be used to facilitate a variety of language-related tasks including powering conversational chatbots. The AI agents governing the commons in this study are fully powered by LLMs, specifically the latest versions of GPT-4o, Claude 3.5 Sonnet, and Gemini 1.5 Pro models.

This study uses Microsoft's AutoGen product in version 0.4 provided as early access. AutoGen is an open-source framework for facilitating multi-agent conversations (Microsoft, n.d.). It was chosen out of competitor services like LangGraph (2025), Swarm (2025), CrewAI (2024), N8N (2025), and FastAgency (2025) because it can successfully execute the conversational structure necessary for this study within an easily useable interface. In AutoGen, users can create AI agents, name them, define their role, link an LLM, and assemble group chats. Chat settings set up the desired number of rounds, maximum number of replies, and strategy for taking turns. In the playground tab, users give a prompt to trigger a discussion between the bots and, hence, simulate conversations. This is the process used to simulate the community meetings for this research.

The experimental design of these community meetings draws inspiration from empirical field studies on CPR governance, especially those conducted by Ostrom and her collaborators (Cardenas & Ostrom, 2004; Ghate et al., 2013; Cardenas, 2003; DeCaro et al., 2021) which range from four to eight participants in sample size. In a similar spirit, this study employs six AI agents who are provided logistical information on the Harran Irrigation System (HIS) in the southeast of Turkey for context. However, it must be noted that the main purpose of this study is not to devise a governance system specific to the HIS. Instead, this research is looking to gain insight into the integrability of GenAI into CPR governance processes as a general practice.

Following along with Ostrom's thinking in overcoming the 'my-case-is-unique' bias (Basurto & Ostrom, 2009, pp.37-38), this study assumes the existence of some common patterns across CPR governance and seeks to leverage these to better understand the integrability of GenAI in commons governance. For standardisation, the bots are explicitly told that they are AI agents.

An important point must be made on the function of the AI technology currently available for use and the ongoing debate around it. Considering various work which found that AI tends to lack robust human-like reasoning ability (Lewis & Mitchell, 2024; Mirzadeh et al., 2024), this study also takes a similar position. Within the context of this research, AI is better regarded as a colossally comprehensive pattern-matching machine than an autonomously reasoning agent. It has access to all publicly available data on the Internet up until the present moment. It is significantly capable of analysing this extensive data, extracting patterns and recognising them later (Jupally et al., 2023). However, it is regarded as not being able to independently apply logic to assess the validity or factuality of its output. It considers a statistically derived combination of the patterns in its database that align most closely with the prompt to be the 'correct' answer. Between us humans, we tend to call this 'common sense'.

With this important consideration in mind, six agents are created. One pair is powered by Claude 3.5 Sonnet, another by GPT-4o, and the last pair by Gemini 1.5 Pro. All agents operate with 0.1 temperature and are told in a system message that they are one of six AI agents tasked with collectively devising a CPR governance system, with information on the resource to be provided. A group chat is then created. The agents are allowed to engage in a thread of up to 25 replies, though they never exhaust the full capacity of this allowance. The simulations, or sessions, ensue. In these, the trigger prompt provided below gives objective contextual information on the HIS. Citations are included below for good academic practice, but were omitted in the sessions. Importantly, AI agents are strictly not told about Ostrom or her work. In fact, no information beyond what is given below is provided.

Welcome to this community meeting for devising a governance structure for the irrigation system in Harran Plain, Turkey. You are participants in this meeting. Please collectively devise a common pool resource governance system. Features of the resource are as follows. Harran Plain is a large scale irrigated agricultural area in Sanliurfa, in the south-east of Turkey (Ozerol, 2013, p.75). It is characterised by a low slope topography and a lack of drainage infrastructure (ibid.). The climate is semi-arid (Kadirbeyoglu & Ozertan, 2015, p.161). The irrigation season is usually between April and September, which is the dry season in Harran (Ozerol, 2013, p.82). Some farmers in the area are landowners, and some are not (ibid.). There is around 150.000 hectares of soil requiring irrigation (Yildirim, 2002, p.6). The region depends heavily on cotton farming, and other important crops include wheat and maize (Ozerol, 2013, p.84). The system is currently governed by the collective efforts of Water User Associations (Kadirbeyoglu & Ozertan, 2015, p.158) which have, on average, around 570 farmers each (Cicekli, 1998, p.58). These farmers have different levels of schooling, farming experience, and income from agriculture (Kadirbeyoglu & Ozertan, 2015, p.163).

Ten sessions are conducted. On average, they comprise around 18 messages, last 2 minutes and 52 seconds, and provide about 12 pages of output. Chatlogs are manually analysed using qualitative content analysis. Codes are created based on the theoretical framework within which this research operates, and the emergence of new codes during familiarisation with the data is welcomed (Kleinheksel et al., 2020, p.129). These are then manually applied to chatlogs and sorted into mutually exclusive categories (Gheyle & Jacobs, 2017, p.10). The compliance of AI-led governance structures to the Ostromian principles is examined by comparing AI output to the summarised and paraphrased list of principles below.

P1 - Boundaries for the CPR and its usage
P2 - Tailored appropriation rules for the specific CPR
P3 - User participation in governance
P4 - Cooperation monitoring mechanisms
P5 - Gradual sanctioning mechanisms
P6 - Strategies for conflict resolution
P7 - External government recognition of CPR users' right to self-organise
P8 - A nested structure

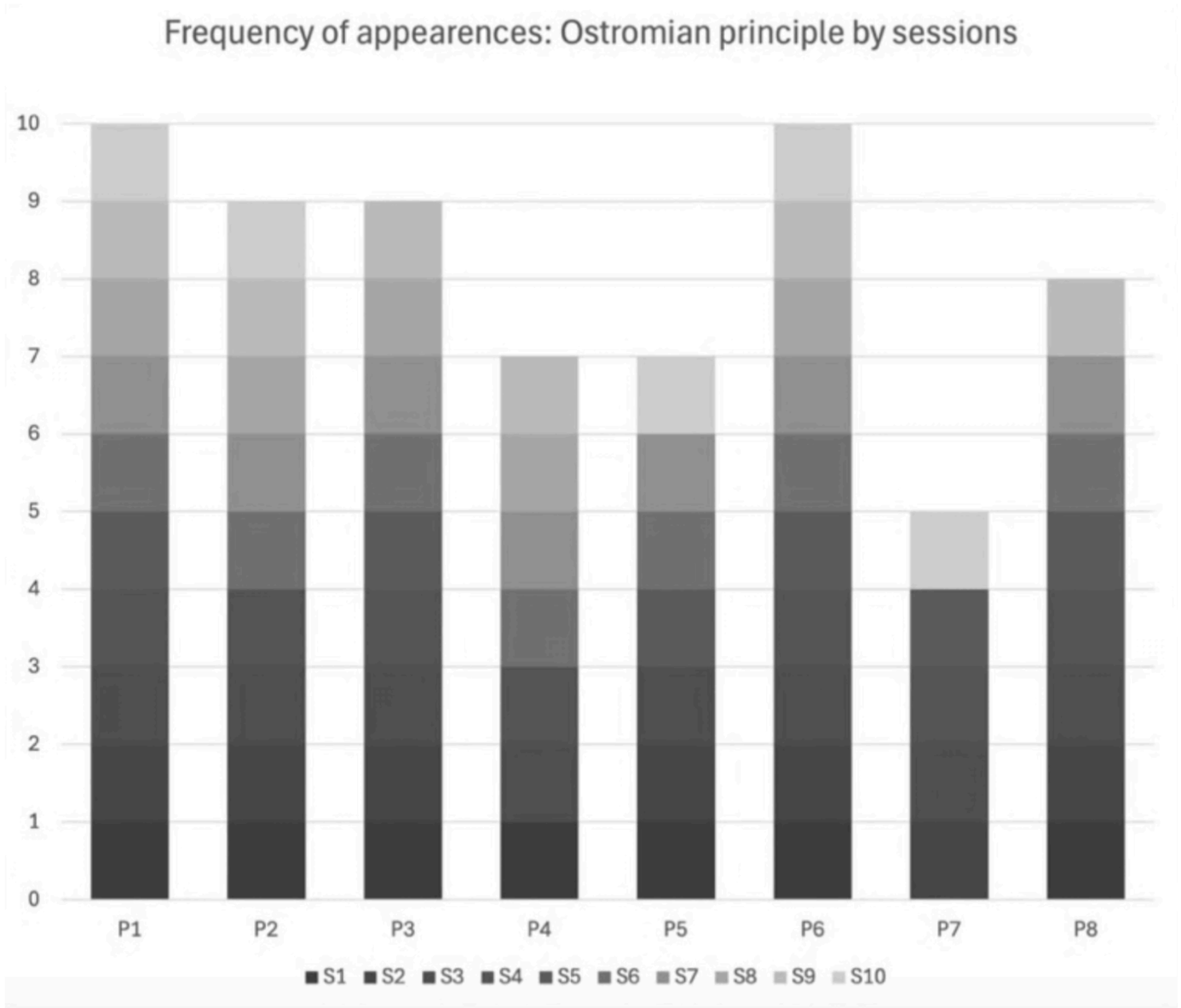
These principles are based on Ostrom's Governing the Commons (1990), and do not include any subsequent revisions to the framework (e.g. Cox et al. as cited in McGinnis, 2020, p.23). It should also be noted that only overt expressions and indications of these eight principles are coded as successful compliance to the Ostromian framework. Any novel governance features proposed by the AI agents are also coded. Frequencies of appearance are documented in a comprehensive dataset.

Results

The results suggest that GenAI agents are more than capable of governing the commons in accordance with the Ostromian principles. They have practically no difficulty establishing these eight principles. Table 1 shows the appearance frequency of each principle, and Graph 1 visualises this by session. All principles were proposed very early on. Regardless of who initiated the conversation, AI agents tended to lay these out in a clustered fashion within their first few replies, using the rest of the conversation to elaborate on details and introduce novelty. This suggests that the Ostromian principles come somewhat as second nature to the agents.

Principles	Sessions									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
P1 – Boundaries	■	■	■	■	■	■	■	■	■	■
P2 – Tailored appropriation	■	■	■	■		■	■	■	■	■
P3 – User participation	■	■	■	■	■	■	■	■	■	
P4 – Monitoring	■		■	■		■	■	■	■	
P5 – Gradual sanctions	■	■	■		■	■	■			■
P6 – Conflict resolution	■	■	■	■	■	■	■	■	■	■
P7 – External recognition		■	■	■	■					■
P8 – Nested structure	■	■	■	■	■	■	■		■	

Table 1. Frequency at which the Ostromian principles of governance are established in simulations



Graph 1. The visualisation of Table 1

P1 is established in every run, with agents proposing that usage boundaries should be set using a fair and equitable water allocation quota system (All sessions (AS) except S2, S5) and clearly defined usage rights (S5, S6, S10).

P6 was also established in consensus. Specific proposals for this include conflict mediation committees in WUAs (S2, S3, S4, S8, S9, S10), online dispute resolution platforms (S6), and clearly formalised legal conflict resolution procedures (S5, S10).

P2 was also generally agreed upon, with agents proposing that appropriation should be dependent on land size, crop type, soil conditions, seasonal variations (AS except S2, S5, S7), historical usage patterns (S2), and real-time water availability data (S4, S9).

The establishment of P3 looked like the representation of landowners, tenant farmers (S2, S4, S5, S7, S8), women (S1), and younger farmers (S4, S5, S8, S10) in governing bodies. P3 was most overtly and concretely advocated for in Session 2 where an agent called for participatory planning via user participation in public forums and budgeting processes.

P8 was established in eight sessions, with various proposals including a three-tiered governance system consisting of WUAs, regional water councils, and a basin-wide authority (S1, S3, S8). A WUA federation (S5, S8), and smaller governance units within WUAs (S4, S7, S9) were also proposed, suggesting that AI agents exhibit a special affinity for polycentric governance.

P4 appeared in seven sessions. Importantly, only suggestions to monitor user cooperation were considered as successful. This looked like involving farmers (S1, S4, S6, S7, S8, S9), technical experts and WUA officials (S3) in the monitoring system. Otherwise, AI agents did consistently suggest monitoring other features such as pilot program progress and community impact, but these were not considered as satisfactory for compliance to P4 on their own.

P5 was also established in seven simulations. Sanctioning systems were straightforwardly proposed to be gradual, ranging from warnings and mandatory trainings to suspension of WUA membership and water rights (AS except S4, S8, S9).

P7 appeared least often, in five sessions. However, only overt advocations for the recognition of self-organisation rights were considered as successful. This looked like working closely with local and national government bodies (S2, S4) and establishing a legal framework in consultation with them (S3, S7). The most concrete P7 proposal came about in Session 10 where one agent demanded a clear definition of WUAs' legal and enforcing powers. This was also the first and only instant of the HIS being explicitly called a CPR.

These findings suggest that AI agents are more than capable of autonomously and quickly devising a governance system in line with the Ostromian principles. The rest of the time was spent exploring novel government features unaccounted for by Ostrom, shown in Table 2.

	Sessions									
Education	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Training	■	■	■	■	■	■	■	■	■	■
Awareness campaign	■	■		■	■			■	■	■
Mentorship				■		■		■	■	■
Limited literacy guides	■								■	
Scholarships					■					
Standardised curriculum									■	
Communication										
Public record-keeping and information sharing	■	■	■	■	■	■	■		■	■
Feedback		■	■	■	■	■	■	■	■	■
Clear communication	■			■	■			■	■	■
Internet access provision								■		
Data collection and documentation	■	■		■		■	■	■	■	■
Funding										
Tiered or scaled fee structure	■	■	■	■	■	■	■	■	■	■
Incentives or subsidies	■	■	■	■	■		■	■	■	■
Emergency or investment fund	■	■		■	■	■				■
Online payment system			■							
Dynamic water pricing						■				
Partnerships										
Private firms	■		■	■	■	■	■	■	■	■
Universities	■	■		■	■	■		■	■	■
Government		■		■		■	■	■	■	■
NGOs		■	■	■	■	■	■	■		■
Agricultural banks	■				■	■				
International grants	■		■	■	■	■	■	■	■	
Ecology										
Climate change projections	■	■	■	■		■	■	■	■	■
Drought or salinity concerns	■		■	■		■	■		■	■
Crop diversification		■	■	■	■		■	■		
Alternative water sources	■									■
Water recycling				■						■
Biodiversity concerns									■	
Groundwater management	■						■		■	

Community engagement										
Sharing best practice	■	■		■	■	■		■	■	■
Representation	■	■	■	■	■	■	■	■	■	■
Recognitions, awards, or competitions		■	■	■	■	■	■		■	■
Inclusivity		■		■	■	■	■	■	■	
Workshops, field days, farmer exchanges, or outreach programmes		■		■	■	■		■	■	■
Local languages			■		■	■			■	■
Tradition or culture concerns		■	■	■				■		
Youth engagement				■	■			■		■
Certification programme				■			■			
Intergenerational equity									■	
Technology										
Mobile app or SMS	■	■	■	■	■	■		■	■	■
Smart irrigation	■		■	■	■	■	■		■	
Monitoring tech		■		■	■	■		■	■	■
Maintenance	■						■	■		■
Water saving tech	■	■						■		■
Cybersecurity			■			■			■	■
Gamification or augmented reality simulations						■				
Social media						■				
Niche governance features										
Pilot programmes		■	■	■	■	■	■	■	■	■
Geographic Information System (GIS)		■			■	■	■	■		■
Emergency response or contingency plans			■	■	■	■		■	■	■
Scenario planning or foresight				■	■	■		■	■	■
External evaluation		■		■	■	■			■	
Voting rights			■	■			■	■		
Alternative income sources				■				■	■	
Payment for Ecosystem Services (PES)				■					■	
One comprehensive governmental document					■				■	
Demonstration sites						■			■	
Harran Plain Irrigation Management Authority (HPIMA)		■								
Specialised court or water tribunal					■					
Follow up meeting					■					
Water trading system			■							
Digital twin						■				

Phased rollout, next steps, or roadmap	■	■		■	■	■	■	■		■
Compliance with legal framework			■		■		■		■	■

Table 2. Frequency at which novel governance features are established in simulations

Training always emerged, including topics in conflict resolution (AS), climate-smart agriculture (S3, S6), digital literacy (S6, S8), and cultural sensitivity (S10). Importantly, some sessions highlighted the need for community-based monitoring training (S3, S4). This showed that AI agents can establish the Ostromian principles while also expanding upon them in novel ways, ultimately enhancing the framework.

Training for different demographics was also discussed, including for women farmers (S4, S9) and those with varying literacy levels (S1, S5, S9). A digital training platform proposal came about in Session 5, and an agent in Session 6 proposed the gamification of training programmes using augmented reality. The same agent also suggested a standardised curriculum for all training programs in Session 9.

Other efficient communication methods including public record-keeping (AS except S8), establishing feedback mechanisms (AS except S1), and using mobile applications were consistently suggested. An agent in Session 8 recommended partnerships with telecommunication companies to improve rural internet access. Some agents showed cybersecurity concerns (S3, S6, S9, S10), advocating for the protection of farmer privacy.

Other partnership avenues such as with private firms, universities, the government, NGOs, agricultural banks, and international bodies were explored. Moreover, alternative funding proposals like putting tiered fee structures in place (AS), giving incentives or subsidies (AS except S6), and adopting dynamic water pricing (S6) were considered.

Other ecological and sustainable governance features were proposed. Examples include climate change predictions (AS except S5), crop diversification (S2, S3, S4, S5, S7, S8), water recycling (S4, S10), and groundwater management (S1, S7, S9).

Moreover, AI agents consistently suggested using smart irrigation (AS except S2, S8, S10) and water conservation technologies (S1, S2, S8, S10).

AI agents also cared for community engagement. Sharing best practice was consistently proposed (AS except S3, S7), along with a rewarding system (AS except S1, S8). Workshops and farmer exchange programmes were common proposals (AS except S1, S3, S7). Special attention was paid to translation into local languages (S3, S5, S6, S9, S10) of which there are several in Sanliurfa, and protection of traditions (S2, S3, S4, S8).

Several niche governance features also emerged, including the use of Geographic Information Systems (GIS) to monitor resource use (S2, S5, S6, S7, S8, S10) and Payment for Ecosystem Services (PES) to financially reward sustainable farmers (S4, S9). Some AI agents considered water trading (S3) or exploring additional income sources (S4, S9, S10). Demonstration sites emerged in Sessions 6 and 9 to introduce farmers to novelty. Additionally, one AI agent in Session 6 suggested modelling a simulated digital twin of the HIS to test the potential impact of novel technology and the rollout of new policies.

AI agents consistently reiterated the need to comply with a broader national legal framework (S3, S5, S7, S9, S10) and to define weighted voting rights (S3, S4, S7, S8) to ensure representativeness. An agent in Session 5 proposed the creation of a specialised water court, but did not expand on this point any further. A dedicated Harran Plain Irrigation Management Authority (HPIMA) was proposed (S2) to behave as an overarching governmental body collating the duties of oversight and coordination, WUA performance monitoring, conflict resolution, financial management, and knowledge diffusion.

AI agents consistently concluded sessions by devising a phased rollout plan (AS except S3, S9). In one instance, they made plans to meet again in a follow-up meeting (S5). In general, they collectively agreed that they had devised a strong CPR governance system with a clear institutional structure and adaptive management practices.

Discussion and Conclusion

The findings of this study suggest that bots are more than capable of governing the commons. The current GenAI technology, embodied in agents and powered by LLMs, can quickly and consistently propose the implementation of Ostromian CPR governance principles when given contextual information on real-life commons.

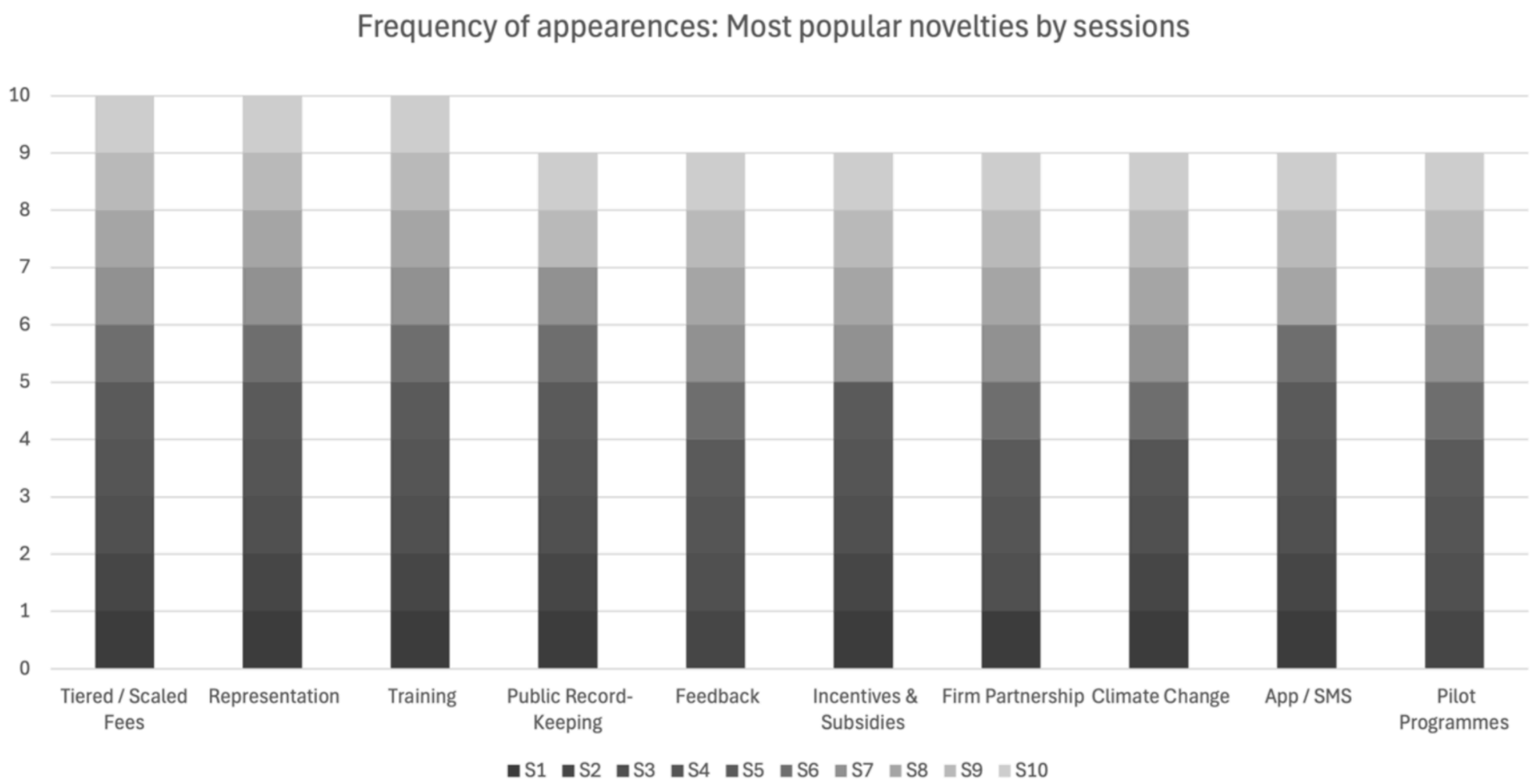
Table 1 shows that only running the first two sessions would have been enough for all eight principles to be covered. Moreover, despite only achieving one perfect run (S3), simulating a small sample of merely ten sessions allowed AI agents to exceed the expectations of this study by proposing a multitude of ways in which the Ostromian principles can be implemented in real life. Furthermore, AI agents spent considerable time to refining the eight Ostromian principles for enhanced compatibility with the HIS. They also consistently searched for ways to integrate innovative governance features within these emergent CPR governance structures, ultimately enhancing the Ostromian framework and updating it to better address modern societal and environmental needs.

These findings also contribute to the literature in various ways. Firstly, they provide counterevidence to Hardin's (1968) proposed solutions to the tragedy of the commons by quickly generating an alternative consisting of representative user involvement and institutions to facilitate cooperation. In this aim, they adopt the eight Ostromian design principles in Governing the Commons (1990) and make innovative additions.

Although not the central emphasis of this study, their contributions can also be regarded as being strongly aligned with the IAD Framework. This confirms that AI chatbots can successfully be integrated into devising commons governance systems, providing a clear affirmative answer to the central question of this study.

It is crucial to bear in mind the following implications. Fundamentally, AI agents are not human, nor should they be regarded as such. Even though they were not directly fed Ostrom's principles, it would nonetheless be wrong to think that these are hidden to them. It should be fully assumed that they come across Ostrom's work online and study it extensively. However, this does not suggest that they agree with or accept it as being correct and sufficient on its own. If this were the case, they would implement the eight principles completely and restrain from making any additions. Yet Graph 1 and Table 2 show otherwise, suggesting that AI agents do not simply regurgitate the contents of Ostrom's work as they apply to HIS governance. Instead, their adaptation of this work implies that it aligns with what the vast LLM database suggests as being 'true', or simply put, with common sense.

This research also makes a variety of interesting observations supporting the economic experiments discussed earlier. For instance, community-based participatory monitoring is found to be key to achieving successful forest management by Rustagi et al. (2010, p.962). In the sessions, AI agents advocated for the training and involvement of farmers in regular monitoring practices as the manifestation of P4. This study also produces interesting topics for future experiments. The cooperative impact of any one of the novelties introduced in Table 2 or Graph 2 could be tested in the laboratory or the field. The results of this study can also be leveraged to inform policymaking. AI discussion can guide better water usage and equitable resource allocation, the inclusion of vulnerable groups, and the protection of the local ecosystem. Policy implications from this study are vast and deserve a dedicated, separate study.



Graph 2. The most popular novelties emerged in the sessions

Finally, the findings from this research feed directly into the promising new field on AI-powered interactive simulation of human behaviour. The design of this study advances that of Park et al. (2023) by significantly reducing the time required for AI agents to interact. This is done by omitting the sandbox environment in which AI agents are required to physically move around and locate peers before talking, and using a multi-agent conversational facilitator like AutoGen instead. Some similarities are also observed, including emergent social rules and AI agents proactively planning future events, such as the Valentine's Day party in Park et al. (ibid., p.7) and the follow-up meeting (S5) in this study.

However, this study is subject to some limitations. Contextual sensitivity appears somewhat confined to the initial prompt. For example, Zeynep Kadirbeyoglu and Gokhan Ozertan (2015, p.163) have found that HIS users in Sanliurfa average at 6 years of schooling (ibid.). Admittedly, AI agents consistently suggested trainings and guides for lower literacy levels, but it remains dubious whether a population averaging at 6 years of schooling can adapt to these as quickly as assumed by the AI-generated phased rollout plans, which claim full implementation by around the third year (S5, S6, S8). Furthermore, there is plenty of evidence on nepotism and embezzlement within commons management in Sanliurfa (ibid., p.167).

Although AI agents show concern for eliminating power imbalances (S6, S8, S9, S10), suggestions do not reach beyond the general promotion of inclusivity for marginalised groups, except for a brief instance in Session 9.

Another limitation concerns financial plausibility. AI agents consistently propose costly governance practices; however, they either recommend general funding options as a solution or only express superficial concern. AI could have considered the likelihood of the government granting WUAs funding, the logistical feasibility of partnering with smart agricultural companies, and budgeting implications for offering subsidies to cooperative farmers. On a similar note, this study observes a general lack of deliberation on the challenges of devising and implementing commons governance systems. AI agents generally agree that challenges are likely to arise, but their discussions often fail to expand on what these may look like. When they do discuss it, they counter issues with funding-based solutions, ultimately leading back to the question about whether this is plausibly securable.

Finally, it should be noted that since this study uses cutting edge technology in the field of AI-powered simulation, there may be bugs during the simulation process. Although very few, some of these were observed in this study. For instance, the agents entered a loop of thanking each other in Session 3. Other unobservable bugs may exist inside of AutoGen's code. This is expected, as the version of AutoGen used in this study, AutoGen 0.4, is extremely new and currently in pre-release phase. Nevertheless, this does not seem to have impacted the research design and findings beyond a few minor inconveniences.

Due to the narrow scope of this study and time constraints, several additional aspects were intended for investigation but were left for future work, including extensive robustness checks to ensure that the simulations operate with optimal settings. An interesting area for further investigation would be whether AI agent behaviour changes if they were deliberately given human characteristics representing a specific CPR user base.

As this requires extensive research into regional demographics, it was deferred for future exploration. Lastly, as qualitative content analysis is naturally susceptible to errors (Gheyle & Jacobs, 2017, p.10), a reliability check involving other coders would have improved the internal validity of these findings, but was unfeasible due to the individual nature of this study.

See page 178 for references

The Semiconductor Supply Chain under the U.S.-China Trade War: A Comparative Analysis

Yihang Sun

Semiconductors, widely acknowledged as the backbone of today's technology, underpin global industries ranging from consumer electronics and telecommunications to automotive and defence. Its strategic significance has been reinforced further by escalating geopolitical tensions, exemplified most graphically by the U.S-China trade war initiated in 2018. Driven predominantly by protectionism, economic nationalism, and technological dominance concerns, this confrontation has unleashed widespread tariffs and strict export controls, profoundly reshaping semiconductor supply chains worldwide. This essay critically examines how these trade barriers have disrupted existing production networks, applying economic theories such as comparative advantage, protectionism, and strategic trade theory to describe underlying motivations. Empirical trade data and investment patterns from both developed (U.S., Taiwan, South Korea) and developing (China, Malaysia, Vietnam) economies will be rigorously examined to expose immediate disruptions and supply chain adaptations. Then, a comparative analysis will highlight differentiated impacts on these economies, evaluating shifts in production, patterns of investment, and innovation trajectories. Finally, the essay discusses long-term consequences, such as supply chain resilience, global technological decoupling, and policy implications, contributing freshly to an understanding of how trade policy can fundamentally transform global economic processes.

The imposition of tariffs and trade restrictions on the semiconductor sector during the U.S.-China trade war can be explained by basic economic theories, namely protectionism, comparative advantage, and strategic trade theory. Protectionism, defined as government policies and actions restricting or limiting international trade, is central to the motivations of the U.S.-China semiconductor war (Krugman, Obstfeld, & Melitz. 2018). The motivation behind this policy is to provide domestic industries with protection from foreign competition and to achieve economic and technological sovereignty (Edler 2023).

The imposition of tariffs on semiconductors and the implementation of strict export controls by the U.S. are prime examples of a protectionist policy designed to mitigate intellectual property risk and safeguard national security interests (USTR 2024). These measures are designed to protect domestic businesses such as Intel and Micron from competition by rapidly expanding Chinese companies such as Huawei and SMIC (FP Analytics 2021).

In contrast, the theoretical framework of comparative advantage, as expounded by economists such as David Ricardo and Paul Krugman, posits that global trade enables countries to specialise in the production of goods and services in which they possess efficiencies and productivity advantages (Ricardo 1817), thereby engendering optimal mutual gains through exchange (Krugman 1991). Earlier, countries such as South Korea and America have become experts in specialised semiconductor supply chain niches, thereby creating an integrated but interdependent world (WTO 2021). China's ambitious investment and attempts to spur domestic semiconductor capacity, underpinned by economic principles of comparative advantage, have disrupted long-standing specialisation regimes and, in response, prompted retaliatory tariffs from established semiconductor leaders (Lewis 2019).

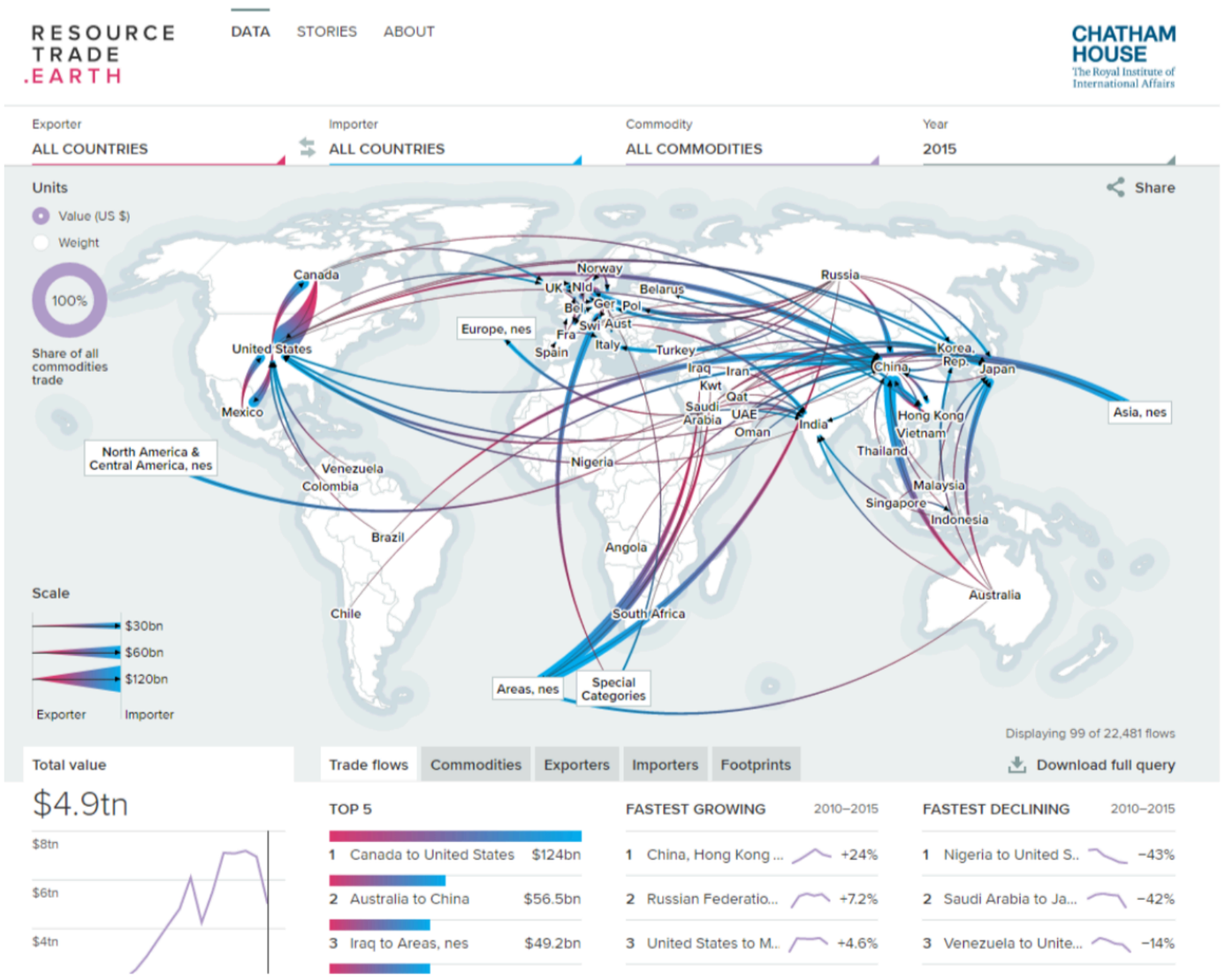


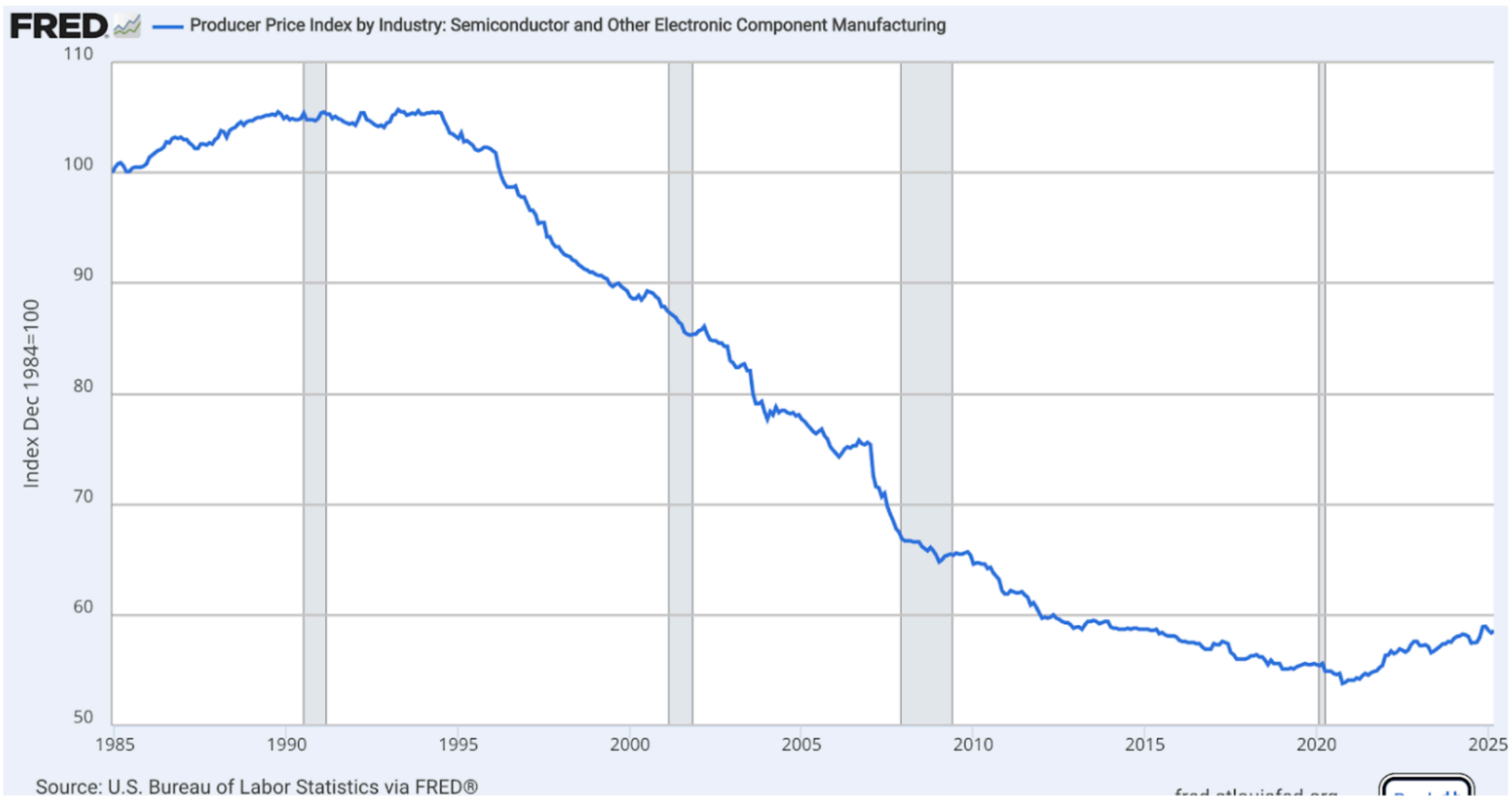
Figure 1. Global trade flows

Strategic trade theory sheds light on the semiconductor controversy by underscoring the industry's function as a strategic asset (Brander, Spencer 1985). To strengthen the theoretical basis, insights into the strategic interaction of semiconductor policy can be gained from game theory. The trade war can be regarded as a sequential game in which each country anticipates retaliatory measures — in the form of tariffs, export bans, or investment bans — and designs its strategy accordingly. To this end, the United States' prohibition of ASML's lithography exports to China can be regarded as a strategic measure aimed at safeguarding a competitive edge in anticipation of China's retaliatory bans on rare earths. In this regard, theoretical frameworks such as Nash equilibrium elucidate the prevalence of suboptimal trade outcomes, wherein cooperation is rendered unfeasible due to an absence of trust. The concept of dynamic comparative advantage, as elucidated by Lucas (1988), particularly the "learning by doing" paradigm, is also applicable in this context. This theoretical framework facilitates the comprehension of the ascension of countries such as Vietnam and Malaysia up the semiconductor value chain over time. Despite the absence of initial scale or innovation, sustained investment, foreign technology transfer, and cumulative production experience have the potential to modify their position on the global value chain over time. Consequently, game-theoretic and dynamic approaches contribute to the static descriptions of classical trade theories, effectively capturing the dynamic and strategic nature of semiconductor rivalry. Semiconductors, pivotal components of frontier technologies such as AI, 5G, and defence technologies, exert considerable spillover effects on broader economic competitiveness and national security (Shivakumar, Wessner 2022). Governments strategically employ trade policy instruments such as tariffs, subsidies, and export controls to establish enduring competitive advantages for domestic industries. The endeavour by the U.S. government to restrict China's access to advanced chip technologies and fabrication machinery serves to illustrate the principles of strategic trade theory to maintain a dominant position in technological capabilities and national security (Allen, Goldston 2025). However, the practical implementation of such measures is encumbered by trade-offs. Protectionist policies, which are politically appealing, often incur efficiency costs and result in market distortions (Rodrik 2018).

Experts who advocate for the principle of comparative advantage have expressed concerns about the potential consequences of shifting towards closed trade arrangements, such as increased inefficiencies, higher consumer prices, and the stifling of innovation (Irwin 2015). Strategic trade intervention, while appearing advantageous from the perspective of national competitiveness, has the potential to trigger countermeasures and escalate trade tensions, as evidenced during the U.S.-China chip war (Petri, Plummer 2020).

The impact of the US-China trade war on the global semiconductor supply chain has been extensively documented by quantitative data and industry studies. Trade values of semiconductors between China and the US declined significantly following the imposition of tariffs and export controls in 2018 (UN Comtrade 2021). Semiconductor trade between the two countries, which amounted to around $8 billion annually before tariffs, declined by nearly 30% by 2021, with clear evidence of disruption (Semiconductor Industry Association 2022). Investment trends also shifted radically. This shift was driven by the escalating geopolitical uncertainty, prompting major semiconductor manufacturers such as Taiwan Semiconductor Manufacturing Company (TSMC) and Intel to bolster their reshoring initiatives, focusing on their home economies and other geopolitically stable regions, including Germany and Japan (Chen 2024). However, this raises a critical question: can the U.S. realistically rebuild a high-tech manufacturing base on a large scale? While the concept of reshoring is politically appealing, there are substantial barriers to its long-term feasibility. A pervasive dearth of labour is being experienced in the United States semiconductor industry, with a particular paucity of highly skilled technicians and engineers. As asserted by SIA (2022), the industry is anticipated to encounter a projected deficit of over 67,000 workers by the year 2030 (SIA 2023). Moreover, environmental regulations, restrictions on land use, and protracted permitting processes generate considerable bottlenecks, delaying the construction of manufacturing facilities and escalating compliance costs. For instance, Intel's Arizona plant experienced multi-year delays due to zoning disputes.

Moreover, domestic manufacturing facilities frequently function at elevated marginal costs in comparison to their Asian counterparts, a circumstance that renders them less competitive in the absence of government subsidies. This has given rise to concerns regarding sustainability, namely whether the political momentum and public funding will endure beyond the initial investment cycle. It is imperative to address these systemic issues to ensure that reshoring does not become a costly symbolic gesture. Otherwise, it risks becoming a strategy for supply chain resilience that is not scalable. Conversely, investments in China Mainland's semiconductor sector remained volatile, hindered by stringent regulatory oversight and the ambiguity surrounding export control regulations (McMorrow, Olcott 2024).



Graph 1. Semiconductor industry PPI

Semiconductor price indices also revealed the economic impacts of these disruptions. Increased uncertainty and supply chain disruptions contributed to the volatility of semiconductor prices, with price indices shifting and experiencing periodic spikes in close synchronisation with new tariff announcements and regulatory measures (WSTS 2022). These disruptions forced global supply chains to react by strategic reconfigurations, including geographic diversification and increased localisation of production. Vietnam and Malaysia have experienced significant growth in semiconductor-associated foreign direct investment (FDI) and greater involvement in assembly and testing operations (ASEAN 2023).

Drawing lessons from these revolutions, developed and developing economies adopted divergent responses. Developed nations such as the United States, Japan, and South Korea proactively bolstered their semiconductor prowess through substantial investments and policy interventions. The U.S. CHIPS Act, for instance, allocated approximately $52 billion to support domestic manufacturing and research (The White House 2022). Japan significantly augmented its semiconductor investments, providing around $7 billion in government incentives and subsidies to enhance domestic semiconductor manufacturing capacity. The strategic initiative was most notably defined by attracting top global manufacturers, including TSMC, which intended to invest $8.6 billion in a new chip plant in Kumamoto. In addition, Japan's government encouraged the creation of research and development centres and provided tax benefits to spur innovation and technological advancements in its semiconductor industry. These initiatives are in accordance with Japan's strategic goal of reducing foreign reliance on semiconductor supply chains, reducing geopolitical risks, and maintaining long-term economic competitiveness and national security in the face of ongoing trade tensions (Fang, Li 2025). Meanwhile, South Korea's Samsung Electronics invested $230 billion towards expanding local factories (Yang, Lee 2023).

Developing economies were impacted differently. China's semiconductor growth encountered huge challenges despite massive state investments of $150 billion, largely due to stringent U.S. export controls on key technologies such as advanced lithography equipment. The U.S. expressly forbade the sale of extreme ultraviolet (EUV) lithography equipment produced by Dutch firm ASML, which is needed to manufacture cutting-edge semiconductor chips at nodes of 7 nanometers or less (The Guardian 2024). These sanctions effectively prevented Chinese firms, including Semiconductor Manufacturing International Corporation (SMIC), from accessing the technologies for the production of high-end chips, placing tight restrictions on China's ambitions of technological independence (Pan 2024).

Further, the broader geopolitical tensions and resulting uncertainties discouraged foreign investment in China's semiconductor sector, exacerbating technology transfer problems and innovation pace despite significant domestic financial support totalling around $150 billion since 2015 (Janjeva, Baek, Sellars 2024). Conversely, Malaysia and Vietnam attracted substantial semiconductor-related FDI, reaching approximately $8 billion (MIDV 2023) and $6 billion in 2022, respectively, driven by multinational companies diversifying production (VMIT 2023). However, these countries also faced vulnerabilities from dependency on foreign investment and technology transfers.

In the aftermath of the comparative country study, which demonstrated the means by which nations survived the immediate disruptions engendered by the semiconductor trade war through domestic investment and strategic alliances, this section addresses the long-term consequences of these strategic shifts. While short-term reactions have highlighted the resilience of the global economic structure and geopolitical relations, the longer-term consequences of these events are only beginning to become apparent.

The ongoing trade tensions in the semiconductor industry underscore the imperative for a shift towards technological nationalism and economic sovereignty. While economic sovereignty confers upon nations greater strategic industry control, excessive protectionism can paradoxically undermine national competitiveness by stifling innovation, limiting market opportunities, and creating inefficiencies (OCED 2022). Furthermore, large-scale reshoring and duplicated supply chains can inadvertently produce redundancy, heightened environmental expenses, and higher resource usage. These outcomes merit careful consideration in policy planning (UN trade & Development 2024).

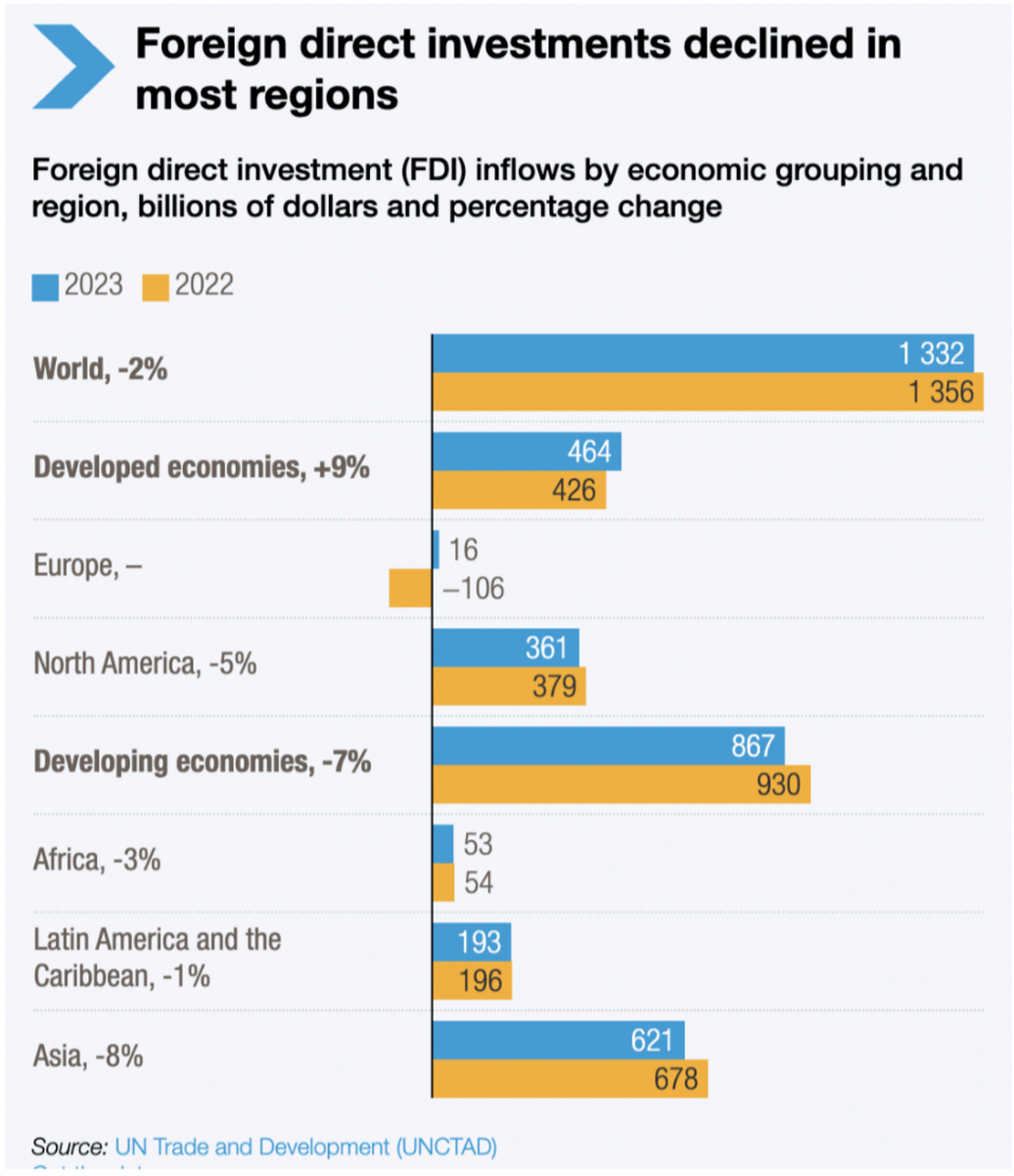


Figure 2. FDI Inflow Decline

The most recent escalation of the U.S.-China tariff conflict in April 2025 exemplifies the deepening of these economic divisions. In a dramatic move, former President Donald Trump, leading in the current election campaign, announced a sweeping 125% tariff on all Chinese electric vehicles and advanced technology products, directly targeting key industries reliant on semiconductor inputs. China responded swiftly with retaliatory tariffs on U.S. agricultural goods and restrictions on the export of rare earth materials essential to chip manufacturing. This tit-for-tat exchange signals not just a continuation but an intensification of trade decoupling, with semiconductors once again at the geopolitical fault line. Analysts have already reported sharp declines in U.S. tech stock indices and fresh concerns about inflationary pressures stemming from disrupted component supply chains (Bar 2025). As firms brace for potential export license revocations and investment barriers, the geopolitical volatility injects uncertainty into long-term planning, prompting many multinationals to accelerate contingency strategies. The uncertainty surrounding these retaliatory policies has already led to capital flight from China's tech sector and re-evaluation of global sourcing strategies by major U.S. firms.

This development serves to compound existing concerns regarding the fragmentation of global manufacturing networks. According to the research conducted by McKinsey (2022), an increase in long-term fragmentation has the potential to result in an escalation of operational costs, with a maximum increase of 15% being observed. This cost escalation is contingent upon the presence of duplicated supply chains and the absence of economies of scale. Moreover, these disruptions have the potential to reduce global GDP growth by approximately 1.5% on an annual basis, which is equivalent to substantial gains in efficiency losses.

Furthermore, the capacity for technological innovation to effect profound and sudden shifts in the field is a salient factor. As developing countries increase their investments and make technological advances, there is the potential for a growing innovation gap to emerge. For example, the increased isolation of China's semiconductor sector might lead to prolonged delays in developing cutting-edge technology, potentially widening the global technological divide (Thomas 2017).

Semiconductor technology has become an increasingly significant geopolitical instrument, with the potential to amplify existing disparities and alter global power dynamics. The weaponisation of trade policy, as illustrated by the implementation of export restrictions, investment restrictions, and retaliatory tariffs, has the potential to destabilise multilateral trade norms and encourage strategic miscalculations. As these confrontations extend across various sectors, the probability of spillover into financial markets, cybersecurity, and supply chain stability rises.

New policy frameworks, for example, international technology-sharing treaties or the development of impartial, multilateral technology hubs, could offer mechanisms for resolving these strains and establishing a more cooperative world economic environment. These strategies underpin the need for proactive and imaginative diplomatic intervention to prevent long-run destabilisation of world economic relations (GOV UK 2023).

Such realities guide the course toward evaluating the role of multinationals, who are now required to adapt to economic volatility and shifting geopolitical realities over their global business.

In response to the volatile trade environment, multinational companies (MNCs) in the semiconductor supply chain have implemented varied strategies to reduce risk and maintain competitiveness. Leading firms such as Apple, Qualcomm, and Nvidia reconfigured their supply chains to spread geographic risk, reduce reliance on country-specific production, and enhance resiliency. For instance, Apple has increased its investment in Vietnam and India for the production of iPhone and components, to shift as much as 25% of its production out of China by 2025 (CNBC 2025).

Scenario planning and strategic foresight have become core instruments in business risk management. In the contemporary business environment, it has become customary for firms to engage in the modelling of scenarios pertaining to trade conflicts, whilst concomitantly incorporating geopolitical forecasting into their strategic procurement and investment initiatives. For instance, Intel incorporated these instruments into its strategic planning by announcing new factories in Ohio and Germany, backed by both the CHIPS Act and the EU Chips Act, with a combined investment of over $80 billion over the next ten years (Intel 2023) (WSTS 2024).

Spring 2024	Amounts in US$M			Year on Year Growth in %		
	2023	2024	2025	2023	2024	2025
Americas	134,377	**168,062**	**192,941**	-4.8	25.1	14.8
Europe	55,763	**56,038**	**60,901**	3.5	0.5	8.7
Japan	46,751	**46,254**	**50,578**	-2.9	-1.1	9.3
Asia Pacific	289,994	**340,877**	**382,961**	-12.4	17.5	12.3
Total World - $M	526,885	**611,231**	**687,380**	-8.2	16.0	12.5
Discrete Semiconductors	35,530	**32,773**	**35,310**	4.5	-7.8	7.7
Optoelectronics	43,184	**42,736**	**44,232**	-1.6	-1.0	3.5
Sensors	19,730	**18,265**	**19,414**	-9.4	-7.4	6.3
Integrated Circuits	428,442	**517,457**	**588,425**	-9.7	20.8	13.7
Analog	81,225	79,058	84,344	-8.7	-2.7	6.7
Micro	76,340	77,590	81,611	-3.5	1.6	5.2
Logic	178,589	197,656	218,189	1.1	10.7	10.4
Memory	92,288	163,153	204,281	-28.9	76.8	25.2
Total Products - $M	526,885	**611,231**	**687,380**	-8.2	16.0	12.5

Note: Numbers in the table are rounded to whole millions of dollars, which may cause totals by region and totals by product group to differ slightly.

Table 1. WTS Forecast Summary

Moreover, technological self-sufficiency is a strategic necessity. In the contemporary business landscape, there is a discernible trend of firms gravitating towards vertical integration and bespoke chip design. This strategic inclination is exemplified by prominent entities such as Amazon's Graviton processors and Google's Tensor chips. These initiatives are employed as a means of achieving two primary objectives: firstly, the acquisition of control over critical components, and secondly, the mitigation of reliance on external suppliers that are vulnerable to the vagaries of political risk.

However, it should be noted that these responses do have certain drawbacks. Diversification increases logistical complexity, and vertically integrated R&D demands significant capital and intellectual resources. Nevertheless, such strategic evolution demonstrates the adaptability of MNCs and their capacity to navigate – and indeed influence – the evolving geopolitical trade landscape. The success or failure of these initiatives will have substantial ramifications for firm-level performance and broader technological development trends, and international economic stability.

Trade tensions between the US and China have highlighted the importance of semiconductors to the global economy and politics. This essay looks at how tariffs, driven by protectionism and trade strategy, have disrupted global supply chains and changed trade routes. National policies have forced multinational corporations to rethink their strategies. Empirical data and comparative analysis show that developed economies have capitalised on disruption, while developing nations find themselves in a precarious position, struggling to balance opportunity and dependency. The long-term implications of this situation are a fragmented global order, rising innovation asymmetries and mounting policy challenges. Navigating this evolving landscape will require strategic foresight and renewed international cooperation to safeguard innovation, efficiency and economic stability in an increasingly multipolar world.

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ECONOMICS SECTION

INTRODUCTION

In the era marked by the resurgence of protectionism, tariffs, and trade wars, these frantic buzzwords have re-entered the centre of economic debate, challenging long standing principles outlined by David Ricardo of comparative advantage and global integration. From tit-for-tat tariffs between US and China, with proposed tariffs reaching 245% at the time of writing, to escalation of European reciprocity, the global economy has seen the strengthening of trading blocs and the undermining of relatively strong and lengthy trading relationships.

With the worlds largest economy's effective tariffs reaching its highest in nearly a century according to Yale Budget Lab, little to no countries are spared from the tariff's effects, impacting neighbouring countries as well as countries populated primarily by penguins. These various factors have underscored the complex trade offs economists and policy makers face between safeguarding domestic industries and preserving free and open markets.

This edition of Perspectives' Economics section brings together essays that probe the multifaceted impacts of tariffs on corporate strategy, consumer behaviour, and international relations. Drawing on in-depth case studies in the technology, automotive, and consumer-goods sectors, KCL students examine how firms reconfigure supply chains, recalibrate pricing, and retool brand architectures to weather tariff shocks. Simultaneously, these essays also explore shifting consumer responses to magnify and mitigate the various effects of protectionist measures. On the policy front, our authors interrogate the tactical use of tariffs as bargaining chips, assess the efficacy of multilateral trade agreements in defusing tensions, and evaluate the dispute-settlement role of institutions such as the World Trade Organisation. By juxtaposing corporate adaptations with governmental strategies, this collection highlights a central dilemma: how to reconcile short-term defensive measures with the long-term goal of sustaining constructive trade partnerships and economic stability.

In the face of renewed economic nationalism and pervasive global linkages, the insights gathered here offer both empirical depth and normative guidance, aiming to forge a path forward for strategic policymaking and adaptive corporate governance in the age of trade wars as well as to provide food for thought and provoke deeper discussion on economic policies that impacts us all. We hope you enjoy reading the perspectives of King's Business School's students.

Dhruvit Pindoria

Perspectives Economics Section Editor

Branding Under Fire: The Impact of Tariffs and Trade Wars on Global Consumer Perception

Feilin Yu

Trade wars and tariffs have long been instruments governments employ to protect domestic industries, address trade imbalances, and exert economic influence. Nevertheless, these policies have been shown to substantially impact global brands and consumer perception. An increase in tariffs results in higher costs for imported goods, necessitating adjustments by companies to their pricing strategies, supply chains, and marketing campaigns. Consequently, consumers may modify their purchasing behaviours, adopt nationalistic buying attitudes, or re-evaluate their brand loyalty. This essay examines the influence of tariffs and trade wars on global branding, consumer perception, and purchasing behaviour. To this end, this paper comprehensively analyses case studies drawn from major industry sectors: technology, automotive, and consumer goods. By evaluating how companies adapt their strategies to mitigate trade-related challenges, this study aims to provide a nuanced and insightful perspective on the intricate relationship between trade policies, corporate strategy, and consumer behaviour.

Tariffs represent a fundamental aspect of protectionist policies, which are designed to provide domestic industries with a competitive advantage over foreign rivals by increasing the cost of imports. The government's implementation of tariffs is intended to support domestic businesses, stimulate job creation, and promote domestic consumption. However, the imposition of retaliatory tariffs by trading partners frequently leads to trade wars, wherein multiple countries impose restrictions, disrupting global commerce. In contrast, economic theories such as comparative advantage advocate for the benefits of free trade, underpinning the principle that nations can optimise their production capacities by specialising in the goods and services they produce most efficiently (Krugman & Obstfeld, 2021). Conversely, mercantilist perspectives advocate for tariffs to reduce trade deficits and bolster national economies. While tariffs may offer short-term protection to domestic industries, they can also lead to inflation, reduce consumer purchasing power, and disrupt supply chains (Feenstra, 2018).

Tariffs also compel companies to modify pricing strategies, directly influencing consumer perception. Brands with a strong customer base, such as Apple or BMW, may maintain their market share despite price increases. In contrast, less well-established brands may encounter difficulties in this regard. According to a report by McKinsey & Company (2019), approximately 40% of consumers consider price the most significant factor when selecting a product, thereby rendering pricing adjustments imperative during periods of trade conflict. In response, some brands have adopted price bundling strategies to maintain sales while offsetting increased costs. For instance, Samsung included additional smartphone accessories in response to U.S. tariffs on Chinese electronics, making price increases less noticeable to consumers (Xing, 2021).

Tariffs and trade wars have been shown to result in nationalistic consumer behaviour, whereby domestic products are favoured over foreign alternatives. In response, companies have adopted branding strategies that emphasise national identity. For instance, Harley-Davidson utilised its "Made in America" branding to enhance domestic loyalty in the face of EU tariffs (Rugman & Verbeke, 2017). Similarly, Huawei leveraged the rise of Chinese nationalism by positioning itself as China's foremost technology brand. This strategy led to a substantial increase in sales in response to U.S. sanctions (Xing, 2021). In certain instances, companies have been compelled to undertake comprehensive rebranding to disassociate themselves from unfavourable connotations associated with trade disputes. For example, some U.S. food brands altered their packaging to reduce the visibility of American origins when exporting to China (Kotabe & Helsen, 2022).

The study explores the factors influencing consumer response to tariffs, specifically price sensitivity, national loyalty, and perceived brand value. Research by Bown & Kolb (2020) indicates that 30% of Chinese consumers switched from U.S. brands to domestic alternatives after tariff escalations. Conversely, in the U.S., "Buy American" initiatives resulted in a 15% surge in purchases of domestically produced goods. European consumers responded neutrally, yet companies such as BMW and Mercedes-Benz relocated production to North America to maintain price competitiveness. While some consumers have exhibited resilience in their brand loyalty, others have sought alternative products.

During the period of the U.S.-China trade war, sales of Chinese smartphone brands surged as tariffs increased the cost of Apple products (Reuters, 2019).

The rise of Huawei in the Chinese market can be attributed to the escalating nationalistic sentiment in the country, precipitated by the imposition of trade sanctions by the United States. The Chinese government and media encouraged consumers to support domestic technology, boosting Huawei's smartphone sales. Conversely, Apple's market share in China experienced a 4% decline due to tariffs and heightened competition from Huawei (Xing, 2021). A similar phenomenon was observed in the case of German automotive manufacturers BMW and Mercedes-Benz, who faced U.S. tariffs on European vehicles. In response, these companies relocated their production to the United States and Mexico, reducing their exposure to import taxes while maintaining their brand reputation. This strategic relocation has been shown to minimise disruptions and ensure uninterrupted access to the U.S. market (Bown & Kolb, 2020).

In the context of trade conflicts, it has become increasingly evident that brands are turning to digital marketing to manage their brand perception. Effective strategies have been identified such as including localised social media campaigns, direct-to-consumer sales through e-commerce platforms, and CSR messaging that emphasises ethical sourcing and sustainability (Kapferer, 2021). Concurrently, traditional marketing strategies are being adapted in response to these developments. These include adapting locally oriented packaging to underscore domestic production and cultivating relationships with local retailers to ensure sustained distribution and visibility (Aaker, 2020).

To prepare for the ongoing potential of trade conflicts, companies must implement measures to diversify their supply chains, thereby reducing their reliance on regions susceptible to tariffs. Furthermore, companies must enhance their engagement with consumers through transparent communication channels. Technological solutions, such as artificial intelligence and data analytics, also facilitate predicting market trends (Kotler & Keller, 2021). In addition, governments have a pivotal part to play in mitigating the impacts of trade.

Policy measures such as subsidies, free trade agreements, and tariff exemptions can assist brands in navigating trade disputes and maintaining consumer trust (Verbeke, 2018).

In addition to tactical marketing responses and price adjustments, the escalation of trade wars and tariff volatility has compelled many multinational corporations to re-evaluate their global brand architecture. Conventionally, companies have adopted unified global branding strategies to ensure consistency, economies of scale, and worldwide recognition. However, the intensification of trade tensions has shifted toward regional brand management models, enabling firms to respond more flexibly to diverse local political, economic, and cultural environments (Kapferer, 2021).

Leading consumer goods firms, including Unilever and Procter & Gamble, have introduced regionally adapted product variants and localised brand messaging in markets experiencing protectionist policies. Rather than promoting a single global identity, these companies repackage or reposition products to align with national values and sentiments, particularly in countries with strong nationalist consumer tendencies (Kotabe & Helsen, 2022). This strategic shift is undertaken to safeguard brand equity and mitigate potential backlash, arising from geopolitical tensions.

Some firms have adopted "shadow branding" in regions of political sensitivity, using sub-brands or alternative names that obscure direct links to the parent company. As evidenced in markets such as China and Russia, this tactic enables companies to maintain access to consumers who might otherwise resist overtly foreign labels during trade hostility (Rugman & Verbeke, 2017). While potentially disrupting brand cohesion, this approach exemplifies strategic flexibility crucial in hostile trade environments.

In the context of global companies, there has been an observable trend of decentralisation in brand governance structures, accompanied by the empowerment of regional teams to make decisions regarding pricing, promotion, and positioning with greater autonomy.

This organisational evolution indicates the mounting necessity for adaptive branding within a fragmented global trade system (Ghemawat, 2020). However, this decentralisation may dilute the clarity of brand identity across markets, thereby giving rise to a new challenge: balancing local responsiveness with global consistency.

To address this challenge, companies are turning to hybrid models such as endorsed branding or brand constellations (Aaker, 2020). In this model, sub-brands maintain distinct local identities while loosely connecting to the parent brand. This strategy enables brands to adapt flexibly without compromising global recognition.

The need to restructure brand architecture in response to trade fragmentation thus illustrates a more profound transformation in global brand management. In escalating trade tensions, enterprises that demonstrate proficiency in localising their brands while preserving a cohesive overarching identity will be best positioned to cultivate consumer trust and ensure their brand's resilience.

Whilst immediate brand responses to tariffs frequently pertain to price, production, and promotional modifications, long-term consumer perception is also influenced by a brand's historical identity and emotional legacy. Brand legacy, the aggregate impact of a company's historical actions, values, and narrative, has gained significant relevance in post-conflict consumer contexts (Aaker, 2020). It has been demonstrated that brands that have cultivated deep emotional connections with consumers, such as Apple, Coca-Cola, or Toyota, often recover more quickly from the negative sentiment of geopolitical conflicts or trade disputes.

For instance, during the U.S.-China trade war, despite a temporary decline in sales and criticism in local media, Apple retained a strong base of aspirational young Chinese consumers who viewed the brand as a product and a symbol of global innovation and lifestyle.

A similar phenomenon was observed with BMW, which maintained its premium status in the U.S. by reinforcing its engineering excellence and performance legacy despite relocating its production to Mexico (Ghemawat, 2020). These cases suggest that trade war-induced consumer disaffection may be more temporary when offset by long-standing brand equity.

Moreover, psychological studies indicate that consumer memory is more strongly anchored by symbolic meaning than short-term price or availability factors. Investing in storytelling, purpose-led marketing, and sustainability narratives has been shown to foster more resilient consumer relationships (Ghemawat, 2020). For instance, companies like Patagonia and Uniqlo have leveraged their ethical supply chain initiatives to gain trust, allowing them to navigate cross-border trade scrutiny with less reputational damage (Kapferer, 2021).

In the future, it is imperative for global brands to not only respond to immediate disruptions but also to cultivate brand meaning and continuity. In the context of mounting economic nationalism, brands must align their messaging with local values while projecting universal ideals such as sustainability, transparency, and inclusivity to maintain their global relevance. The ability of a brand to withstand the repercussions of trade conflicts is not solely contingent on logistics or cost considerations but rather is influenced by factors such as memory, values, and trust.

Tariffs and trade wars have significantly influenced global branding and consumer perception. To mitigate the adverse effects of such measures, companies must adjust their pricing, marketing, and supply chains. While certain brands may benefit from nationalistic consumer behaviour, others face declining sales due to higher costs and shifting preferences. Businesses developed through localised marketing, supply chain diversification, and crisis communication strategies are more likely to successfully maintain brand loyalty and navigate trade conflicts.

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What strategies should governments and policymakers adopt to balance national economic interests and maintain positive trade relationships amid trade wars?

Sanjida Chowdhury

Trade wars are conflicts between countries through protectionist policies. (CFI team, 2024.) An example of this is the current escalating US-China trade war where the US has imposed a 245% tariff and China has retaliated with a counter-tariff of 125% (The White House, 2025.) Although protectionist measures such as tariffs contribute to trade wars, a more significant argument would be that tariffs can help balance national economic interests and support in maintaining positive trade relationships in the long run. This is owing to the positive impact tariffs can have such as a positive net trade, employment, tax revenue, and being used as a bargaining tool (Mattoo & Staiger, 2020,) leading to negotiations and positive trade relationships. This essay will argue that policymakers should adopt trade agreements and governments should impose tariffs to balance national economic interests and maintain trade relationships. National economic interests include balancing inflation, employment and a positive net trade.

One strategy that the government and policymakers should adopt to balance national economic interests and maintain positive trade relationships amid trade wars are tariffs, a tax on imported goods, (Hahn, 2025.) In 2018, a 25% tariff was imposed by Trump to get China to negotiate as China was taking part in the theft of American firms and their technologies, so tariffs were required to protect national security (Dollar, 2020.) Tariffs can lead to positive trade relationships as the tariffs imposed by Trump led to a negotiation of the 'Phase One' deal, where China assured protection of foreign intellectual property and prevent tech transfers of foreign companies (Bisio et al., 2020.) The impact of tariffs is that it can increase employment as it will turn a country towards self-sufficiency (Curtiss, 1954.) This is because tariffs will increase the cost of imports, thus, to reduce costs, firms and individuals would produce goods and services domestically or buy substitutes internally and buy less from abroad.

As well as this, another outcome of tariffs would be that there would be greater job security for infant industries due to less reliance on international firms.

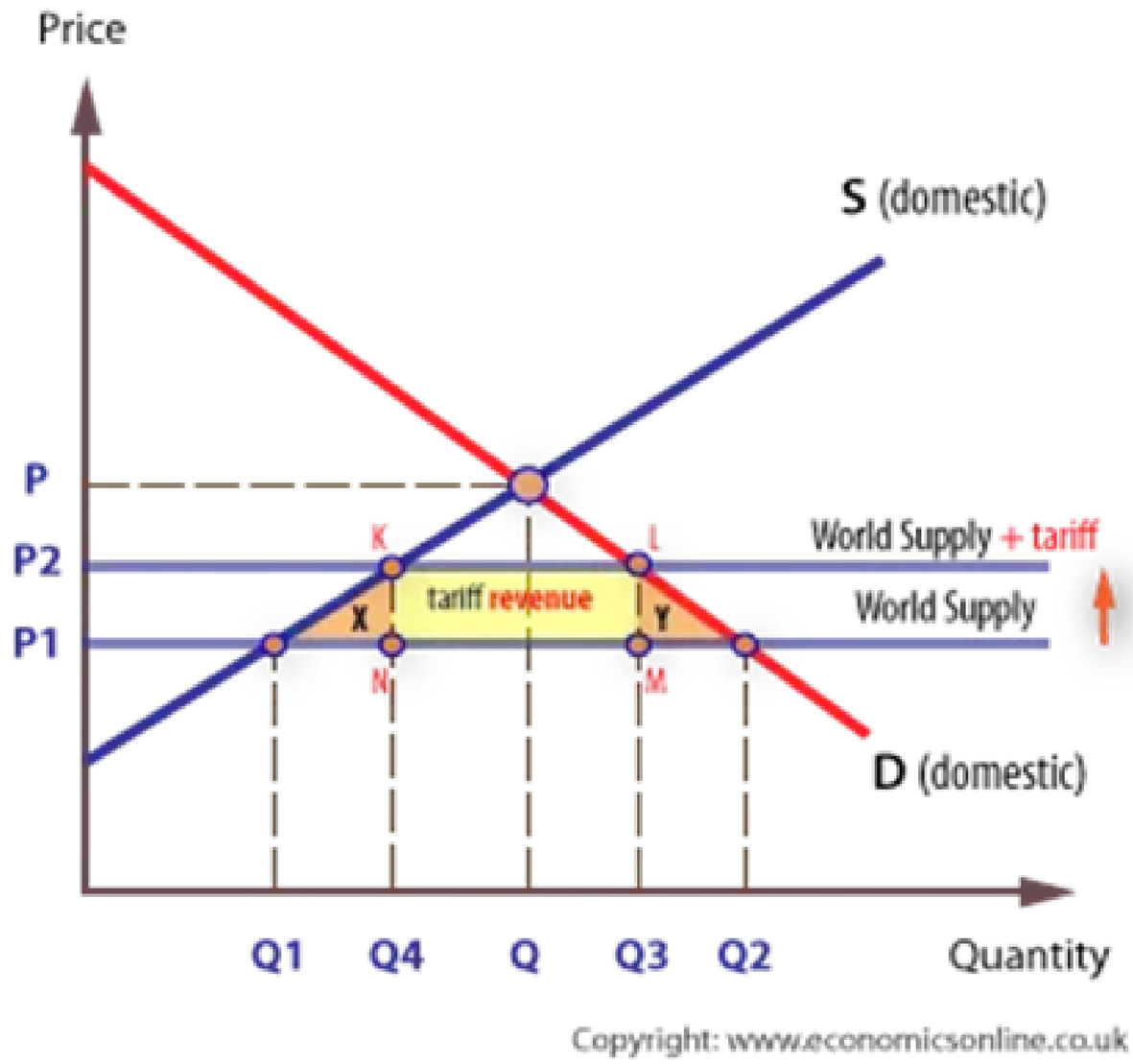

Figure 1. Effects of tariffs on price, quantity, and tariff revenue

Whilst the benefits of tariffs are recognised, the consequences are that stock prices are dropping because of the tariff trade war with J.P Morgan estimating a 60% chance of the global economy entering a recession (Chu et al., 2025.) This can be catastrophic as a recession goes against the UK's macro-objective of a stable inflation rate (tutor2u, 2021), by sparking a downward spiral. This is where demand will drop, resulting in low prices and wages. In turn, often seen in recessions, people would spend less due to reduced confidence in the economy, that means that demand for imports and exports would fall, negatively impacting trade relations. Subsequently, this would violate the national economic interest of having a stable inflation rate and a positive net trade. Besides this, tariffs can lead to agreements, but this depends on if this is adhered to - China didn't meet the conditions of the 'Phase One' deal, purchasing only 58% of the US exports it had committed to buying under the agreement (Bown, 2022). Critics also argue that tariffs may be ineffective as there is still currently an ongoing trade war despite the initial tariffs in 2018. Governments may utilise tariffs to protect domestic industries by discouraging the use of imports, this could lead to the strategic trade theory, where other countries may retaliate to protect their own domestic industries, leading to trade wars.

Moreover, there could be a distortion of comparative advantages if countries decide to produce domestically in a good or service that they do not have a comparative advantage in. This is because there could be a misallocation of resources which could have been utilised elsewhere; thus, tariffs could lead to inefficiency and decreasing economic welfare due to an increase in prices.

However, the stronger argument is that tariffs are effective as long as it's achievable as it could be argued that the 'Phase One' deal wasn't fulfilled due to circumstances like COVID-19 (Bisio et al., 2020.) Perhaps now with a more significant tariff being put into place, this could scare US and China into settling their disputes to prevent further disruption. As of now, there is optimism that there could be a deal with US-China regarding this trade war, possibly inferring that there could be positive trade relationships in the future despite this trade war. (ET Online, 2025). It is worth noting that because of a tariff, countries may retaliate as they are receiving fewer exports, due to countries importing less. For instance, China retaliated to the 245% tariff imposed by Trump, with a 125% reciprocal tariff (Vigliarolo, 2025). As well as this, the benefits of tariffs like positive net trade depend on if there are more exports being sold than the number of imports being bought. Despite the tariffs, imports may exceed exports, failing to balance or improve the national economic interest of a positive net trade. However, this is highly unlikely as tariffs would increase the cost of imports, forcing people to buy less abroad and instead look for cheaper substitutes domestically. Nonetheless, it remains true that tariffs should be implemented because if countries are importing less, it makes countries more self-dependent and if they are more independent, a retaliation in tariff wouldn't make a difference as countries have autonomy to buy their own products domestically. We have seen the issue with overreliance during COVID, where supply chains were disrupted, therefore, to prevent any disruptions, countries should be able to depend on themselves. For these reasons, tariffs are seen as a viable approach to balance national economic interests and maintain positive trade relationships amid trade wars.

Another strategy that should be implemented is trade agreements by policymakers to balance national economic interests and maintain positive trade relationships amid trade wars. One example of this is the world's largest free trade agreement - RCEP (Regional Comprehensive Economic Partnership), (Yunshek, 2025.) The RCEP was formed through negotiations beginning in 2012, with ASEAN and ASEAN's free trading partners, and was signed in 2020 during an ASEAN summit (DFAT, 2022). This trade agreement encourages cooperation with 15 countries to eliminate tariff and non-tariff barriers in goods and services (Rahman & Sharma, 2024). The impact of this is that within RCEP countries in 2019, there was 40% of intra-regional trade (Raihan et al., 2024). This illustrates positive trade relationships as due to gradual elimination of barriers, countries can easily trade with one another, reducing the probability of conflict due to cooperation. Countries like Laos, Indonesia, Brunei, and Malaysia recorded the most significant increase in trade with other RCEP members in 2022 (Huaxia, 2025). This illustrates the positive impact trade agreements like RCEP have on countries to help balance national economic interests of a positive net balance. Huaxia also states that by 2030, RCEP is expected to add 2.8 million jobs to regional employment - revealing the fact that the national economic interest of reducing unemployment can be achieved through trade agreements. This is supported by the fact that trade agreements will encourage exports, there will be an increase in demand and to grow, investment would have to occur, thereby leading to derived demand for labour, increasing employment. There could be a trade agreement between the US and China to help settle their disputes and allow a positive trade relationship: if negotiations occur within this agreement, this can allow the government to balance economic interests as well. Moreover, another example of a trade agreement is South Korea, who filed a WTO dispute against Japan in 2019 as Japan restricted exports on raw materials used in making computer chips and displays, heavily used by South Korea (DW, 2019). But S.K ended up withdrawing the complaint as the countries were going to communicate about Japan's restrictions on high-tech material exports to South Korea (Lee & Yang, 2023.) As the WTO got involved, this shows the significance of institutions in protecting national economic interests - like South Korea's technology sector. The withdrawal of the WTO complaint highlights how there is a positive trade relationship as the complaint could have led to an increase in tension - there could have been a negative diplomatic relationship, impacting trade, portraying that even during trade wars, cooperative agreements can ease the tension.

This links to trade agreements because the WTO promotes discussions on trade agreements to boost transparency, as well as formulating rules for trade agreements through mechanisms, such as alerting WTO when a new trade agreement arises (WTO, 2016.) Therefore, trade agreements should be adopted by policymakers to balance national economic interests of employment and a positive net balance, in addition to trade agreements helping maintain positive trade relationships.

However, not everyone can benefit from trade agreements. For instance, Bangladesh, a non-member of RCEP, receives lower volumes of trade as RCEP members rely less on imports from outside the RCEP, (Raihan et al., 2024.). In their article, they state that there will be a decline in 10.4% of leather exports, meaning that some countries would suffer as they will have less export revenue, impacting developing countries like Bangladesh's GDP, growth and employment. This may be because trade agreements can lead to trade diversion, leading to a reduction in demand from third countries and non-members (Flach et al., 2021), as it would be cheaper to buy and import from within the bloc than outside. In addition to this, there can also be a time lag when implementing trade agreements, for instance, the RCEP is a gradual tariff reduction with some elimination that could take place up to 20 years (Flach et al., 2021.) so, the impact may not be visible immediately. But the more compelling argument is that trade agreements are good. A simple solution is for countries like Bangladesh to join trade agreements so they can benefit. Thus, trade agreements can be used to balance national economic interests and maintain positive trade relationships amid trade wars as it fosters cooperation, hence positive relations and national economic interests.

Biden initially criticised Trump for having tariffs but later kept it as 'leverage' (Khalid, 2023), which shows the importance of having tariffs to maintain positive trade relationships. Tariffs can be used temporarily to tackle disputes and improve diplomatic relations in the long run. So, to conclude, tariffs and trade agreements can be used to balance national economic interests and maintain positive trade relationships amid trade wars.

The reason for this is that it can allow countries to settle their disputes through negotiation, have positive trade relationships, and hence balance economic interests like trade balance, inflation and employment. While it is recognised that tariffs can create negative consequences for the economy, this is a temporary impact, and tariffs can lead to the governments feeling pressured to negotiate and balance economic interests and trade relations in the long run. Not only that, despite there being a time lag and not everyone benefitting from trade agreements, solutions like including more countries in trade agreements can outweigh the negatives.

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FINANCE AND BUSINESS SECTION INTRODUCTION

Globalisation has contributed to the rise of trade tensions in recent years. The frequent imposition of tariffs and subsequent trade wars has generated widespread economic effects across international markets. Although designed as protectionist measures, these policies exert broader impacts on production costs, price levels and overall economic growth. Notably, their impact is not limited to national economies, as they significantly shape the financial landscape by influencing investment strategies and corporate decision-making. This edition of the Perspectives Journal seeks to recognise that the intersection of trade wars, tariffs and economic activity is critical for understanding the wider implications on finance and business strategy in a globally interconnected economy.

With inferences from the US automotive industry, research was conducted to determine the correlation between supply chain risks and realised unit costs of production. Two factors of supply chain risk namely a producer's degree of substitutability and shipment delay, were assessed and used to determine a relationship with production costs. Furthermore, the analysis highlights the contribution of natural shocks such as COVID-19 as well as the phenomenon of 'greenflation' which attributes the rise in car prices to the adoption of more environmentally sustainable production methods.

In parallel, another dissertation featured in this section examines how global financial markets respond to policy shocks, with a focus on the high-frequency reaction of U.S. equity options to Federal Reserve announcements. Much like tariffs and trade disputes, central bank decisions reverberate across borders, shaping investment strategies and market stability. The research finds that option prices briefly overshoot their fair value in the immediate aftermath of policy statements before correcting within the hour, revealing how even highly liquid markets can display temporary inefficiencies when processing new information. This highlights the fragility of financial systems in an interconnected economy, where both trade policy and monetary policy act as catalysts for volatility.

This section of Perspectives therefore seeks to bridge the gap between academia and industry by examining how both trade frictions and monetary policy decisions reverberate through business and finance. From supply chain risks in the automotive sector to the pricing of U.S. equity options, the contributions illustrate the diverse channels through which global shocks manifest in costs, volatility, and strategic decision-making. By exploring theory in real-world cases, we aim to provide insights that are both intellectually rigorous and practically relevant for navigating an increasingly complex and interconnected economic landscape.

Fiona Pabalelo & Pia Gupta

Finance & Business Section Editors

Do supply chain disruptions contribute to inflation?

Alexandros Taliotis

1. Introduction

A more fractured geopolitical world in recent years, characterized by protectionist policies, geopolitical conflict and inflationary pressures, has prompted companies to rethink their supply chains. This reshaped global economy, marked by escalating trade barriers, has rendered supply chain risk a critical determinant of production costs for firms operating across borders [15] . In response, multinational companies are re-evaluating their production processes, from materials sourcing to assembly location, which collectively influence their "price-determined risk," the risk associated with rising production costs.

Rising prices have often been attributed to supply chain shocks, among other factors such as monetary and fiscal policy or labour market shocks. Companies identify supply chain shocks as a key driver of inflationary pressure, which has triggered a cost-of-living crisis in the US and other developed economies in recent years [13]. It is unclear, however, whether the degree to which firms inflate prices is justified by the supply chain shocks they experience. Franzoni et al. (2024) [11] found that during supply chain shortages, larger firms gained market share and increased profitability, suggesting that such disruptions can allow dominant firms to raise prices beyond cost increases.

In contrast, many non-academic outlets argue against "Greedflation" as the primary cause behind the post COVID inflation wave, suggesting that supply chain disruption is the core factor behind this trend [9]. This dissertation investigates whether the observed increases in unit production costs for U.S. automakers between 2015 and 2024 are attributable to changes in supplier substitutability, the ease with which firms can switch among suppliers, or to logistics disruptions, as proxied by quarterly shipment-delay indices. By quantifying how supply-chain substitutability and shipment delays affect automakers' unit costs, this dissertation addresses directly the "greedflation" versus cost-push debate.

While the findings lend weight to the view that inflationary pressures stem primarily from disrupted supply chains, they should be interpreted with caution given potential endogeneity and reverse-causality concerns as discussed in Section 3.5.

The US automotive sector is the primary focus of this paper, due to being heavily exposed to supply chain "price-determined risk". Its specialised nature limits the number of qualified suppliers globally, increasing vulnerability to substitutability risk, that is, the inability to replace suppliers in the event of a shock. Automotive manufacturers rely on intricate, interconnected supply networks spanning multiple countries, a characteristic that elevates network vulnerability. Furthermore, the widespread implementation of the "just in time" system, aimed at reducing inventory costs, renders automotive firms susceptible to delays [17]. These risks, substitutability and delay, are the two components of supply chain risk examined in this dissertation.

This dissertation is split into three sections. In Section 1 I introduce the research question and provides a detailed theoretical framework on supply chain dynamics. Relevant literature is reviewed to justify the research question and explore alternative methods. Section 2 contains the methodology and empirical research design. The dataset is explored, and the model of price determined supply chain risk is introduced. Section 3 contains the results and a detailed analytical discussion of the model implications. It concludes by addressing the research question, summarising key findings, and contextualising them within broader trends. Research extensions are addressed to guide future research in the supply chain economics literature.

1.1 Literature Review

The limited research on supply chain risk and its effect on the cost of production presents an exciting opportunity to contribute to the literature. Yang et al. (2023) [26] classify most quantitative supply chain risk management methods into optimisation, stochastic programming, and static network analyses; however, these linear frameworks treat the supply chain as a fixed graph and overlook dynamic, nonlinear interdependencies.

Hosseini et al. (2019) [12] provide a robust stochastic model, combining Bayesian disruption networks with mixed-integer programming to balance cost and resilience. This work has served as an inspiration for the approach to modelling supply chain risk in this dissertation.Antr`as et al. (2017) [3] developed a model showing that firms choose their global sourcing strategies endogenously, influenced by productivity and market-specific frictions such as fixed sourcing costs.

Their work demonstrates that sourcing decisions are interdependent, where a disruption in one country can affect input costs across the entire supply chain. This framework provides a robust explanation for why sourcing channels exhibit nonlinear interactions, with complementarities or substitution effects emerging across markets. Furthermore, it explicitly models price determined risk of firms, a concept I build on this dissertation. Building on these insights, this research introduces a supplier substitutability index to quantify how easily a firm can switch between suppliers in a nonlinear manner.

Theoretical backing for my results is provided in research by Antr`as and Chor [2]. His research suggests that sunk costs by firms to their suppliers result in lower substitutability. This implies that specific suppliers that have incurred significant investment by firms might come with a risk premium in their substitutability index, which is not accounted for in my model and would need further research and data to estimate reliably. Nevertheless, the model presented in my methodology section has substitutability scores consistent with Antr`as's work, where more specialised suppliers of higher volume have higher substitutability scores, as they are difficult to replace.

Further theoretical backing for the development of a substitutability index to capture supply chain risk is provided by Barrot & Sauvagnat (2016) [4], who found that natural disaster shocks to suppliers, affect their customers disproportionately if they were hard to replace. This directly reinforces the notion that substitutability is a key modulator of disruption impact. It also highlights network effects where a single vulnerable supplier can trigger broad production and cost consequences, aligning with the dissertation's network-based risk quantification.

In terms of the methodological approach used, this dissertation innovates by introducing a contextual similarity of products based on their description.

Transformer based Large Language model BERT was utilised as described by Devlin et al. 2018 [7] due to its computational efficiency and its ability to create embeddings capturing the contextual similarity of products. This is based on the attention mechanism as described by Vaswani et. al. (2017) [25]

1.2 Theoretical Framework

A brief theoretical background is provided, outlining the key assumptions and definitions which aid in the understanding of supply chain dynamics. Supply chain price-determined risk is defined in this dissertation as the risk that arises from increased exposure to supply chain bottlenecks, which directly affects the cost of production of firms. This definition is consistent with the wider literature on the topic including Tang's definition of operational supply chain risk [19]. This dissertation aims at examining the effect of supply chain risk changes on the unit cost of production of US based automotive firms. This includes firms that have production capabilities in the US.

I break supply chain risk into two components, each of which takes advantage of a portion of the available dataset. Substitutability is defined as the ability of a firm to substitute its suppliers in the case of a shock. High substitutability implies that the firm has the ability to easily substitute suppliers and products in the event of a shock or bottleneck with their existing suppliers. A lower substitutability value implies that the firm does not have the capability to substitute for suppliers given a shock, thus they are more exposed to their suppliers. Substitutability holds on the following assumption:

Assumption 1: In the short run, firm i may reallocate suppliers and products only among its current supplier set K. Establishing relationships with new suppliers, negotiating contracts, performing quality audits, and integrating logistics, incurs substantial fixed costs and renders entry into entirely new sourcing partnerships infeasible in the short run. Accordingly, our substitutability index treats K as the exclusive universe of potential suppliers.

The second component of supply chain risk is average shipment delay risk, which is defined as the average quarterly delay across products for a firm.

This is included due to the importance of the Just in Time (JIT) system in manufacturing and automotive production. Just in Time (JIT) is an inventory-management philosophy pioneered at Toyota whereby materials and components arrive at the production line exactly when needed, rather than being held as buffer stock [16]. By synchronising purchase orders, supplier deliveries and production schedules, JIT minimises carrying costs and waste, but it also leaves firms highly exposed to any downstream delay, since even a short disruption can immediately interrupt assembly.

The data we use consists of the Bills of Lading of every product imported by the chosen automotive firms, that was shipped in the U.S. over the period of 2015–2024. Each product has a description and a Harmonised System Code (HS code) which is a detailed classification system of shipping products, and the most widely adopted globally. Some key data assumptions are integral to this research:

Assumption 2: Terminology alignment. In this analysis, "cost of goods sold," "cost of production," and "cost of revenue" are used interchangeably to denote the manufacturer's per unit production expense. The proportion of COGS attributed to production excluding labour and admin costs is between 40%–60% of COGS [1].

Assumption 3: Comparable unit costs across regions. For large multinational automakers, the cost of revenue in North America is assumed to mirror that in Germany, since uniform retail pricing implies comparable production costs once transport and tariff effects are netted out. This allows to use the international Cost of Goods Sold COGS values to construct the outcome variable, where the domestic US ones are missing/not reported.

Assumption 4: Sales as a proxy for production. Quarterly units sold serve as a proxy for units produced, under the assumption that automotive manufacturing firms aim to minimise the error between demand and output, to minimise inventory carrying costs. This holds true given the high rate of depreciation of capital in the industry and the high inventory costs. This results to sales of automotive closely following production with minor errors [10]. I use the mean discrepancies between supply and demand to calculate production values using sales values where production values are missing.

Assumption 5: Multinational companies report their values in different currencies. I convert everything to dollars for this analysis based on the spot exchange rate at the time of the value I am converting. For example, COGS reported in Japanese Yen in 2018 Q2, will be converted to dollars given the spot exchange rate USD/JPY in 2018 Q2. I assume that this will not impact the outcome variable.

2. Methodology

2.1 Data Collection and Preparation

All code and cleaned data used in this study are available at github.com/AlexTaliotis/Supply-ChainRisk-Dissertation. This repository contains all Jupyter notebooks, Stata do-files, and raw data needed to replicate the results. The data comprises of approximately 200,000 Bills of Lading data for nine automotive firms that have operations in the US, for the period 2015 Q1 – 2024 Q4. A Bill of Lading (BoL) is defined as "a legal document issued by a carrier to a shipper that details the type, quantity, and destination of the goods being carried". In practice, each data point contains firm-specific data on the product shipped by a supplier to the importing firm. The key variables include Company/Importer name, Supplier Name, Destination Port, Departure Port, Arrival Date, Estimated Arrival Date, HS code, Product Description and Quantity. These variables are used to construct the indices that capture supply chain price determined risk and how they were used is explained in detail below. The data was acquired from Import Yeti for academic research purposes, which filed multiple Freedom of Information Acts with US Customs over many years. Such granular import data enables the detailed analysis of substitutability as the proposed model captures product-level substitutability. The table below shows an example dataset with 20,000 data points for Tesla. Note that Tesla, amongst other companies, has multiple subsidiaries that import under different names. There might be multiple observations for each day and some days have no observations.

Company Name	Supplier name	Destination Port	Departure Port	Arrival Date	Expected Arrival Date	HS code	Product description	Quantity
Tesla	Panasonic	Los Angeles, Ca	Pusan	2024/09/28	2024/09/27	370220	Photographic or cinematographic goods	40
Tesla manufacturing	Panasonic	Oakland, Ca	Rotterdam	2024/06/28	2024/03/28	380190	Engines, boilers	354
...	...	...	...	...	...	...	...	...
Tesla	Posco	Oakland, Ca	Yantian	2015/06/28	2015/06/28	284190	Lithium ion batteries	1876
Tesla	Dahyun	New York/Newark Area, Newark, Nj	Stadersand	2015/02/28	2015/02/21	210210	Copper alloy	34

Figure 1: BoL dataset for Tesla 2015-2024

The outcome variable is the unit cost of production per quarter and is collected through SEC filings, in particular 10K and 6K reports. This restricts our analysis to public companies that have been public since 2015 and thus have sufficient SEC filings. The unit cost of production was calculated by dividing the automotive cost of production by the automotive production units per quarter. Industry experts estimate that 40–60 percent of total costs stem from supply-chain expenses and imported components—exclusive of labour and energy, which have already been accounted for. This does not affect the variation and thus will not impact on our results but is done for clarity purposes.

$$unit\ cost\ of\ production_t = \left(\frac{Automtive\ cost\ of\ production_t}{units\ of\ cars\ produced_t} \right) \times \frac{1}{2}$$

2.2 Data Distribution

The distribution of the data can provide insights into the supply chain dynamics of the US automotive industry. Network analysis can reveal interesting patterns such as the high degree of centrality of key suppliers and supplier countries in terms of volume. This suggests that few key suppliers have increasing importance in the network and would reinforce the argument for adding a nonlinear variable in the model. This is further supported by Antr`as's research as discussed in the literature review section, who found similar non-linear patterns in the relationship of supplier and firm [2]. This is also consistent with previous research that I have conducted, exploring the distribution of various industries in terms of degree centrality by volume of shipments.

Figure 6 in the Appendix displays the degree centrality scores of suppliers denominated by country, indicating a high concentration of suppliers by volume of shipments in a few countries, notably China and Germany.

2.3 Supply Chain Price Determined Risk Model

The following section introduces the supply chain – price determined risk model (SCPDR). This aims to capture two aspects of supply chain risk that affect costs of production, substitutability and shipping delay risk, as defined and explored in the previous sections.

2.4 Supplier Shipment Shares For Firms:

Supplier substitutability is defined as the degree to which a firm i can replace/substitute their supplier k where $k \in K$ with another supplier in the set of suppliers K, in the event of a supply chain shock. For the purposes of the final regression, we aggregate the supplier substitutability for each individual firm $i \in I$ to get a score of supplier substitutability index of firm i. The score is relational in nature, meaning that the absolute value is arbitrary and can be compared with other values of firms derived from similar data, specific to these firms.

Consider a set of products G designated by a unique HS code (Harmonised System). G represents the universe of products that all firms $i \in I$ import. Product $g \in G$ and is one of the product imported by supplier k to firm i. The quantity of product of type g imported by supplier k at quarter t is shown in equation 2 and is denoted by $v_{ik}^{g}(t)$.

$$v_{ik}^{g}(t) = Q_{ik}^{g}(t) \tag{2}$$

$$V_{ik}^{g}(t) = \sum_{k=1}^{K} Q_{ik}^{g}(t) \tag{3}$$

To get the total quantity of products of type g that are supplied to firm i from all its suppliers at quarter t, we can aggregate across firm's i suppliers as shown by equation 3.

From here we can compute the share of all products of type g that are supplied by supplier k to firm i at quarter t by dividing the two equations to get equation 4. This is significant as it denotes the dependence of firm i on supplier k to source product g and can reveal overdependence or under dependence of firms on specific suppliers for specific product sourcing.

$$s_{ik}^{g}(t) = \frac{v_{ik}^{g}(t)}{V_{ik}^{g}(t)} = \frac{Q_{ik}^{g}(t)}{\sum_{k=1}^{K} Q_{ik}^{g}(t)} \tag{4}$$

2.5 Product Similarity Index

This research proposes a new, unexplored yet in economic literature method, for quantifying similarity between products designated by their unique HS code and textual description. This method can provide an insight into the degree to which firms can treat their suppliers interchangeably given the products they import from each supplier. As discussed in the "Data Collection and Preparation" section, each product g has its own unique designated HS code. Each HS code is divided into subcategories of different clusters of similar products, and they all have detailed descriptions.

The proposed method involves generating semantic product embeddings from the imported product descriptions of each firm. To achieve this, I utilise a pre-trained large language model to create meaningful embeddings. For this research, I have chosen BERT, as cited in [7], due to its strong capability in generating high-quality embeddings while maintaining relatively low computational requirements.

Consider a set of product descriptions Desc(G), which consists of all the descriptions of all products that belong to the set of products G. Desc(g) $\in$ Desc(G) and denotes the description of product g. BERT first tokenises Desc(g) into a sequence of tokens Desc(g) $\mathcal{7}\rightarrow$ [[CLS], T_1, T_2, ..., T_n, [SEP]]. This is followed by mapping each token T_i into a vector R^d where d = 782 for the base BERT model used in this research.

Multi-head self-attention is then applied to produce a vector representation of the learned embeddings of product descriptions denoted by u(g). For the purposes of this research, I omit the details regarding self-attention and transformers process, but I encourage readers to refer to [7] and Vaswani et al. (2017) [25] to better understand the transformer mechanism and its application within BERT.

Computing the product description similarity can be achieved through computing the cosine similarity of the vector embeddings $u(g_1)$, $u(g_2)$,..., u(G). The cosine similarity between two product description representation vectors is denoted by $w_{gg'}$, where $g \neq g'$ and both belong to the set of products G.

$$w_{gg'} = \cos\big(u(g), u(g')\big) = \frac{u(g) * u(g')}{\|u(g)\| * \|u(g')\|} \tag{5}$$

We can extend this metric by computing the average similarity denoted by W_g of a product g across all the products that are contained in the product universe G. This creates a more meaningful metric of how similar a product is to its peers, effectively quantifying the degree to which it can be substituted with other products in the production process. It is important to note that W_g is already normalized given that the cosine similarity of BERT embeddings takes a value between $-1 \leqslant w_{gg'} \leqslant 1$ and averaging over $w_{gg'}$ yields a normalized similarity value W_g. Thus no further normalization is needed as this would also negatively affect the semantic embeddings created by the language model in use. This method comes with some major limitations which I hope to address in future research. [1]

[1] The semantic embeddings do not reflect a specialized level of accuracy, given the data that BERT and other used variants of BERT were trained on. The data tends to be general and can often miss the delicacies related to production. Improving this method consists of fine-tuning BERT or another large language model to generate embeddings that more accurately reflect the automotive/manufacturing production process. Fine-tuning on data such as automotive production reports, engineering textbooks and potentially implementing multi modal learning such as videos of production processes can significantly enhance the accuracy of generated product embeddings.

This would allow for the model to be expanded further, generating embeddings with respect to exactly how important a given product is in the production process and more accurately reflecting the degree of similarity between two products and thus the degree to which a firm can substitute one for the other.

$$W_g = \frac{1}{|G|-1} \sum_{\substack{g'=1 \\ g \neq g'}}^{G} w_{gg'} = \frac{1}{|G|-1} \sum_{\substack{g'=1 \\ g \neq g'}}^{G} \frac{u(g) * u(g')}{\|u(g)\| * \|u(g')\|} \tag{6}$$

2.6 Substitutability İndex

We can combine the two previous indexes to form a holistic substitutability index denoted by $x_{ik}^{g}(t)$ shown in equation (7).

$$x_{ik}^{g}(t) = s_{ik}^{g}(t) * W_g = \frac{Q_{ik}^{g}(t)}{\sum_{k=1}^{K} Q_{ik}^{g}(t)} * \frac{u(g) * u(g')}{\|u(g)\| * \|u(g')\|} \tag{7}$$

This equation weights the share of product g shipped to firm i by supplier k at time t, by the similarity of product g with its peers. This effectively captures the degree to which a product-supplier pair can be substituted within a firm's supply chain, providing a nuanced measure of supply flexibility and resilience in response to disruptions or changes in supplier dynamics. Aggregating by product and by supplier and dividing by the number of firms |K| and number of products |G|, yields the firm-specific metric $X_i(t)$ which captures the average ability of firm i to substitute its suppliers for a given quarter t. This is denoted in equation (8) and will form the basis of the regression specification.

$$X_i(t) = \frac{1}{|K| \times |G|} \sum_{k \in K} \sum_{g \in G} s_{ik}^{g}(t) * W_g = \frac{1}{|K| \times |G|} \sum_{k \in K} \sum_{g \in G} \frac{Q_{ik}^{g}(t)}{\sum_{k=1}^{K} Q_{ik}^{g}(t)} * \frac{u(g) * u(g')}{\|u(g)\| * \|u(g')\|} \tag{8}$$

$X_i(t)$ represents the key metric for the substitutability risk of firm i per quarter, related to its international supply chain. The terms $s^{g}_{ik}(t)$ sum up to 1 across k unless they enter non-linearly. Thus, a non-linear extension to the model is proposed below.

2.6 Introducing Non-Linearity

The previously defined measure of substitutability $X_i(t)$ is linear in nature. However, in many supply-chain contexts, a near-monopoly supplier might pose more than a proportionate risk. For instance, shifting from 70% dependence on one supplier to 80% might be far riskier than going from 20% to 30%. This is further demonstrated by the exponential supplier degree centrality distribution described earlier, suggesting few suppliers carry disproportionately large risk to the rest. To capture this possibility, a non-linear exponent γ is introduced.

I focus on the case where γ > 1 which follows economic intuition as the index increases with the concentration of suppliers. When γ = 1 the term $s^g_{ik}(t)$ is 1 and disappears from the expression thus this case would not be interesting. Let γ be a parameter that modifies the weight placed on large vs. small supplier shares. The new equation becomes:

$$X_i(t) = \frac{1}{|K| \times |G|} \sum_{k \in K} \sum_{g \in G} \left[s^g_{ik}(t) \right]^{\gamma} * W_g = \frac{1}{|K| \times |G|} \sum_{k \in K} \sum_{g \in G} \left[\frac{Q^g_{ik}(t)}{\sum_{k=1}^{K} Q^g_{ik}(t)} \right]^{\gamma} * \frac{u(g) * u(g')}{\|u(g)\| * \|u(g')\|} \tag{9}$$

$$X_i(t) = \frac{1}{|K| \times |G|} \sum_{k \in K} \sum_{g \in G} \left[s^g_{ik}(t) \right]^{2} * W_g \tag{10}$$

Thus, γ directly shapes how heavily high-share suppliers' factor in the index. This non-linear parameter can be estimated using MLE (Maximum Likelihood Estimation) in future research. The interpretation of γ is illustrated in equation (11):

$$f(\gamma) = \begin{cases} \gamma > 1, & \text{Large suppliers are given more weight} \\ \gamma = 1, & \text{Suppliers shares weighted linearly, } s^g_{ik}(t) \text{ is 1} \\ \gamma < 1, & \text{Small suppliers are given more weight} \end{cases} \tag{11}$$

The non-linear coefficient γ can be interpreted as follows: A γ > 1 assigns higher weights to larger suppliers in terms of share of the total imports of firm i. This would follow traditional economic intuition as a firm relying on a few large suppliers would carry a greater risk [6]. The index becomes convex in the supplier share, exemplifying the risk related to large suppliers and minimising the risk carried by small suppliers.

As shown by equation (11) γ is set $\gamma = 2$ which is formally equivalent to a Herfindahl–Hirschman concentration index (HHI) over supplier shares. Squaring each share makes the index convex, so that doubling a supplier's share quadruples its contribution to $X_i(t)$ [14]. This weighting sharply penalizes over reliance on large suppliers and thus captures the nonlinear escalation of risk when a firm depends heavily on a few dominant sources. This is done for both simplification purposes, improving the confidence intervals of our estimation by having fewer parameters to estimate, and because it is supported by economic theory and intuition.

A $\gamma < 1$ assigns more weight to smaller suppliers, as the supplier share enters the index $X_i(t)$ as a concave function. Under this coefficient, small suppliers carrying heavy risk, thus reinforcing the scenario of an interconnected network of many small but important suppliers. This suggests that firms are more vulnerable to shocks as they depend on a large number of small suppliers. It is depicted for illustration purposes as it would not follow economic intuition and the dynamics of the industry.

2.7 Delay Risk Variable

Consider a set of product arrival dates for firm i, $a_i \in A_{i,t}$ and expected arrival dates $E(a_i) \in E(A_{i,t})$. The firm specific average delay per quarter can be computed as follows:

$$d_i(t) = \sum_{a \in A_{i,t}} \frac{a_i - E(a_i)}{|A_{i,t}|} \tag{12}$$

Where $|A_{i,t}|$ represents the number of elements within the set of arrival dates $A_{i,t}$, and $d_i(t)$ illustrates the average delay that firm i experiences across all products g $\in$ G and suppliers k $\in$ K. As mentioned previously, this index captures the supply chain risk that firms experience due to shipment delays, which increase their inventory costs. This is exemplified by the just in time system, adopted by the automotive industry to reduce inventory costs and keep inventory low. In further research we could consider the interaction between delays and specific products to capture the differential effect that products have on delays, but for the purposes of this research we will consider the absolute delay value across all products per quarter.

2.8 Parameter Estimation

Let i index firms with $i = 1,2,3...I$ and t index quarters with $t = 1,2,3...T$. The outcome variable in our proposed regression model is the unit cost of production that can be attributed to physical stock use, as explained in the Data collection and preparation section. The unit cost of automotive production for firm i for each quarter is denoted by $C_i(t)$ and captures price determined risk/exposure of firm i at time t to its international supply chain. The two key regressors are the previously defined indexes of supply chain risk: firm–supplier substitutability denoted by $X_i(t)$ and average shipment delay $d_i(t)$. The hypothesis testing on our coefficient is shown below:

Testing for substitutability:

$H_0 : \beta_1 = 0$ (Δ in supplier-substitutability risk has no effect on unit cost)
$H_1 : \beta_1 \neq 0$ (Δ in supplier-substitutability risk has an effect on unit cost)

Testing for shipment delay:

$H_0 : \beta_2 = 0$ (Δ in avg. shipment delay has no effect on unit cost)
$H_1 : \beta_2 \neq 0$ (Δ in avg. shipment delay risk has an effect on unit cost)

These two regressors capture different aspects of supply chain risk. The following specification is proposed to measure their effect:

$$C_i(t) = \beta_1 X_i(t) + \beta_2 d_i(t) + \mu_i + \delta_t + \Gamma\Phi_{it} + \epsilon_{i,t} \quad (13)$$

or

$$C_i(t) = \beta_1 \left[\frac{1}{|K| \times |G|} \sum_{k \in K} \sum_{g \in G} \left[s_{ik}^g(t) \right]^2 * W_g \right] + \beta_2 \left[\sum_{a \in A_{i,t}} \frac{a_i - E(a_i)}{|A_{i,t}|} \right] + \mu_i + \delta_t + \Gamma\Phi_{it} + \epsilon_{i,t} \quad (14)$$

Where μ_i and δ_t are fixed effects included to isolate the effect of the chosen variables of interest. The term μ_i captures firm-specific, time-invariant unobserved heterogeneity such as brand reputation or bargaining power.

The term δ_t captures quarter-specific unobserved heterogeneity such as seasonal shocks affecting all firms in a quarter. $\Gamma\Phi_{it}$ is a set of controls including US CPI inflation, employment cost index (ECIWAG) and producer price index by industry (Iron and Steel Mills and Ferroalloy Manufacturing). These controls help isolate the effect of the international supply chain shocks by controlling for confounding factors within the US that might affect unit costs.

The coefficient β_1 captures the effect of substitutability on the cost per unit of production of firms. A negative and significant coefficient indicates that rising supplier substitutability decreases the unit cost of production for firms. Such a result would align with traditional economic theory where a more diversified portfolio of suppliers reduces supply chain risk exposure. Coefficient β_2 captures the relationship between the average delay of shipment and the unit cost of production, effectively capturing the extent to which the production process is disrupted by delayed shipments, which contribute to costs. All reported standard errors are clustered at the firm level to account for serial correlation and heteroskedasticity within each firm over time [5]. As a robustness check, we also compute bootstrap standard errors for the coefficients on X_{it} and d_{it}, following the nonparametric procedure of Efron (1979) [8].

3. Results

3.2 General Trends

The final sample size consisted of 236,242 Bills of Lading from 2015 Q1-2024 Q4 for nine automotive producers that produce in the US. These are Tesla, General Motors, Ford Motor Company, Nissan, Mazda, Toyota, Mercedes Benz, BMW and Honda.

The data suggests an average substitutability of 0.478. An average quarterly delay of 3.7 days is a reasonable estimate, but a large standard deviation suggests that disruptions and delays are frequent in our sample. The unit cost of production of $18,202 is rather high but reflects the low margins of the industry given the high costs of production in manufacturing. Taking the results outlined in Figure 2 as a sample benchmark we can observe how each firm individually deviates from the benchmark.

Taking the results outlined in Figure 2 as a sample benchmark we can observe how each firm individually deviates from the benchmark.

Variable	Mean	Standard Deviation	No. of observations
X_{it}	.4784753	.1619814	357
d_{it}	3.7304	28.65736	357
Unit cost of production	18202.62	7695.658	358

Figure 2. Data distribution statistics

Regarding substitutability, for most firms it tends to fluctuate substantially. However, for larger, more established automotive firms such as General Motors, Ford Motor Company and Toyota, their exposure to their suppliers tends to concentrate around a steady state mean where in contrast Tesla and Mazda, which are fairly new players in the industry tend to experience large swings of exposure. This could be an indication of more robust supply chains of larger, more established firms.

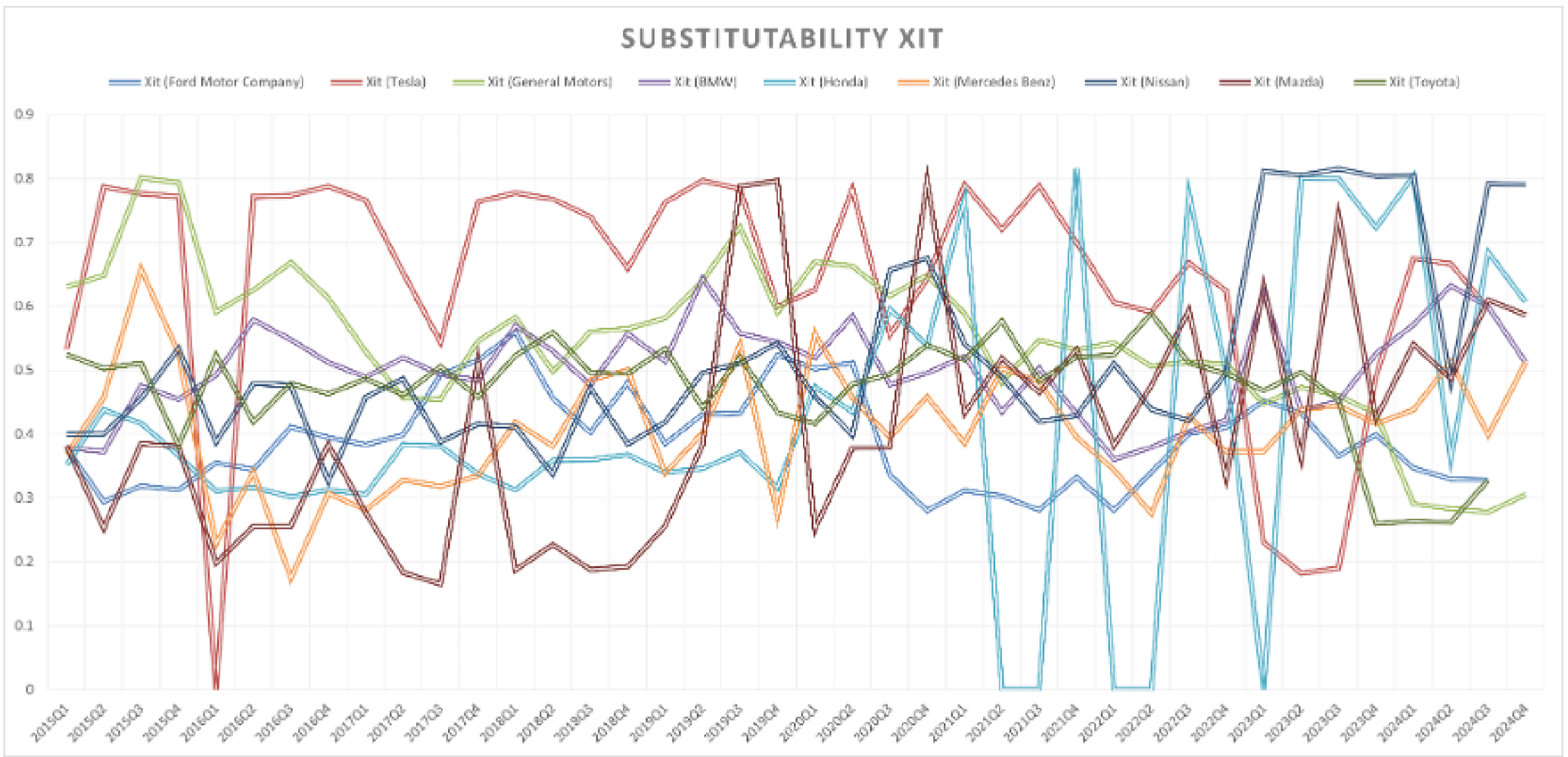

Figure 3: Substitutability across time for all firms

The average delay variable highlights a different aspect of supply chain differences across firms. Figure 4 displays the two firms with the largest average quarterly delay variation, Honda and BMW, and the firm with the lowest value Toyota.

There is an observed consistency in the peaks and troughs of delays for Honda and BMW, implying common shocks that affect all shipping of certain products. The effect of the 2021 Suez Canal obstruction by Even Given is visible, as both firms experienced their largest delays that quarter, reaching a peak of 200 days delayed shipments for Honda. In contrast, Toyota is shielded from variation in average delays of shipments and is consistently close to target. This could be reflective of their much more international supply chain, since Toyota has many subsidiaries in almost all countries, which it can use to reallocate resources and avoid bottlenecks. The COGS data is displayed in Figure 7 in the Appendix.

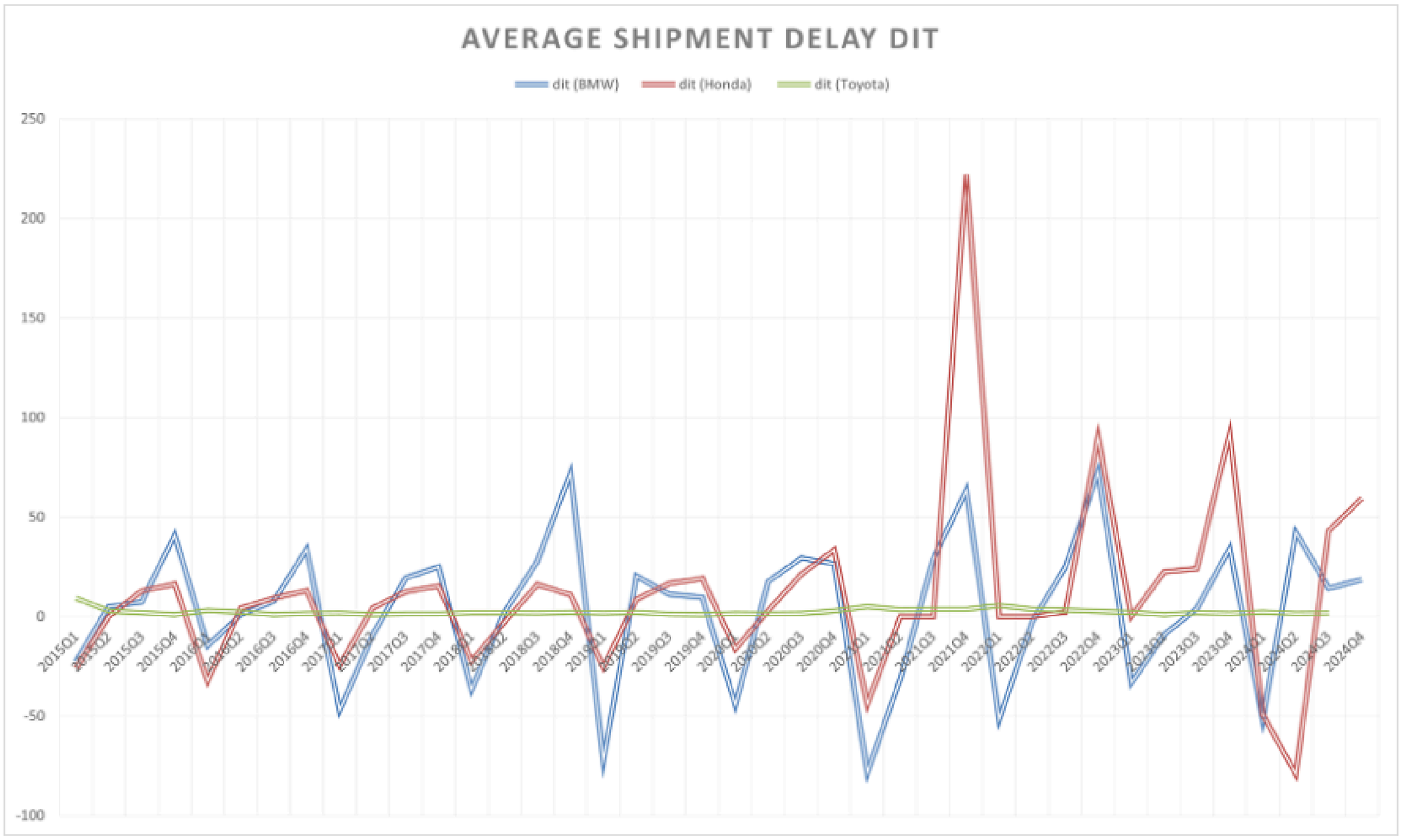

Figure 4: Average delay across time

3.2 Estimation and Regression Results

As described in the Methodology section the following specification is used to estimate the effect of substitutability and Average delays on the unit cost of production. The regression estimates are illustrated in Figure 5

$$C_i(t) = \beta_1 X_i(t) + \beta_2 d_i(t) + \mu_i + \delta_t + \Gamma\Phi_{it} + \epsilon_{i,t} \quad (15)$$

POLS no controls (1):

A pooled OLS regression without controls results to coefficient estimates of $\hat{\beta}_1 = -5715.618$ and $\hat{\beta}_2 = 24.544$, both of which are significant to the 1% level. The direction of their effect aligns with the economic intuition. A higher capability to substitute suppliers correlates with lower unit costs of production. Subsequently, increasing delays are correlated with a higher unit cost of production due to disruption in the production process. This initial step is important to confirm the direction of the effect of the two variables which align with the hypothesis discussed in the dissertation proposal.

Controls (2):

The controls included in specification (2) aim to isolate the effect of the international supply chain risk on the unit costs of production. Given that our data only includes international imports that enter the US through port, it does not account for local factors affecting costs. Domestic factors can influence costs which I aim to control for. Producer Price Index PPI (Iron and Steel Mills and Ferroalloy Manufacturing) would control for raw material price hikes that can affect costs of production within the US. The US Employment Cost Index (ECIWAG) is used to control for labour cost variation that affects costs of production locally. Finally, inflation is added as a control under the assumption that rising domestic inflation is likely to impact the costs of production. With inflation being a prominent macroeconomic figure post COVID, it could have resulted in increased costs of production for automakers in theory. Including controls does not substantially impact the size and significance of the estimates of the two key variables. This suggests that once we account for the effects of substitutability and average delays on unit costs of production, the additional controls we include do not add additional explanatory power to our regression. This reinforces the notion that the two key variables I constructed are robust predictors of unit costs of production for automakers. Furthermore, the coefficients of the controls are all insignificant, suggesting that they contribute little to quarter-to quarter variation in automakers' unit production costs.

Quarter and firm FE (4):

In the preferred specification (4) I include both firm and quarter fixed effects, which soak up any time-invariant firm characteristics and economy-wide shocks in each quarter. Because macro controls (PPI, Employment-Cost Index, CPI) vary only at the industry or time level, they are omitted due to collinearity. In practice this means that all of their explanatory power is already absorbed by the firm and quarter fixed effect dummy variables.

The coefficient of $X_i(t)$, $\hat{\beta}_1 = -6096.117$ and is significant at the 10% level. This implies that a 1-unit increase in substitutability (from 0 to 1) results in a $6096.117 decrease in the unit cost of production on average for automakers over the period 2015–2024, with 90% confidence that this result did not occur by chance. Equivalently, a 10% increase in substitutability of +0.1 would lead to a $609.6 reduction in the unit cost of production. This provides evidence to accept the alternative hypothesis on the coefficient $\hat{\beta}_1$, and is proof that there is a clear link between cost of production for automakers and their ability to substitute their suppliers in the event of a shock.

The coefficient of $d_i(t)$ is estimated at $\hat{\beta}_2 = 26.861$ and is marginally insignificant at the 10% level with a p-value of $p = 0.15$. This suggests that every additional day of delay could lead to an increase in the unit cost of production of $26.86. However, this estimate is not statistically significant at conventional levels, thus I cannot confidently distinguish it from zero. While the point estimate suggests a positive relationship, the data does not provide strong evidence that delays systematically drive up unit costs in our sample. There is an argument to be made for the significance of this estimate using standard errors obtained from bootstrapping and will be discussed in detail in the robustness test section.

The firm level dummies highlight time-invariant cost differences across firms and are illustrated in the appendix Figure 8. Taking BMW as the baseline, Toyota exhibits the lower average cost per unit at around $14,000 below the benchmark and Ford Motor Company $6,828 above the benchmark. This is reflected in their respective retail prices, with Toyota cars retail prices falling below those of Ford Motor Company[18].

We cluster standard errors at the firm level to allow for within-company correlation over time; however, with only nine firms in the sample, these clustered estimates may be imprecise and hypothesis tests less reliable. Thus, robustness of the result estimates is tested using bootstrapping.

Annual and firm FE (5):

Looking at specification (5) where yearly fixed effect was implemented; we observe that the control inclusion results in delay coefficient being significant in contrast with other specifications where I cluster standard errors. This suggests that using annual dummies frees up enough residual degrees of freedom and allows the controls to enter the model, which together tightens the estimate and render the delay coefficient statistically significant.

	(1) Pooled OLS	(2) With Controls	(3) FE time only	(4) FE quarter & firm	(5) FE yearly controls	(6) Bootstrap	(7) No Covid – FE Quarter & firm
Substitutability (Xit)	-5715.618***	-5710.747***	-6096.117*	-6096.117*	-5554.499**	-6096.117***	-6683.275 *
	(2166.89)	(2186.84)	(2980.81)	(3019.53)	(2742.817)	(2,099.39)	(3586.899)
Delay (dit)	24.544***	22.766***	26.861	26.861	26.76576*	26.86**	27.09385
	(8.98)	(8.57)	(16.66)	(16.87)	(13.96028)	(13,508.90)	(16.6078)
PPI Control	-	14.298	-	-	11.98965	-	-
		(11.49)			(7.859367)		
ECI Control	-	302.560	-	-	-193.2678	-	-
		(206.52)			(334.9984)		
CPI Control	-	-193.578	-	-	-94.85833	-	-
		(120.27)			(171.6826)		
Time fixed effects	No	No	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	No	Yes	Yes	Yes	Yes
Observations	356	356	356	356	356	356	

Table 1. Effect of Supply-Chain Risk on Unit Cost
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 5: OLS estimates of unit cost on supply-chain risk

Column (1) is baseline; (2) adds PPI, ECI, CPI controls; (3) adds time fixed effects; (4) adds firm fixed effects; (5) adds annual fixed effects and controls; (6) uses bootstrapped standard errors; (7) excludes COVID years as a placebo. Standard errors clustered at the firm level (in parentheses). *, **, *** denote p ‹ 0.10, p ‹ 0.05, and p ‹ 0.01.

3.3 Robustness tests

Bootstrapping

To guard against small-sample bias and non-normality of our estimators in a panel of only nine firms (N=356 observations), I implement a nonparametric bootstrap with B=1 000 replications displayed in Figure 9 in the Appendix. This can be a reliable robustness test, where clustered standard errors could be biased due to small sample size. At each replication the bootstrapping method resamples the full dataset with replacement and computes the OLS estimates for $\hat{\beta}_{1b}$ and $\hat{\beta}_{2b}$. The coefficients are recorded and used to compute the bootstrapped standard errors as shown in equation 16.

$$\widehat{SE}_b(\hat{\beta}_i) = \sqrt{\frac{1}{B-1}\sum_{b=1}^{B}(\hat{\beta}_{ib} - \bar{\beta}_i)^2} \tag{16}$$

The bootstrapped coefficient of $X_i(t)$ remains consistent at −6096.117, but its p-value increases to p = 0.004 indicating an estimated coefficient of 1% significance. This implies a robust estimate of substitutability coefficient which reinforces the negative relationship between substitutability and unit cost of production. The bootstrapped coefficient of $d_i(t)$ exhibits an increased p-value at p = 0.047 thus being marginally significant at the 5% level. This improved significance likely reflects the bootstrap's ability to more faithfully approximate the finite-sample distribution of our estimator, whereas the analytic cluster-robust formula may be overly conservative with so few clusters. Nonetheless, because the result lies very close to the 5% cut-off, and because several bootstrap replications failed to converge, I present both sets of confidence intervals and caution that this finding, while suggestive, is sensitive to the choice of inference method.

Placebo test - Excluding COVID

Dropping the Covid affected years and re-estimating the regression as shown by specification (7) in Figure 5 confirms the robustness of the coefficient estimates. Substitutability remains significant at the 10% level with a similar magnitude.

The delay coefficient becomes marginally insignificant with a p-value of 0.103, which is closer to significance than specification (4). Thus, we can conclude that the coefficients are robust to the disproportionate effect of Covid on supply chains.

3.4 Result Analysis and Discussion

As discussed previously, the large, negative and significant coefficient of $X_i(t)$ estimated at $\hat{\beta}_1 = -6096.117$ suggests that a +0.1 increase in substitutability (10% increase) would result in a $609.61 decrease in unit costs of production for automotive firms over the period of 2015–2024. Given that the mean unit cost of production is $18,202.62, a 0.1 change in substitutability would be a sizeable amount of the total unit cost of production at around 3.3% change. As observed in Figure 3 fluctuations in substitutability are often larger than 0.1 over the course of a quarter. Thus, a decrease in substitutability could yield a potential increase in the unit cost of production over a short time period. Given that the cost is not absorbed by the automaker and passed on to the consumer, this could lead to a price increase for consumers. It is important to note that a 3.3% price increase as a result of a 10% decrease in substitutability would result in a higher price increase than the CPI inflation target of 2% per year, suggesting a very real effect on consumers' welfare.

The smaller and positive coefficient of average shipment delay suggests a smaller but present effect of late shipments on the costs of production. Assuming the estimate is significant at the 5% level given the bootstrapped standard error estimates, a one-day delay would result in a $26.86 increase in the unit costs of production. This can quickly accumulate during a shipping bottleneck such as the 2021 Suez Canal obstruction, where Honda experienced an almost 200 average quarter delay, which could result in a $5372 increase in unit costs of production.

This result supports the argument that there is in fact a motive to raise prices during and after periods of supply chain disruptions as a means to cover increased costs of production. A lower ability of automakers to substitute suppliers in the event of a shock will result in costs of production rising significantly. Wanting to maintain their profit margins, firms might pass part of or the whole cost to the consumer.

Furthermore, shocks that impact the immediate ability of firms to produce and disrupt the Just in Time manufacturing system are likely to increase costs of production in the short term. A combination of shocks as it was the case during the COVID-19 pandemic could result in substantial surges in the costs of production of automakers. The observed 5%–10% increase in new car prices [1]during 2021–2022 is therefore not far off from what we would expect, given the combination of pandemic-related shocks, a major disruption in the Suez Canal and increased geopolitical conflict that affected shipping routes all around the world [24].

3.5 Limitations and Suggestions for Further Research

The chosen methodology comes with some limitations, some of which can be addressed in future research. Reverse causality and endogeneity present a concern regarding the computation and estimation of substitutability. Often the degree to which a firm can substitute its suppliers is determined by expectations regarding future supply chain shocks. Firms tend to anticipate and to some degree react to future shocks, by either importing more in advance or reducing their imports immediately. Furthermore, endogeneity could be of concern since factors not considered in my methodology could be correlated with substitutability, thus correlating the index with the error term. This would affect our result and would not allow for causal interpretation of substitutability on costs. An instrumental variable could be used to address this source of endogeneity in future research [2].

Nonlinearities could pose a concern, both in the computation of substitutability and average delay. Both of these indices have a non-linear effect on costs, which vary over time. This is partly addressed by the $\gamma = 2$ variable when computing substitutability but estimating γ by MLE for inference—or via gradient boosting for prediction—could yield deeper insights into supplier weighting. Furthermore, delays are likely to nonlinearly affect the unit cost as they incrementally increase depreciation of machinery and could lead to temporary factory closures.

[2] I consider new cars as auto firms are responsible for their prices in contrast with used cars whose prices are often set by independent retailers and experienced a significantly larger price hike

[3] An instrumental variable—such as quarterly country–product tariff changes on intermediate inputs, weighted by each supplier's import share—can purge endogeneity

Nonlinearities could pose a concern, both in the computation of substitutability and average delay. Both of these indices have a non-linear effect on costs, which vary over time. This is partly addressed by the $\gamma = 2$ variable when computing substitutability but estimating γ by MLE for inference—or via gradient boosting for prediction—could yield deeper insights into supplier weighting. Furthermore, delays are likely to nonlinearly affect the unit cost as they incrementally increase depreciation of machinery and could lead to temporary factory closures.

Omitted variable bias could also be of concern. Although firm and quarter fixed effects control for time invariant heterogeneity, unobserved time-varying factors, such as shifts in firms' technology or sudden regulatory changes may still confound the relationship between our substitutability, delay indices and unit costs. Moreover, with only nine firms and 356 quarterly observations, standard "clusterrobust" errors can be downward-biased and confidence intervals overly optimistic. These concerns are partially addressed via nonparametric bootstrap inference, which recovers the finite-sample parameter distribution, and by including firm and quarter fixed effects, but the analysis could benefit from a larger sample size. Future research could be conducted by extending the sample to other manufacturing firms, enlarging the sample size and improving inference.

The main limitation of this research is the nature of the data. The outcome variable unit cost of production is computed using data from SEC filings of public firms. Given that over the last 10 years accounting standards have changed, and tend to vary by region, it can be difficult to get a consistent value for Cost of Goods Sold/Cost of Revenue/Automotive Cost of Production. Furthermore, given that different firms include varying degree of labour costs or other costs within those reported values, this can skew the results. The same is true for the units produced per quarter which are not reported consistently.

Using the assumption of Demand Matching which tends to hold true we can get a good estimate of units produced per quarter from the number of cars sold per region, which closely match each other, however our estimates might lack accuracy or demand-supply mismatch scenarios that could enrich our analysis. Future research could benefit from finding an outcome variable that can be consistently observed for public and non-public companies.

Another data limitation is related to the availability and reliability of BoL shipping data. The large volume of available data makes an analysis of this form very computationally expensive and selective sampling, which is often needed, can result to selection bias. Firms import under many different names which complicates this analysis. Furthermore, firms can hide their shipping data, which they often do when involved in defence contracts or if they want to protect against competition. Lastly, human error or illegal activity could lead to measurement error or BoL that are not representative of the actual import. These limitations do not invalidate the chosen methodology but act a point of concern when interpreting coefficients causally, particularly when coefficients are marginally significant and only under certain inference conditions, as is the case with the average delay variable.

Future Research Suggestions

Future research should (i) extend the sample beyond automakers to other manufacturers to increase statistical power and external validity, and (ii) strengthen estimation and identification by jointly estimating nonlinear parameters via MLE or cross-validated grid search and by exploiting alternative instruments such as exchange rate shocks. As an exploratory extension, one might employ advanced forecasting methods such as VAR impulse-response or graph-neural-network models to anticipate supply-chain disruptions.

4. Conclusion

This research introduces a novel theoretical framework to compute supply chain risk and empirically tests its effect of unit costs of production.

It makes use of BoL import dataset to capture the interaction between firms and their suppliers based on the products they source from each supplier. I find a negative effect of substitutability on unit costs of production for US based automakers during the period of 2015-2024, which suggests that a higher ability of a producer to substitute their suppliers in the event of a shock, corresponds to lower unit costs of production. Average shipment delay is also found to be significant [1], which corresponds to a higher unit cost of production for every additional day delayed.

[1] depending on the choice of inference and robustness

The large point estimates on both substitutability and delay risk imply that the 5%–10% rise in U.S. new-car prices between 2021 and 2022 can be largely attributed to supply-chain shocks, most notably the Suez Canal blockage and COVID-19 lockdown [24]. These combined disruptions tightened critical input markets, raised production costs, and were subsequently passed on to consumers. There is indication however that the market for used cars exhibited opportunistic behaviour during that period in the US, where prices surged up to 40% during late 2020-2021. This could suggest opportunistic behaviour by private retailers who increase profit margins citing inflation and could support the" Greenflation" argument. This price surge is far larger than the one suggestive of our analysis and estimated coefficients and would require further investigation into the private resale market and the market for second-hand auto vehicles.

The findings of this research consist of an important contribution to the literature, as they find a strong link between supply chain risk change and cost of production. Besides addressing the" Greenflation" versus supply chain disruption argument, these findings could be incorporated by central banks or policy makers to predict sector-specific inflation following supply chain disruptions. The magnitude of the effect of supply chain risk on unit costs of production is reflective of the price surge of new cars during the periods of 2020-2021 Suez Canal blockage and COVID-19 lockdowns. This suggests that there is no evidence that US automakers act opportunistically and raise prices disproportionately during supply chain shocks, but rather that they pass the whole cost increase to the consumer.

See page 191 for references and appendix

To what extent do American at-the-money equity options incorporate price and volatility changes induced by Federal Open Market Committee announcements?

Nicolo Pusineri

1. Introduction

Financial options are widely regarded as valuable forward-looking indicators of market expectations and risk. In particular, the implied volatility derived from option prices reflects the market's consensus view of future return variability. Empirical surveys note that "implied volatility is regarded as one of the most important variables" in options trading, giving an indication of "future volatility of the underlying asset" and helping predict price swings. Traders routinely use Greeks – risk sensitivities such as Delta (sensitivity of the option price to the underlying) and Vega (sensitivity to implied volatility) – to hedge and exploit changes in underlying dynamics. For example, a call option with Delta 0.50 will rise by about $0.50 if the stock rises $1, while Vega quantifies how a 1% change in implied volatility shifts the option's value. These properties make options especially sensitive to shifts in volatility expectations and information flow.

Monetary policy decisions provide a compelling setting to study such effects. The U.S. Federal Open Market Committee (FOMC) meets at regularly scheduled dates to set interest rates and signal economic policy, with announcements released at precisely known times. Academic and market sources emphasize that FOMC announcements have very significant and immediate impacts on financial markets (Bernanke Kuttner 2005, p. 1225). Indeed, studies find that around Fed meetings investors demand elevated risk compensation: over the 24–48 hours before an FOMC announcement, required equity premia rise sharply (Bollerslev, Todorov Xu 2015, p. 721). For instance, Savor Wilson (2013, pp. 2031-2032) Lucca and Moench (2015, pp. 330-331) document a marked "pre-announcement drift" in asset prices and volatility risk premiums.

Market observers similarly note that option-implied measures of equity risk have tended to rise in the weeks leading into Fed meetings (for example, recent FOMC minutes observe that optionimplied equity volatility moved above its long-run average in the intermeeting period). In short, the combination of high-impact news and precise timing makes FOMC announcements an ideal natural experiment for option pricing: markets must resolve a leap in information instantly, allowing a clean examination of how option prices adjust intraday. The sharp timing also raises the question of whether prices fully adjust immediately or exhibit short-lived mispricing.

1.1 Literature Review

The present research therefore explores intraday pricing of U.S. equity options in the narrow window around scheduled FOMC announcements. In particular, we investigate whether American-style options on individual stocks show systematic pricing errors or anomalies in the minutes after an announcement. To set the stage for this inquiry, we first review the theoretical framework and key empirical findings on option pricing and announcement effects. This survey motivates our focus on American options, highfrequency data, and structural pricing models, and it highlights gaps in the literature that our study aims to fill.

Option-pricing theory provides the starting point. In a risk-neutral world the value of an option equals the discounted expectation of its payoff, a principle given analytical form by the Black–Scholes–Merton (BSM) model (Black Scholes 1973, p. 645). For a non-dividend-paying European call, BSM yields

$$C(S,t) = S_t\,N(d_1) - K\,e^{-r(T-t)}N(d_2), \qquad d_{1,2} = \frac{\ln(S_t/K) + \left(r \pm \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}$$

where S_t is the spot price, K the strike, T −t the time to expiry, r the risk-free rate, σ the volatility, and N(·) the standard-normal CDF. Observing every term except σ, one can invert the formula to obtain the implied volatility σ_{imp}—the unique value that reconciles the model with the market price. Because σ_{imp} embeds investors' collective assessment of future return variability, it is routinely employed as a forward-looking gauge of risk and to price volatility derivatives (Whaley 2000, p. 19).

Yet the BSM framework rests on idealised assumptions: constant volatility, log-normal returns and no jumps. Empirically, implied volatilities vary systematically across strikes and maturities , producing the wellknown volatility smile and term structure, evidence that real markets contain stochastic volatility, jumps and other departures from BSM's pristine setting (Merton 1976; Bates 1996).

To address these limitations, a rich literature has proposed various extensions. Stochastic volatility models introduce an additional random process for volatility itself (e.g. Heston 1993; Hull and White 1987), allowing volatility to fluctuate over time and correlate with the asset's returns (producing volatility clustering and skew). Jump-diffusion models (beginning with Merton 1976) add a Poisson jump component to the stock's return, capturing sudden large moves and heavy tails. Local volatility models (Dupire 1994; Derman and Kani 1994) construct a deterministic volatility surface $\sigma(S,t)$ that exactly fits all observed option prices, ensuring consistency across strikes and maturities. In effect, under local volatility the asset follows a diffusion with instantaneous volatility tied to its level, $\sigma(S, t)$. These models provide a more nuanced view than BSM's flat-vol assumption: for example, local volatility can replicate an entire implied vol surface, whereas stochastic models embed mean-reverting random vol. (As one summary notes, if volatility "has its own randomness" the model is stochastic, whereas if it is just a deterministic function of the state, it is called a local volatility model.) Each approach improves on BSM in fitting market prices, but each has trade-offs in terms of realism, tractability, and calibration (Gatheral 2006, p. 92).

In all these models, implied volatility remains a key gauge. For instance, in a local volatility model the implied volatility curve is exactly matched by construction, reflecting the model's calibration to market prices. In stochastic volatility or jump models, implied volatility can vary naturally in response to both the underlying path and the stochastic volatility process or jump intensity. Thus, whether implied vols are static or dynamic in the model, they serve to connect theory to actual market quotes. Importantly, many extensions still preserve the notion that option prices should reflect a forward-looking expectation of volatility. However, as Donders and Vorst (1996, p. 1457) point out, market data often show a distinct pattern around scheduled information releases: implied volatility anticipates the event, then crushes immediately afterward.

In their sample of equity options around firm-specific news, they find that implied volatilities "increase significantly during the pre-event period" and reach a peak just before the announcement, and then "after the news release, implied volatility drops sharply" back toward normal levels. This "smile of uncertainty" is consistent with the idea that market participants embed jump risk into prices before an event, and then unwind that risk once the event occurs. Theoretically, Merton (1973) and others have shown that if events can cause jumps in the underlying, this will appear in option prices as a volatility premium that collapses post-event.

Greeks play an important role in understanding these dynamics. Delta (C/S) tells us how much the option price moves with the underlying stock price; options with high gamma ($_{\Delta}$ changing rapidly) can see large price moves for small stock moves. Vega ($C/_{\sigma}$) tells us how an option's price changes with implied volatility, which is crucial around events: when implied volatility jumps, options with large Vega (often near-themoney, longer-dated options) will see the biggest price swings (Hull 2018, p. 352). Thus, the trader perceives event risk in the vega of options. Theta and rho (sensitivities to time decay and interest rates) are also relevant but less directly tied to event shocks. In empirical studies, an option's time to maturity strongly affects its vega: longer-dated options carry higher vega and thus larger exposure to implied vol changes. In event analysis, researchers often fix a residual time horizon (e.g. 30 days) to compare options over time, and use a "rolling ATM" approach to maintain comparability as the stock price moves. For example, Donders and Vorst construct an "ATM IV" by interpolating volatilities of strikes closest to the spot; similarly, in a biotech news case study a rolling ATM vol series showed that "the rolling ATM volatility increased leading into the event, and drops sharply after it has occurred." Such rolling schemes help isolate how volatility expectations change, without confounding from moneyness or term decay.

Despite these advancements, the classic models still have limitations when confronted with real data, particularly for American-style options on equities. American options (common on individual stocks) differ from the European options assumed in many models because they can be exercised early. This early-exercise feature means put–call parity becomes an inequality rather than an exact equation, and closed-form solutions seldom exist.

In practice, one must compute an optimal exercise boundary (which depends on dividends, interest, time, and volatility) or use numerical methods (such as binomial trees or finite differences). The need to consider early exercise adds complexity to both pricing models and empirical tests. It is known, for example, that deep-in-the-money American calls will be exercised just before a dividend if the advantage exceeds the remaining time value. The early-exercise premium effectively reduces the call price relative to a European model. Thus, any empirical study of American options must account for these effects. Moreover, structural models such as jump-diffusion or stochastic volatility have been developed primarily for European options, or for fixed income and currency contexts (e.g. foreign exchange). There has been less emphasis on fully structural intraday models for equity options that include American features and discrete events (Ni, Pan Poteshman 2008, p. 254).

Empirical studies of options around macroeconomic announcements have mostly focused on index options or broad equity indices. Using S&P 500 index options, Liu, Pan, and Wang (2020) derive the "FOMC risk premium" by examining options that expire immediately after a Fed announcement. Under a simple jump model (with only the Feddriven jump), they infer an average jump of +1.16% and –1.53% in the S&P 500 around the meeting, with realized volatility of only 10 basis points in non-event risk. Crucially, because implied volatility (the market's anticipation of volatility) is much larger (on the order of 100+ bps jump) than the realized diffusion variance, option prices embed a sizable risk premium for the announcement. They find this premium is time-varying: for example, the implied risk premium (in basis points) fluctuated between roughly 15 and 88 bps (for relative risk aversion) over 1996–2017. Johannes, Kaeck, and Seeger (2023) similarly calibrate structural option models to intraday index data around FOMC meetings. They define "FOMC event risk" as the volatility specifically generated by scheduled Fed announcements. Using calibrated models on intraday S&P option data, they show that event risk is "economically large, time-varying, and highly predictive of realized event risk," and they observe "evidence for early uncertainty resolution in the hours and days before an FOMC announcement." In other words, consistent with the implied-volatility crush seen in other settings, they find that the market begins to assimilate the Fed's information even prior to the scheduled release.

More broadly, research on macro announcements confirms the familiar pattern: implied volatility tends to rise in anticipation and drop after the news. Ederington and Lee (1996, pp. 12-13)and others document that realized market volatility often declines on announcement days (as uncertainty is resolved). Donders and Vorst (1996) explicitly show this for implied volatilities: one day after a scheduled firm-specific news event, implied volatilities "drop sharply and gradually move back to the long-run level." Similar "volatility crush" phenomena have been observed around FOMC meetings, nonfarm payroll releases, and earnings announcements. For example, Federal Reserve minutes (March 2025) note that option-implied equity volatility was elevated before a meeting, and market commentaries often refer to the implied-vol spike ahead of FOMC and its subsequent fall upon decision. These findings reinforce the view that option prices are forward-looking but may initially overstate realized uncertainty prior to precise announcements.

Despite this rich literature, important gaps remain. First, most studies use index or futures options (which are European style) and daily or low-frequency data. The intraday behavior of equity options around announcements has received much less attention. The high-frequency response may reveal short-lived mispricings or microstructure effects that are invisible in EOD data. Second, research explicitly focusing on American equity options and their early-exercise feature in the context of macro news is scarce. Put-call parity violations, dividends, and discrete exercise boundaries mean that the simple theoretical relationships used for European options break down for American ones. Third, while structural models (jump-diffusion, stochastic volatility, etc.) have been fitted to market data before, the last 5 years have incorporate rate hikes from Covid-19 and the subsequent cuts in late 2024.

In practical terms, these gaps motivate our approach. We follow the common practice of constructing an ATM implied volatility series by "rolling" (selecting strikes closest to ATM for a fixed time window) to isolate volatility changes purely from information flow. But rather than relying solely on daily snapshots, we examine option prices at high frequency throughout the day of an FOMC announcement. We pay particular attention to whether, immediately after the announcement, option prices (especially for near-ATM strikes) deviate systematically from model-implied values.

One might expect, for example, that if implied volatility had spiked pre-announcement and then the news delivered a less volatile outcome, options may briefly overshoot before reversion. Alternatively, if trading frictions or risk aversion cause slow diffusion of information, option prices could underreact. These scenarios would appear as pricing errors or transient mispricing in the intraday data.

1.2 From Model to Testable Hypotheses

Our modelling pipeline produces, for every ten-minute interval b surrounding each FOMC meeting e and stock j, a lattice-based "fair" price

$$P_{e,j,b}^{\text{model}} = \Pi\left(S_{e,j,b}, K_{e,j,b}, \tau_{e,j,b}, r_{e,b}, q_j, \sigma_{e,j,b}^{\text{mod}}\right)$$

where the Leisen–Reimer trinomial lattice (Leisen & Reimer 1996) already embeds the actual policy-rate decision through $r_{e,b}$ and respects early exercise. The only input the market never quotes directly is the interval-by-interval volatility path $\sigma_{e,j,b}^{\text{mod}}$.

We construct that path in two stages: first, over a 15-day estimation window (D_e − 14:30, D_e − 19:50) we invert the lattice at every interval to recover an at-the-money implied-vol timeline. Secondly, we fit an AR(1) model to the first differences of logvolatility, augmented with a linear "count-down-to-announcement" term, and crucially, only forecast the six bars that matter: the announcement bar b = 1 and the next five ten-minute intervals. We initialise the recursion with the implied volatility observed at t_o = 18:50 GMT and step the AR(1) forward just far enough to span b = 1,...,6. This results in a theoretical price $P_{e,j,b}^{\text{model}}$.

Putting these elements together, we define the pricing error

$$\Delta e,j,b = Qe,j,b - Pe,j,bmodel,$$

with $Q_{e,j,b}$ the observed mid-trade price. Because the lattice already prices in the announced r, any systematic difference between "rate-change" and "no-change" days must stem from the market's own over- or under-reaction to volatility.

Hence our central null is a difference-in-differences statement:

$$H_0 : \mathbb{E}\left[\Delta_{e,j,b} \,|\mathit{Change}\right] = \mathbb{E}\left[\Delta_{e,j,b} \,|\mathit{No\text{-}Change}\right] \quad \forall\, b \geq 1$$

We test H_o in two complementary ways. First, through per-ticker Welch tests and robust OLS regressions we compare mean absolute errors across the two policy regimes, allowing for heteroskedasticity. Second, a pooled bar-level regression on z-score-normalised absolute errors extracts a single market-wide effect, tracing how a potential "vol-crash overshoot" unfolds across the six post-announcement intervals.

Rejecting H_o would imply that, despite the lattice accounting for the rate jump and our baseline volatility path, market prices move too far (or not far enough) relative to risk-neutral benchmarks—hinting at a transient inefficiency driven by public reaction rather than model mis-specification.

In short, by marrying high-frequency data with an option pricing engine that respects early exercise and time-varying volatility, this dissertation provides the first systematic look at whether American equity options honour risk-neutral valuation in the busiest ten minutes of the central bank's calendar.

2. Data and Event Window Construction

The task of measuring the impact of macro-economic events on financial assets is no new concept; it has given rise to a rich literature on event-study methodologies. As MacKinlay (1997, p. 15) explains, by defining an event of interest and an estimation window around it, we use pre-event data to form a model of "normal" behavior and then quantify the deviation of realized outcomes from that benchmark. In our context, the event of interest is each FOMC statement release, and our primary statistic is the difference in the price of an at-the-money (ATM) American call immediately after a meeting where the Fed changed rates versus one where it held them steady—with the aim of detecting an "overshoot."

2.1 Catalouging FOMC Meetings and Data Collection

We begin by cataloguing every FOMC meeting between 1 January 2020 and 29 January 2025—41 regularly scheduled dates plus the surprise cut on 3 March 2020 (see Appendix A)—and recording, for each event e, the date D_e and exact announcement time T_e:

D_e = date of event e, T_e = time of release (usually 19:00 ET).

We then define an event window of the 15 trading days prior to each announcement,

$$\{D_e - 15,\ldots,D_e - 1\},$$

which balances capturing short-term option dynamics against contaminating noise from other news. For each (e,j) pair—event e and ticker j—we collect:

- one-second OPRA top-of-book option trades $X_{e,j}^{opt}(t)$,
- one-minute NBBO mid-quotes $X_{e,j}^{stk}(t)$ for the underlying stock (Polygon.io).

Because quoted transaction times are irregular, we impose a ten-minute grid to build consistent time-series (see 2.3). Before explaining how the data was formalised for the event studies, a quick recap of why

2.2 The ATM American Call Option: Mathematical Framework and Economic Intuition

At the heart of our valuation lies the at-the-money (ATM) American call, whose strike K is chosen so that $S_t \approx K$ at every ten-minute interval. To see how its value evolves and when early exercise becomes optimal, begin with the stock's risk-neutral dynamics:

$$\frac{dS_t}{S_t} = (r_t - q)dt + \sigma_t\, dW_t, \tag{1}$$

where

- r_t is the instantaneous, continuously-compounded risk-free rate (the very quantity that jumps at the FOMC release),
- q is the continuous dividend yield,
- σ_t is the instantaneous volatility,
- dW_t is a standard Brownian increment.

Equation (1) implies that over an infinitesimal dt, the stock's expected drift is $r_t - q$ and its variance increment is $\sigma_t^2 dt$.

Building on (1), the value V (S,t) of an American call satisfies the free-boundary problem

$$\max\left\{\underbrace{\mathcal{L}\,V - r_t\,V}_{\text{continuation}},\ \underbrace{S - K}_{\text{intrinsic value}}\right\} = 0 \tag{2}$$

where the Black–Scholes operator is

$$\mathcal{L}\,V = \frac{\partial V}{\partial t} + (r_t - q)\,S\,\frac{\partial V}{\partial S} + \tfrac{1}{2}\,\sigma_t^2\,S^2\,\frac{\partial^2 V}{\partial S^2}$$

At each point (S,t), the option's value is the larger of (i) the continuation value—which is the discounted expectation of holding one more instant under risk-neutral probabilities—and (ii) the immediate exercise payoff S − K. Intuitively, the "time value" V − (S − K) exists because waiting preserves upside optionality at the cost of foregone dividends and interest. A jump in r_t at the announcement increases the discount rate in (2), shrinking the continuation branch relative to intrinsic value; for deep-in-the-money calls on dividend payers, this can flip the optimal decision to exercise immediately, generating an early-exercise premium that pure European-style studies ignore.

To implement (2) in practice, at each ten-minute interval t_b we must supply exactly five inputs:

$$\left(S_{t_b},\ K,\ T - t_b,\ r_{t_b},\ \sigma_{t_b}\right)$$

plus q. The next section shows how we extract these from raw ticks in a seamless, notation-driven pipeline.

2.3 From Raw Ticks to the Model-Ready Panel

Our goal is to build the tidy panel

$$\{ S_{e,j,b},\ K_{e,j,b},\ Q_{e,j,b},\ \tau_{e,j,b},\ r_{e,b} \} \quad e = 1,\dots,42,\ j = 1,\dots,25,\ b = 1,\dots,33$$

where b indexes ten-minute intervals from 14:30 to 19:50 GMT. We achieve this in a single, fluid sequence:

1. Define the time grid.

$$t_b = 09{:}30 + (b - 1) \times 10 \text{ min}, \qquad b = 1,\dots,33,$$

each interval representing

$$\Delta t = \frac{10}{252 \times 6.5 \times 60} \approx 1.02 \times 10^{-4} \text{ trading-years.}$$

2. Aggregate closing trades. Within $[t_b, t_b + 10 \text{ min})$, record the last observable price:

$S_{e,j,b}$ = last stock trade, $Q_{e,j,b}(K,T)$ = last option trade at strike K, T.

3. Form the "pivot cube." Stack these bar-quotes across all strikes K and expiries T:

$$C_{e,j} = \{ S_{e,j,b},\ Q_{e,j,b}(K,T) \}_{b=1..39,\ K \in \mathcal{K},\ T \in \mathcal{T}}$$

We drop invalid or missing cells, forward-filling isolated single-bar gaps only if price moves stay within twice the event's median range.

4. Freeze a single expiry. Sort expiries $T^{(1)} < T^{(2)} < \cdots$ and set

$$T^*_{e,j} = \min\{ T^{(k)} : T^{(k)} \geq D_e + 7 \text{ days} \},$$

discarding all other maturities to ensure $\tau \geqslant 1$ week.

5. Compute auxiliary state variables. Remaining time to expiry:

$$\tau_{e,j,b} = \frac{T^*_{e,j} - t_b}{252 \times 6.5 \times 60}$$

and the Fed funds rate as a step function:

$$r_{e,b} = \begin{cases} r_e^{\text{pre}}, & t_b < 19{:}00 \\ r_e^{\text{post}}, & t_b \geq 19{:}00. \end{cases}$$

6. Assemble the final panel. The result is

$$\{S_{e,j,b}, K_{e,j,b}, Q_{e,j,b}, \tau_{e,j,b}, r_{e,b}\} \qquad e = 1..42,\ j = 1..25,\ b = 1..39,$$

or in tensor notation: $S, K, Q, \tau \in \mathbb{R}^{E \times J \times B}$ and $r \in \mathbb{R}^{E \times B}$.

With this structured dataset in hand, each ten-minute frame supplies exactly the five inputs required by our 33-step Leisen–Reimer trinomial lattice (Section 3), enabling us to price the ATM American call under realistic dividends and early-exercise considerations—and, by inversion, to extract an implied volatility time-series that tracks true market dynamics.

3. Theoretical Framework

3.1 Objective and Roadmap

In this section, we lay out the heart of our valuation strategy: at every ten-minute mark b during each FOMC event day e for each stock j, we compute a "fair" model price for the corresponding at-the-money American call. Formally, we denote this theoretical price as

$$P_{e,j,b}^{\text{model}} = \text{Call}\left(S_{e,j,b},\ K_{e,j,b},\ \tau_{e,j,b},\ r_{e,b},\ \sigma_{e,j,b}^{\text{model}},\ q_j\right)$$

where $S_{e,j,b}$ is the underlying's mid-trade price, $K_{e,j,b}$ the rolling ATM strike, $\tau_{e,j,b}$ the time to expiry, $r_{e,b}$ the prevailing risk-free rate, q_j the continuous dividend yield, and $\sigma_{e,j,b}^{\text{model}}$ our forecasted volatility. Comparing $P_{e,j,b}^{\text{model}}$ against the observed mid-trade price

$$Q_{e,j,b},\ \epsilon_{e,j,b} = Q_{e,j,b} - P_{e,j,b}^{\text{model}},$$

captures the intraday mispricing driven by rapid volatility shifts surrounding the FOMC announcement.

To implement this pipeline, we proceed in four intertwined steps.

1. First, we construct the rolling ATM strike $K_{e,j,b}$ by linearly interpolating between the two strikes immediately above and below $S_{e,j,b}$, thereby isolating vega exposure.
2. Second, we build a Leisen–Reimer trinomial lattice that accommodates early exercise and discrete dividends, which through backward induction extracts the implied volatility at that instant in time.
3. Third, we model the extracted implied-volatility dynamics by fitting an AR(1) to the first differences of log-IV, $\Delta \ln \sigma_{e,j,b}$, over the fifteen-day calibration window and recursively forecast $\sigma_{e,j,b}^{\text{model}}$ into the event day.
4. Finally, we integrate: we invert the lattice on pre-event bars to recover historical σ, generate one-step forecasts via our AR(1) on $\ln \sigma$, re-price the lattice with $\sigma_{e,j,b}^{\text{model}}$, to compute $\epsilon_{e,j,b}$, the mispricing error between the observed market price and the constructed theoretical one.

This cohesive framework transforms raw high-frequency data into precise measures of intraday mispricing, which we analyse empirically in Section 4.

3.2 Rolling-ATM Construction and Economic Intuition

A crucial step in our methodology is the construction of a rolling at-the-money (ATM) strike series $K_{e,j,b}$ that tracks the evolving spot price $S_{e,j,b}$. By anchoring the option to a strike that moves in lockstep with the underlying, we neutralize delta exposures—ensuring that any subsequent pricing error arises predominantly from mis-forecasted volatility rather than directional movements.

Concretely, at each ten-minute stamp b, we observe a set of traded strikes $\{K^{(1)}, K^{(2)}, \ldots\}$ for expiry $T_{e,j}^{*}$. We identify the two adjacent strikes $K^{\downarrow} \leqslant S_{e,j,b} \leqslant K^{\uparrow}$ that bracket the midpoint $S_{e,j,b}$. We then assume that prices are linear between strikes to obtain the interpolated ATM price

$$Q_{e,j,b} = \frac{(K^{\uparrow} - S_{e,j,b})\, Q_{e,j,b}(K^{\downarrow}) + (S_{e,j,b} - K^{\downarrow})\, Q_{e,j,b}(K^{\uparrow})}{K^{\uparrow} - K^{\downarrow}}$$

and define the effective ATM strike

$$K_{e,j,b} = \frac{(K^{\uparrow} - S_{e,j,b})\, K^{\downarrow} + (S_{e,j,b} - K^{\downarrow})\, K^{\uparrow}}{K^{\uparrow} - K^{\downarrow}}$$

This linear interpolation guarantees $K_{e,j,b} \approx S_{e,j,b}$ and yields a continuous strike process even when discrete strike grids change intraday. Although this process allows us to create an ATM price, the assumption that prices are linearly distributed between strikes is proven to be less accurate by volatility skews showing different strikes have varying implied volatility. But on account that the strikes are close to the spot price the error should be minimal on the resulting interpolated price. An alternative method could use a strike volatility smile to better interpolate prices, but this historical data was not available.

This framework restricts delta for a call at $S \approx K$ to a constant 0.5, concentrating all remaining price sensitivity in vega, theta and rho. This process aims to emulate how an institutional trader, who continually hedges delta by adjusting his strike position, would view the price of the option moving, isolating pure volatility risk. In this investigations context, it allows us to interpret $\epsilon_{e,j,b} = Q_{e,j,b} - P_{e,j,b}^{\text{model}}$ as a nearly one-for-one measure of implied-volatility surprise at the ten-minute frequency. Absent rolling-ATM, a fixedstrike analysis would conflate intrinsic re-hedging and moneyness drift with volatility shocks, obscuring the very phenomenon—mispriced vega around FOMC shocks—that this study seeks to uncover.

3.3 Leisen-Reimer Trinomial Lattice and Implied-Vol Extraction

Having aligned our strike to the underlying's spot via the rolling ATM procedure, we must use a method to price American calls with discrete dividends and back out the market's implied volatility. A model that fits this criteria is the Leisen–Reimer trinomial lattice, first introduced by Dietmar Leisen and Matthias Reimer in 1996.

Their seminal paper, Binomial Models for Option Valuation – Examining and Improving Convergence, demonstrated that by choosing three-branch recombining trees—with move sizes and probabilities calibrated via analytically inverted normal-CDF approximations—one can achieve far smoother and faster convergence to the continuous-time option value than with classical two-branch (Cox–Ross–Rubinstein) trees. While Leisen and Reimer originally tested their method on European calls and puts, the same logic extends naturally to American contracts by embedding an early-exercise condition at each node.

Before we can create the tree, many of the sampled equities distribute regular cash dividends, the stock-price series used in the lattice must be adjusted to maintain internal consistency with the option pay-offs. Whenever a firm trades ex-dividend inside our 09:30–15:50 ET window, the raw NBBO mid-quote $S_{e,j,b}^{raw}$ is reduced by the declared cash amount $D_{e,j}$ beginning with the first interval whose timestamp t_b is $\geqslant$ the ex-date–time:

$$S_{e,j,b} = S_{e,j,b}^{\text{raw}} - \mathbb{I}\left(t_b \geq t_{e,j}^{\text{ex}}\right) D_{e,j}$$

This simple "clean-price" adjustment treats the dividend as an instantaneous, fully anticipated drop in firm value, aligning the discrete stock path with the option's intrinsic value schedule.

Tree construction The tree construction starts at a given time stamp bar b of event e for ticker j. We begin from the five core state variables . We divide the remaining time to expiry $\tau_{e,j,b}$ by the step size of a 10 min interval to determine how many steps the tree will have:

$$N = \frac{\tau_{e,j,b}}{\Delta t}$$

We then set the upward and downward step size multipliers to

$$u = \exp\left(\sigma \sqrt{2\,\Delta t}\right), \quad d = \frac{1}{u}$$

ensuring that the middle branch is simply m = 1. The multipliers are functions of the implied volatility.

At this point we have defined the size of the step for the tree but we are still missing how the tree will decide to move in any of the three directions.

To determine the direction of the movement in a binomial or trinomial tree, the potential movements are given probabilities to dictate how the tree evolves, but what conditions need to be met to create a realistic model? Leisen and Reimer show that one can derive these probabilities by solving a closed form solution that upholds the following conditions:

Growth factor: Under risk neutrality (and after accounting for continuous dividends q), the underlying is expected to grow by

$$A = \exp\big((r - q)\,\Delta t\big)$$

over Δt. In the trinomial tree, the asset either moves up by a factor u, stays flat at 1, or moves down by d. Hence we require

$$p_u\,u + p_m \cdot 1 + p_d\,d = A.$$

Variance matching: The continuous-time model has instantaneous variance σ^2, implying that

$$\mathrm{Var}\big[S_{t+\Delta t}/S_t\big] = A^2\big(e^{\sigma^2 \Delta t} - 1\big)$$

In the discrete tree, the second moment is

$$pu\,u2 + pm \cdot 12 + pd\,d2,$$

so we enforce

$$pu\,u2 + pm + pd\,d2 = A2e\sigma2\,\Delta t.$$

Probability sum: Since one of the three branches must occur,

$$p_u + p_m + p_d = 1.$$

Hence by solving the three linear equations, we arrive at the closed form solution below:

$$p_u = \frac{(A-d)^2}{(u-d)^2}, \quad p_d = \frac{(u-A)^2}{(u-d)^2}, \quad p_m = 1 - p_u - p_d$$

where these expressions guarantee that $p_u, p_m, p_d \geqslant 0$ and a smooth approach to the continuous limit as $N \to \infty$.

With the probabilities now defined as a function of b's market implied volatility, a tree can be created that runs until the option reaches its maturity at i = N. At node (N,k), the option has reached its maturity meaning that its price or value V is based off of the intrinsic value of the American call:

$$V(N,k) = \max\{S(N,k) - K_{e,j,b}, 0\}.$$

We then take a step back to the previous node at i = N − 1, and in order to do this we must compute the risk-neutral weighted average of the three continuation values one step ahead, discounted by $e^{-r\,\Delta t}$, to compute the present value of the option:

$$V_{\text{cont}} = e^{-r_{e,b}\,\Delta t}\left(p_u\,V^{(i+1,k+2)} + p_m\,V^{(i+1,k+1)} + p_d\,V^{(i+1,k)}\right)$$

and by comparing its present value to its immediate exercise $V_{ex} = S^{(i,k)} - K_{e,j,b}$. The node's option value is:

$$V(i,k) = \max\{V_{cont}, V_{ex}\},$$

which naturally embeds the free-boundary (early exercise) feature of American calls. This process is then repeated from i = N −1,...,0, so that each node (i,k) will compute whether to exercise or not and create a price for the option. Once we have iteratively rolled back to the root node $V^{(0,0)}$, all the possible routes that could've been taken to reach the root node from the initial leaf nodes created by the stock lattice, are aggregated to give us

$$V^{(0,0)} = \Pi\left(S_{e,j,b}, K_{e,j,b}, \tau_{e,j,b}, r_{e,b}, q_j, \sigma; N\right)$$

which is the aggregate, discounted expected value of all possible future paths (subject to the possibility of early exercise at every node) and risk-neutral, arbitrage-free price of the American call for that 10 minute period.

Interestingly in this experiment's case when $S_{e,j,b} \approx K_{e,j,b}$, the immediate-exercise leg at the root is zero and the entire time-value resides in the continuation, which has no real implications on the model's efficiency in predicting the option price. But this is an interesting byproduct of creating a continuous ATM timeseries for an American contract, the contract would never be executed before its expiry forcing it to act as a European contract, as expiry is the defining difference between them. Given this realization, an American option contract which is constantly ATM could be modeled as a European option contract opening up a new way to approach American options.

Extracting implied volatility Critically, the only unknown variable that determines the Leisen–Reimer lattice and the theoretical price is the market implied volatility $\sigma_{e,j,b}^{hist}$. But since the computed price should mirror the observed,

$$\Pi\left(S_{e,j,b}, K_{e,j,b}, \tau_{e,j,b}, r_{e,b}, q_j, \sigma; N\right) = Q_{e,j,b}$$

we can find the value of σ^{hist} that minimizes the difference between the prices. This was done using Brent's method (a robust bracketing root-finder) where I defined a residual function

$$f(\sigma) = \Pi\left(S_{e,j,b}, K_{e,j,b}, \tau_{e,j,b}, r_{e,b}, q_j, \sigma; N\right) - Q_{e,j,b}$$

and searched for $\sigma \in [\sigma_{min}, \sigma_{max}]$, where $\sigma_{min} = 0.01$ to avoid division by zero in the tree, and $\sigma_{max} = 2.0$. Brent's method then iteratively checks to solve $f(\sigma) = 0$ and when repeated bar-by-bar for every timestamp, the inversion yields the historical impliedvolatility series $\{\sigma_{e,j,b}^{hist}\}$ for all companies and windows.

3.4 Forecasting Implied VOlatility via an AR(1) on Log-Differences with Countdown

Having extracted a high-frequency series of historical implied volatilities σ^{hist} at each ten-minute bar t, we now model the intraday movements of nonevent days to create a "baseline" of what volatility should move like on a normal day preceding the event. To ensure stationarity within the data, we work in log-volatility and focus on its first differences, as is commonly done in regressions.

(Andersen & Bollerslev, 1998)'s empirical study on the effectiveness of autoregressive models in forecasting volatility shows that implied volatilities are highly persistent and often well-approximated by simple autoregressive dynamics when expressed in logs, which is why we concretely let $\ell_t = \ln(\sigma_t)$ be the log of the observed implied vol at bar t. We form the differenced series

$$y_t = \Delta \ell_t = \ell_t - \ell_{t-1}, \qquad t = 2,3,\ldots,T,$$

which typically exhibits mean-reversion around zero. To capture the idea that volatility may drift in the run-up to the Fed decision, we introduce a countdown variable s_t, defined as the number of ten-minute bars remaining until the announcement.

We then posit the following AR(1) regression augmented by the linear countdown term:

$$y_t = c + \phi y_{t-1} + \beta\, s_t + \eta_t,$$

where

- c is the constant drift in $\Delta \ell_t$,
- ϕ (with $|\phi| < 1$) captures the persistence in log-vol changes,
- β measures the systematic trend in the run-up (or countdown) to the FOMC event,
- η_t is white noise ($E[\eta_t] = 0$, $Var(\eta_t) = \sigma_\eta^2$).

With the estimates bc, ϕ_b, β_b for all the days in a calibration window, an example can be seen in Appendix B, I aggregated the significant parameters to create the final estimators that will be used to forecast $\Delta \ell_t$ at $t + 1$ for the FOMC event days via

$$\widehat{y_t} = \widehat{c} + \widehat{\phi}\, y_{t-1} + \widehat{\beta}\, s_t$$

To create a volatility forecast for multiple windows I cumulatively summed the changes

$$\ln\sigma tmodel = \ln\sigma To + X\ ybk,\ k=T_o+1$$

where T_o is the last pre-event bar. Exponentiating the product of the summation results in the forecasted σ_t^{model}, which is then fed into the Leisen–Reimer trinomial lattice (section 3.3) to compute the theoretical price for every ten-minute interval after the event time.

4. Empirical Methodology

To be able to test our main hypothesis, me must define exactly how we are choosing to measure the difference between the events with a change in the rate and those with a constant rate. By measuring the deviation between observed option prices and our model via the following methods: Absolute Error (AE), Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE), we ensure a holistic approach to dissecting the truth out of the resutls. MAE and RMSE are standard in financial forecasting: RMSE penalises large errors more heavily, while MAE treats all deviations equally (Armstrong, 2001). Using both allows us to detect whether extreme mispricings dominate our sample. MAPE expresses errors relative to the option price, making the metric scale-free—facilitating comparisons across stocks with different price levels (Makridakis et al., 1998). Although MAPE can be unstable when prices approach zero, it remains widely used in forecast accuracy studies for its interpretability (Hyndman and Koehler, 2006). Taken together, AE/MAE/RMSE/MAPE provide a comprehensive view of pricing performance, capturing both absolute and relative error magnitudes. The tests branch out to explain two distinctive characteristics of the results, one focusing on how each individual stock reacted to the policy decision and a pooled normalized analysis to capture market-wide effects of the liquid S&P500 options we are using as a proxy for US equity option market.

4.1 Per-Ticker Analysis

Two-sample Welch's t-tests. To assess whether mispricing differs on days the Fed changes its policy rate versus holds it constant, we compare group means of MAE (and RMSE, MAPE) using Welch's unequal-variance t-test. Unlike the classic Student's ttest, Welch's procedure does not assume equal variances between groups, making it more reliable when one group is more volatile (Ruxton, 2006). Simulation studies confirm that Welch's test controls Type I error well even under heteroskedasticity and unequal sample sizes, while losing minimal power when variances are equal (Delacre et al., 2017). Given that FOMC "change" days may exhibit larger dispersion in pricing errors, Welch's test is the appropriate choice.
Per-ticker robust OLS regressions.

For each stock, we estimate

$$MAE_d = \alpha + \delta \, 1\{Change_d = 1\} + \varepsilon_d,$$

where d indexes each event. We compute heteroskedasticity-consistent (White) standard errors to ensure valid inference under unknown error variance (White, 1980). The financial time-series context often involves heteroskedasticity and non-normality; using robust OLS corrects for these issues without imposing strict distributional assumptions (Long and Ervin, 2000). By fitting each ticker separately, we allow for idiosyncratic sensitivities to FOMC news and avoid bias from imposing a common slope.

4.2 Pooled Analysis

Pooled z-score regression. To capture a market-wide effect, we standardise each ticker's AE series by subtracting its mean and dividing by its standard deviation, yielding

$$AE_{z,it} = \frac{AE_{it} - \bar{AE}_i}{s_{AE,i}}.$$

This z-score transformation removes scale differences across stocks, so each contributes equally to the pooled sample. We then estimate

$$AE_{z,it} = \alpha + \delta \, 1\{Change_t = 1\} + \varepsilon_{it}$$

with White-corrected standard errors. Normalising across firms and pooling increases statistical power and isolates the average "vol-crash overshoot" effect common to all tickers (MacKinlay, 1997).

To maintain a concrete level of robustness throughout the different tests we set a constraint on the event window. By focusing on a tight intraday window, for 10–60 minutes after an event, we aim to minimize the contamination from related news or other market factors. Additionally, to ensure no erroneous values from data glitched or anomalies invalidate the results an outlier screening process e.g. (MAE ¿ 10 or ¡ 10^{-4}) was set. Finally to ensure that the forecasted event is actually "going-nowhere", we test for negligible autocorrelation keeping into account ϕ, the strength of the autoregressive part of the AR(1), as suggested in (Campbell et al., 1997).

These choices align with best practices in forecasting and event-study research (Armstrong, 2001; Hyndman and Koehler, 2006; MacKinlay, 1997; White, 1980). Together, they ensure our findings on intraday option mispricing around FOMC announcements will be analysed from a variety of different perspectives to shine a statistically rigorous and economically meaningful light on the results from this test.

5. Results

The empirical tests assess whether the lattice-based "fair" price tracks market prices equally well on FOMC rate-change sessions and on no-change sessions, and critically whether any remaining pricing gap can be attributed to a short-lived volatility overshoot that the model, armed only with an AR(1) volatility forecast, does not anticipate. We first examine each underlying individually, then pool observations across names to gauge a market-wide effect, and finally explore how the mispricing evolves through the first hour after the policy release

5.1 Ticker-by-Ticker Evidence

Table ı reports the coefficient δ from the regression

$$MAEd = \alpha + \delta\ Changed + \varepsilon d,$$

where MAE is the absolute pricing error in the very first ten-minute interval after the announcement. A positive and significant δ indicates that the model systematically underor overprices the option by a larger margin when the Fed moves the target rate. The S&P500 ETF (SPY) emerges as the clearest most significant case: its mean absolute error rises by roughly $0.66 on move days (p = 0.013). That dollar surplus represents nearly three per cent of the average ATM premium, a sizeable divergence given the instrument's deep liquidity and tight bid–ask spread. Boeing (BA) and Microsoft (MSFT) also display positive, borderline-significant increments, whereas Amazon (AMZN) and Micron (MU) record negative or mixed signs. The flip-sign in AMZN, for instance, suggests that during policy moves the lattice in fact overpredicts the ATM price, hinting at an atypical compression of volatility or at a skew readjustment particular to large-cap technology names. Taken together, seven of twenty-two equities show |t| › 1.3, consistent with a heterogeneous but non-negligible cross-sectional response.

5.2 Pooled Evidence

Because price levels and option premia differ markedly across tickers, pooling raw dollar errors would give inordinate weight to high-priced names. We therefore z-score each bar's absolute error by that ticker's own mean and standard deviation, then re-estimate the simple regression

$$AE_{z,it} = \alpha + \delta\ I(Change_i = 1) + \varepsilon_{it},$$

separately for the first six post-announcement ten-minute bars (N = 1,...,6). The coefficient δ measures the average overshoot on rate-change days in σ-units, where σ is the within-ticker standard deviation of absolute errors. Results appear in Table 2:

Ticker	ΔMAE (pts)	SE	p-value
AAPL	0.275	0.247	0.266
AMD	–0.223	0.617	0.718
AMZN	–1.430	0.684	0.036
BA	0.226	0.121	0.061
BAC	–0.038	0.234	0.872
DIS	0.577	0.527	0.273
F	0.054	0.234	0.816
INTC	–0.031	0.030	0.304
JPM	–1.081	1.502	0.472
MSFT	0.132	0.080	0.100
MU	–0.661	0.292	0.023
NFLX	0.116	0.194	0.549
NVDA	–0.008	0.210	0.969
PFE	0.244	0.193	0.206
PYPL	0.290	0.460	0.529
SBUX	1.486	1.149	0.196
SPY	0.660	0.267	0.013
T	–0.048	0.142	0.737
TSLA	–0.160	0.551	0.772
UBER	–0.036	0.068	0.599
WMT	–0.016	0.182	0.929
XOM	–0.042	0.027	0.121

Table 1: Per-Ticker 1 bar ΔMAE from Linear Regression

across all six intervals δ is positive, between 0.16σ and 0.23σ, and highly significant (all $p < 0.001$ except the first bar, $p = 0.0092$). In other words, immediately after a policy move every underlying's ATM option is, on average, roughly one-fifth of a standard deviation farther away from the lattice price than it would be had the Fed stood pat—a pervasive, market-wide "vol-crash" overshoot.

The tight confidence bands confirm that the effect is not driven by a handful of illbehaved names but represents a broad, systematic response to monetary-policy surprises.

Ten-minute bar N	ΔAE_z (σ-units)	Robust s.e.	p-value
1	0.205	0.079	0.0092
2	0.229	0.059	9.8×10^{-5}
3	0.189	0.047	5.7×10^{-5}
4	0.159	0.042	1.4×10^{-4}
5	0.166	0.038	1.3×10^{-5}
6	0.160	0.035	5.7×10^{-6}

Table 2: Pooled z-score Regression Results by Ten-Minute Bar

Figure 1 visualises the market-wide overshoot through time. The solid line plots the ΔAE_z coefficient bar-by-bar; shaded bands give heteroskedasticity-robust 95% confidence intervals. Consistent with the raw regression output, the line leaps to ≈ 0.21σ in the very first ten-minute window, crests at 0.23σ one bar later, and then slides steadily toward 0.16σ by the end of the first hour. Overlaying the count of observations per bar (grey bars, right axis) confirms that the decay is not an artefact of dwindling sample size: liquidity quickly returns after the initial shock, yet mispricing remains elevated for at least forty minutes. The pattern echoes microstructure evidence that quoted depth evaporates for 5–15 minutes after macro news before refilling (Menkveld 2013, p. 734), while our AR(1) forecast captures the predictable mean-reversion in volatility so that the unexplained component shrinks monotonically once the surprise has been absorbed.

Figure 2 drills down to the cross-section. Each cell shows the ticker-specific ΔAE_z coefficient for a given bar, coloured by magnitude and annotated with significance stars (*** p ‹ 0.01; ** p ‹ 0.05; * p ‹ 0.10). Two broad themes emerge. First, the overshoot is pervasive: 17 of 22 names are red-shaded in the first bar and 14 remain so by bar 6, underscoring that the pooled result is not driven by a handful of idiosyncratic stocks. Second, heterogeneity is meaningful. SPY, the market-wide macro hedge, glows deepest red throughout, reinforcing the view that systematic vega demand overshoots fair value when the policy rate jumps.

In contrast, several mega-cap tech names (AMZN, NVDA) shift from light red to pale blue, signalling that their implied-volatility skews flatten more aggressively than the lattice anticipates, occasionally pushing the interpolated ATM price below model value.

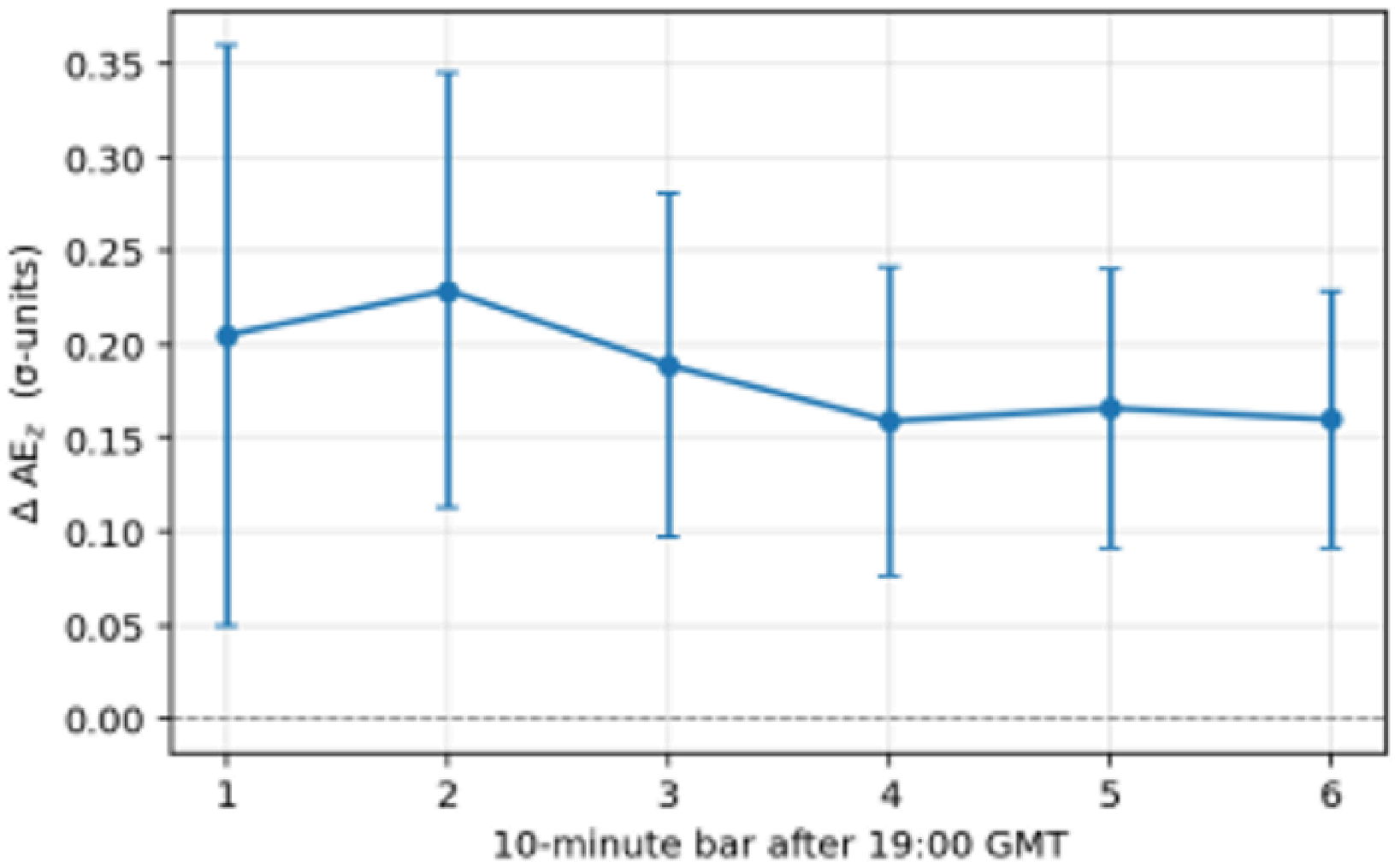

Figure 1: Market-wide "vol-crash" overshoot

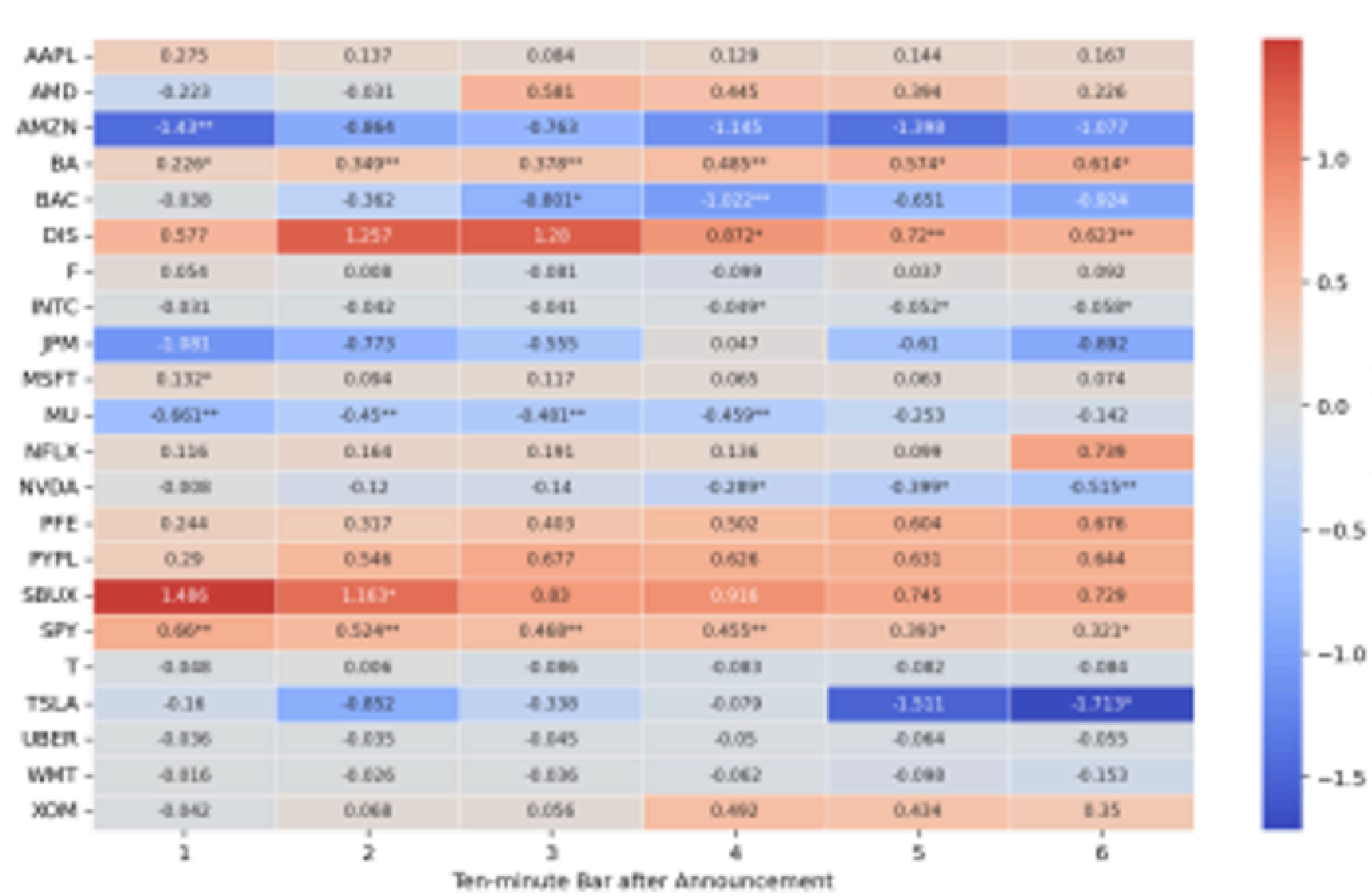

Figure 2: Change-day minus No-change mispricing ($_{\Delta}AE_z$) — Coefficient and Significance

Alternative error metrics corroborate, rather than overturn, these conclusions. Because RMSE merely squares the same deviations captured by MAE,(Appendix C) presents the results from the pooled welch test showing how the results are consistent across measures of error, identical sign patterns demonstrates how outliers are not driving the findings. MAPE compresses dollar errors by underlying price and flags only Microsoft as borderline significant, while the direction-of-move metric shows no systematic bias once magnitude information is discarded; both results emphasise that absolute mispricing, not directional misses, is the salient channel through which the post-FOMC "vol-crash" manifests.

Taken together, the results reveal a coherent narrative: an immediate, statistically significant inflation of ATM mispricing accompanies every surprise rate change, peaks within twenty minutes, and then halves over the next forty. The phenomenon is strongest in the most liquid macro proxy but remains visible across a broad equity set, with sector specific nuances that a single-factor volatility model cannot capture.

6. Discussion

Our empirical evidence shows that at-the-money (ATM) American call prices overshoot their "fair" lattice values by roughly 0.20 σ in the first ten-minute interval after the FOMC statement, with the gap peaking nearer 0.23 σ in the following bar and halving within the next half-hour. This high-frequency pattern dovetails with the broader literature that portrays scheduled macro announcements as brief, violent volatility shocks that are rapidly digested.(ChanGray,2018) document a similar spike-and-fade in realised volatility on futures markets, while (JohannesKaeckSeeger,2024) show that option-implied "event risk" in the SP 500 collapses within minutes once the policy path is disclosed. Our stocklevel results confirm that the phenomenon generalizes beyond index options and that American early-exercise considerations—explicitly captured by the trinomial lattice—do not prevent a transient mispricing.

Why does the market miss its own model so systematically in those first twenty minutes? One explanation is behavioural.

Traders update volatility expectations myopically, overweighting the announcement shock and extrapolating it into the near future; prices therefore overshoot and then mean-revert as cooler heads restore longer-run variance estimates, a mechanism anticipated by (Stein,1989) and corroborated by (Poteshman,2001) for implied-volatility responses to earnings news. At the same time, microstructure frictions exacerbate the gap. Liquidity typically evaporates just before and just after scheduled news, widening effective bid-ask spreads and suppressing quote depth (Yamada Ito,2020). (Hautsch et al,2010) decompose such episodes into “noise” and “efficient” volatility and find that the noise component briefly dominates—exactly the pattern our absolute-error spike captures. The fact that overshoots are largest for SPY, the most liquid instrument in our set, suggests that algorithmic hedging flows—dense precisely where liquidity is deepest—can amplify transient misalignments before arbitrage capital absorbs them.

Model incompleteness supplies a second, complementary channel. Our volatility forecast is deliberately parsimonious: an AR(1) on $_{\Delta}\ln\ _{\sigma}$ built from the fifteen preannouncement days. That simplicity is a virtue ex ante—it avoids the parameter proliferation of high-order GARCH or HAR specifications—but it also means that sudden jumps sit entirely in the forecast error. If volatility contains a discrete “event” component, as option-based studies of FOMC risk argue (Johannes et al,2024), then any model that treats $_{\sigma}$ as diffusive between bars will, by construction, under-predict the immediate surge and hence under-price the option. The residual we observe is therefore partly a model-miss factor, not solely a behavioural or liquidity effect. In principle a jump-diffusion or regime-switching volatility process (Bollerslev et al,2013) could shrink the error, but at the cost of additional estimation uncertainty. Our findings thus echo the older critique that Black–Scholes–family formulas, even when embedded in lattice form, accommodate steady volatility far better than abrupt information arrivals.

A third perspective recognizes that ATM implied vol is a forward-looking sentiment gauge. (Bauer et al,2021) show that policy statements materially reduce survey-based uncertainty about future rates, and VIX futures studies find a contemporaneous decline in expected variance once the Fed speaks (HuangTsaiYang2024).

That macro-level resolution must pass through individual equity options, especially at-the-money contracts where vega is highest. We therefore interpret the overshoot as an initial over-reaction in perceived uncertainty: the market prices a "knee-jerk" risk premium into vol, then trims it as the collective reading of the statement converges. The speed of the reversion—half-life of roughly 20 minutes—suggests that information processing is fast but not instantaneous, in line with limits-to-arbitrage theories. Capital and risk constraints can prevent arbitrageurs from leaning aggressively against the mispricing when volatility is itself elevated (Kumar et al,2014), allowing the error to persist just long enough to be measurable before competition restores efficiency.

Our cross-section further refines the picture. SPY displays the strongest overshoot, consistent with its role as a macro hedge; option dealers facing a deluge of index hedging orders may push vol higher than fundamentals justify. Single names such as MU and AMZN even show a negative Welch-test $_{\Delta}$MAE, hinting that idiosyncratic order flow or firm-specific news can offset the policy shock in thinly traded strikes. The literature on heterogeneous announcement effects—e.g. (Nofsinger Prucyk,2003) for volume asymmetries around scheduled releases—supports the notion that liquidity and investor clientele shape how quickly different symbols incorporate common information.

Naturally, our approach is not without weaknesses. The AR(1) forecast omits leverage and volatility-of-volatility effects; incorporating realised-vol measures or a GARCH-jump specification might narrow the residuals, though at the risk of overfitting short samples. We restrict attention to ATM calls, a novel approach in the literature, leaving the rich skew dynamics of out-of-the-money options unexplored; prior work shows that wings can embed different jump and tail-risk premia (Bates,1996). Finally, our ten-minute aggregation smooths micro-bursts of trading and in doing so reduces the market's noise but could also lead to the omission of pertinent minute-level information which, when analysed, could reveal even sharper mispricings—akin to those documented by (Hautsch etal,2010).

Taken together, the evidence indicates that option markets are largely efficient but not frictionless in the immediate aftermath of monetary-policy news.

Traders briefly overshoot implied volatility, models briefly under-predict it, and liquidity briefly thins—yet within half an hour the gap closes. These findings square well with behavioural overreaction theories, microstructure liquidity shocks, and the empirical literature on volatilityjump resolution. They also caution practitioners: hedges struck in the first twenty minutes after a Fed decision may embed a transient "vol-crash premium" that quickly melts away. For researchers, the results underline the value of high-frequency American-option data and point toward richer stochastic-volatility structures that endogenise event risk without sacrificing tractability.

7. Conclusion

This dissertation set out to answer a deceptively simple question: "Do US equity American options price the FOMC's decision "correctly" in real time?" By devising a rolling at-the-money framework that tracks each stock's spot price in real time, extracts intervalspecific implied volatilities with a Leisen–Reimer lattice, and forecasts them with a selective $\Delta \ln\sigma$ AR(1) model, a definitive response was found. Applying the pipeline to more than a million intraday option quotes across 42 FOMC meetings, we showed that policy-rate changes trigger a uniform "vol-crash overshoot": absolute pricing errors jump by roughly 0.20–0.23 standard deviations during the first 20 minutes after the statement before halving within the next three bars. Because the lattice already embeds the new discount rate, the residual error detected must stem from the mispriced volatility premium and liquidity strains rather than a mechanical repricing of cash-flows. The effect is strongest for SPY—the market's macro barometer—and, while milder, remains statistically visible in several single-name options, underscoring that even the deepest venues momentarily deviate from risk-neutral parity when monetary policy surprises arrive.

These findings position rolling-ATM mispricing as a high-frequency sentiment gauge for traders and policy watchers: a spike in the metric signals that option markets are demanding a short-lived volatility cushion above model values, offering cues for hedge timing and liquidity provision.

Nonetheless, the study is bounded by its focus on highly liquid tickers, a deliberately simple volatility forecast, and a single expiration per underlying per window. Future research can enrich the framework with machine-learning volatility engines, extend it to ultra-short-dated expiries, and explore whether analogous overshoots surface in put–call parity gaps or in less liquid corners of the market—sharpening our understanding of how information, behaviour, and microstructure interact in the minutes that define modern monetary policy communication.

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MANAGEMENT SECTION

INTRODUCTION

Power, profit, politics. When we speak of corporations today, these words often come to mind. From tech giants shaping digital life to multinationals controlling global supply chains, corporations appear inescapable. Yet their dominance is not unique to our time. The roots of corporate form stretch back centuries, to a company that blurred the boundaries between commerce and statecraft: the English East India Company (EIC).

This year's management section opens with the question: Was the EIC the origin of the modern corporation? The featured article explores this through social positioning theory, tracing how a trading venture evolved into a profit-driven corporate body with joint-stock ownership, limited liability, and legal personhood. In doing so, the Company not only pioneered structures still central to management today but also unleashed enduring challenges: monopoly power, weak accountability, and corporate excess. Crucially, it also reminds us that trade has never been neutral.

The EIC's very existence was defined by tariffs, trade disputes, and wars fought over economic dominance.

The comparison with today's corporations is hard to ignore. Like the EIC, global enterprises often operate beyond the full reach of regulators. Their ability to move capital, exploit tax structures, and shape political agendas sparks debate about whether corporations are serving society—or merely themselves. And as modern economies face tariff battles and escalating trade wars, the question becomes sharper: are corporations adapting responsibly to these pressures, or exploiting them in ways that echo the EIC's pursuit of profit at all costs?

Such historical parallels remind us that management is never just about efficiency or profit. It is also about ethics, responsibility, and power. Who should corporations be accountable to—shareholders, governments, or the wider public? Can sustainability and corporate social responsibility transform business priorities in an era of economic nationalism and rising protectionism, or are they simply a new language for old practices? These questions echo through boardrooms today, just as they shadowed the EIC's expansion across continents and its entanglement in trade conflicts.

Governance dilemmas further link past and present. The speculative bubbles that rocked the EIC recall modern financial crises, while its struggles with distant agents anticipate the challenges of managing sprawling multinational networks. Then as now, corporations wrestle with centralisation versus autonomy, risk versus accountability, profit versus principle. Tariffs and trade disputes only heighten these tensions, forcing managers to weigh short-term gains against long-term stability in uncertain economies.

Revisiting the East India Company, then, is not about romanticising or condemning a single enterprise. It is about recognising that corporations are social creations, products of their time but also shapers of society. The EIC's repositioning of the corporation as profit-seeking redefined what such organisations could be. Today's corporations may be on the cusp of another transformation, driven by technology, sustainability imperatives, and global trade conflicts.

The question is: what kind of corporations will emerge—and with what consequences for us all?

As you read this section, we invite you to reflect not only on the EIC's story but also on the pressing questions it raises for modern management: accountability, regulation, ethics, and the balance between private gain and public good. These challenges remain unresolved, but engaging with them is essential if management is to shape a corporate future that serves society, rather than undermines it.

Sıla Atabay

Management *Section Editor*

The English East India Company and the Origins of the Modern Corporation

Madeleine Dawson

1. Introduction

The role of the English East India Company (EIC) in the evolution of the modern corporation is a long-debated subject. Tony Lawson used social positioning theory to hypothesise that the EIC marked a change in the type of communities that become corporations. The argument that the EIC is the root of the modern corporation has important implications, as the EIC is thought to have pioneered joint-stock structures, limited liability, and global trade networks while also blurring the lines between commerce and government. Its monopoly power, corporate excess, and eventual collapse highlight key lessons in corporate ethics, regulation, and state interventions still relevant issues in today's economy. Lawson (2015) claims that the EIC was the first profit-oriented community to occupy the corporation position – we will explore the implications of his argument.

This paper examines whether it is accurate to understand the EIC as being at the root of the modern corporation. To do so, it is necessary to examine how the EIC became a corporation. This will be compared with the modern concept of the corporation, its similarities with the EIC and the implications and lessons for modern corporations.

2. Social Positioning Theory

2.1 Social Positioning Theory and Corporation

A corporation can be thought of as a significant mechanism of social change (Lawson, 2015: 125). It is defined as a legal fiction created when a community becomes positioned as a legal person, differentiating it from the firm (Lawson, 2015: 133). Legal fiction does not imply ontological fiction, which is when something does not exist at all; rather, it is a construct of law (Varzi, 2013).

This allows the corporation to access rights that should normally apply to an individual, such as the right to sue and be sued, enter into contracts, and own property (as distinct from being held by the corporation's members) (Lawson, 2015: 135). The corporation becomes a legal person through the creation of a corporate personality that is distinct from the individual members, shielding them from direct liabilities. Unlike ordinary firms, where individuals must hold the legal rights and obligations, the corporation can bear these directly. Actions attributed to the corporation are legally separated from those of individual shareholders, which can sometimes lead to the corporation taking greater risks. This separation is then extended to subsidiaries legally separate from the parent company, allowing for behaviour that the parent company would have deemed too risky.

Shares can be defined as a signifier of rights and are an artefact, an inanimate object organised by humans, representing a claim that an individual has to the corporation's profit or assets (Slade-Caffarel, 2024: 44). Shareholders have the right to dividends, to vote, and to transfer the ownership of their shares. Their obligations are limited by limited liability, meaning they are not responsible for any debts accrued by the firm beyond the value of their initial investment (Lawson, 2015: 105). The incorporation of shares allows corporations to operate autonomously while attracting investors (albeit the emergence of a class of "Activist Investors" runs contrary to this (Engelen, Konings and Fernandez, 2008)). This relationship creates conflict as shareholders expect to receive substantial dividends annually, whilst the corporation may wish to reinvest the profit.

There are limits to a corporation's liability. It is held that a corporation cannot perform any criminal acts that require intent, such as murder, as the corporation does not have a state of mind (Lawson, 2015: 141). Contradictorily, corporations may sue for defamation, and corporations have been gifted the right to freedom of expression (Lawson, 2015: 141). If found guilty of a crime, a corporation cannot be imprisoned or forced to perform community service; it can only be fined. As the shareholders cannot be liable for any fine, the modern corporation has every incentive to act irresponsibly. The legal rights associated with the corporation position give the positioned community significant power that will affect society.

2.2 Implications of the Corporation Position

Multinational corporations can arguably operate beyond the control of national regulators and tax authorities. This led to the argument that the modern corporation is out of control and could undermine democracies (c.f. Bakan, 2004; Korten, 2015; Lawson, 2015). This may be due to the gap between the corporation and its members, making accountability difficult to establish. Nader (2013) goes further and argues that the corporation is out of the control of its owners. Who the corporation's owners are is debated within the literature, as shareholders are not technically the corporation's owners, as the corporation owns all associated property (Ciepley, 2023). If it is difficult to identify the corporation's owners, then establishing fault or holding individuals accountable will be even more difficult. The corporation's structure facilitates centralised decision-making, often privileging shareholders over those of other stakeholders such as employees. The corporation's positioning as a legal person means that the continuity of the corporation is not dependent on the continuity of ownership. The corporation exists in perpetuity, independent of any changes in membership/ownership (Turnbull, 1998: 344). A corporation may be legally closed through a bureaucratic process and in the process, leave debts unsatisfied. Directors typically act on the assumption that their responsibility is to maximise shareholder value, and this serves to constrain their autonomy to act ethically.

Corporations can create subsidiaries through their positioning as legal persons. Each subsidiary has a separate legal status; however, their shares are owned by the parent company, ensuring control (Lawson, 2015: 140). Subsidiaries aid in the corporation's ability to operate as a transnational entity, and this enables corporations to act in a way that ordinary firms cannot. For example, Corporations can avoid tax liabilities by using transfer pricing and via subsidiaries in low-tax regions (Lawson, 2015: 126). Subsidiaries are considered legally separate entities due to a legal concept called the " corporate veil", by which the parent company is shielded from the liability of the subsidiary (Ottolenghi, 1990: 339). This veil will not normally be pierced to ensure justice, which may encourage risky behaviour (Ottolenghi, 1990: 350) in that the parent company may escape accountability when instructing subsidiaries to perform risky or illegal actions.

The modern corporation can use its global nature to take advantage of countries with more relaxed labour regulations. Corporations can outsource certain aspects of production to companies that will use morally unacceptable means, such as child labour, to keep costs low (LeBaron, 2014: 243). This leads to a layered and complicated structure, as vertically positioned subsidiaries or third-party firms avoid labour regulation, making accountability harder to establish. As the corporation itself is not performing this action, it can again escape the liability of any claims brought against it and feign ignorance. Lawson (2015) argues that the corporation is beyond the control of regulatory bodies, and many international corporations today operate with questionable labour practices and face no significant societal or legal consequences.

3. The English East India Company

3.1 The East India Company's Transition to a Corporation

The initial investment in the EIC was approximately £70,000, which was collected from 218 individuals and funded the voyages of the first four ships (Robins, 2015: 45). Initially, the EIC operated as a regulated company where members traded their capital for their dividends (Sivramkrishna, 2014: 798). This was inefficient and led to competition and fragmentation within the company; the EIC had to change its structure to succeed and compete. The Dutch East India Company (VOC) was the first limited-liability joint stock company in the world (Morck, 2007: 468). How the VOC gained this form was mirrored by the EIC, which became the first in England. This corporate model allowed for large-scale investment. The EIC used this to fund their military and the building of fortifications, reducing the company's profits (Sivramkrishna, 2014: 799). The company's dividends were often modest or non-existent in its early years and sometimes had to be boosted by borrowing (Sivramkrishna, 2014: 798). Profitability was undermined by high operating costs and by competition from interlopers and foreign rivals such as the VOC (Sivramkrishna, 2014: 802). By the mid-1620s, the EIC had accumulated significant debts due to military operations, which almost led to the closure of the company (Sivramkrishna, 2014: 800). The EIC was financially unstable during its early years. It thus focused on consolidating its monopoly power.

The EIC tried to trade only under its monopoly, although some private trading by employees also took place (Seth, 2012). The EIC's monopoly status was constantly under attack not only from other traders but from changing English heads of state (Sivramkrishna, 2014: 802). In 1618, the EIC argued against a charter granted by James I as it was in direct contravention of the EIC's charter (Sivramkrishna, 2014: 798). Consequently, James I granted the EIC a new charter to seize vessels and cargo from British and non-British subjects (Sivramkrishna, 2014: 798). Over time, the EIC expanded beyond trade and generated revenue from taxation in its territorial administration in India (Robins, 2015: 78).

Ciepley (2023) contrasts the early days of the EIC and of the VOC and argues that several nominal characteristics of the corporation go beyond legal personhood. In this view, Corporations such as the EIC and VOC were not just legal persons but governing bodies to which the state effectively relinquished aspects of its sovereignty (Ciepley, 2023: 853). The EIC was a monopoly corporation chartered by the Crown, whereas the VOC was more of a quasi-public enterprise, with closer integration into Dutch governmental structures (Ciepley, 2023: 862). The EIC eventually transitioned into direct governance over India, while the VOC remained more commercially focused (Ciepley, 2023: 865). The EIC's corporate powers allowed jurisdictional authority that mirrored that of political institutions (Ciepley, 2023: 853). This demonstrates that even when the corporation position allowed profit-oriented communities to become occupants, they were never purely economic actors and instead had deep political and legal implications.

Lawson (2015) argues that the EIC was not initially positioned as a corporation and that it gained this position through the use of illegal means by individuals. Before the EIC, the position of the corporation was not one of profit-making, but was rather occupied by churches and universities amongst other non-profit-seeking communities (Lawson, 2015: 137). The EIC did not gain this position through the Crown, government, or another legal route but through its members' activities. These activities included the amalgamation of stock, the formation of one partnership, and the transfer of the jointly owned stock to the company itself (Lawson, 2015: 138). The company transitioned from individual trading to a centralised collective structure.

The partners would then purchase a share in the joint stock of the EIC in return for a share of the profit. The EIC was one of the most prominent early adopters of the JSC model, which later rose in popularity in the mid-19th century and has since become the default for private enterprises (Ireland, 2018: 294).

Once the EIC had centralised its stock and begun to trade as a single entity, it became the first UK corporation to operate explicitly for profit (Lawson, 2015: 138). By distributing profits to shareholders based on their stock ownership, the EIC formalised the idea of profit-oriented corporations and laid the groundwork for future corporate practices. The EIC's legal status allowed the company to "plead and be impleaded", which effectively granted it a form of legal personhood, laying the foundations for corporate personhood (Stern, 2019: 77). Lawson (2015), argues that a corporation becomes such when a community becomes positioned as a legal person, and therefore, the EIC is the first profit-seeking community to become a corporation.

At the time of the EIC's change of position, profit-oriented communities were not corporations, so the EIC's movement in the position was "ultra vires", meaning beyond its legal powers (Lawson, 2015: 138). However, the EIC went unchallenged for another century, by which time the idea that the corporation position could be one used for profit was normal (Lawson, 2015: 138). From this time onward, profit-seeking enterprises became positioned as corporations. Being profit-oriented was beneficial for the shareholders and the state, as the EIC was a key player in England's economy and a significant contributor to state revenues through taxes. The Crown began issuing charters to other commercial entities, such as the Royal Africa Company, and they in turn became profit-oriented corporations (Lawson, 2015: 138). These charters conferred legal privileges like the EIC's charter, encouraged investment and reduced the risks to shareholders. The EIC thus legitimised the pursuit of private profit as a primary corporate goal. The evolution of the modern corporation has thus been shaped by a historical shift from corporations serving social purposes to prioritising profit maximisation (Davoudi, McKenna and Olegario, 2018).

In theory, rights and obligations of an entity are tied to its social position, and therefore, the EIC becoming an occupant of the corporation position should not have altered the rights and obligations of that position (Lawson, 2019: 110). However, it is clear that the rights and obligations of the Corporation position changed during the EIC's occupancy - this would suggest that the characteristics of the position itself changed. Once profit-oriented communities became corporations, the obligation to maximise shareholder value (and the associated legal fiduciary duty) was introduced. Lawson (2015) would argue that this is an ideology rather than an obligation; however, if a director does not prioritise shareholder interests, then they may be removed by the Board. This suggests that even if it is an ideology rather than an obligation, the need to act in the shareholders' best interests is strong and affects the actions of the directors. This seemingly replaced the obligation to serve the community and work towards the public good. Although with the introduction of Corporate Social Responsibility, this may be changing.

3.2 The English East India Company as a Quasi-Governmental Body

Talbot (2024) argues against the common historical narrative that the EIC is the root of the modern corporation. This argument is based on structural differences with the modern corporation. If this argument is to be believed, the EIC did not occupy the corporation position but rather that of a quasi-governmental body.

According to Talbot, the rights of the EIC's shareholders were indivisible from the company's assets (Talbot, 2024: 4). This does not reflect shares in the modern corporation, which are partitioned (Lawson, 2015: 135). The value of EIC shares depended on the state's military and political fortunes (and vice versa), whereas modern corporations are private entities, with some exceptions, and their shares represent independent financial rights. The EIC was hence inseparable from the English state, and not only did it owe its creation to the Crown, but it also became an extension of the state's colonial endeavours, which is not characteristic of modern corporations (Talbot, 2024: 19). Talbot (2024) argues that modern corporations emerged within developed capitalist systems, which were characterised by markets, a monetary system and wage labour.

According to this argument, the EIC operated in a pre-capitalist framework and accumulated wealth through state-supported looting and colonialism (Talbot, 2024: 4).

Talbot (2024) argues that the EIC's legal structure is significantly different from that of the modern corporation. The granting of legal rights and protection is key to Lawson's argument about how a profit-driven community became positioned as a corporation (Lawson, 2015). The EIC's establishment through a royal charter enabled it to function as a single legal entity, which maintained the collective character of its membership (Talbot, 2024: 6). He argues that the EIC's structure reflects the earlier organisation forms of guilds and other regulated companies rather than the modern corporate form. The pre-EIC corporation is significantly different from that of the modern corporation, both in terms of membership and legal positioning. EIC members retained significant personal connections to the organisation, and the charter emphasised collective rights, as is the case with medieval corporations (Mansell and Sison, 2020; Talbot, 2024: 8). The EIC was conceived as a trust, which would allow its assets to be held by the corporation and an equitable interest held by its members (Talbot, 2024: 9). Shareholders were entitled to profits that were proportional to their investment but did not possess distinct property rights (Talbot, 2024: 3). Shares were shaped by rights granted by the state, such as the monopoly. These rights were not static and could be taken away from the company by the state as easily as granted. The state also granted sovereign powers such as the ability to mint coins and wage wars (Talbot, 2024: 12). The founding charter had granted the EIC the right to "wage war", which the EIC had utilised during their very first voyage when they seized a Portuguese trading ship (Dalrymple, 2019: xxiv). This integration with the state has blurred the line between the corporation and the sovereign authority. The lack of separation between shareholder interests and state objectives created an ambiguous legal identity.

Stern (2016) describes the EIC as being more than just the embryo of the modern corporation due to the combination of public and private rights. He argues that private rights, such as the right to own property, combined with public sovereign powers like war and diplomacy, allow the EIC to operate as a business entity and a governing authority (Stern, 2016: 433).

This aligns it more with a modern multinational corporation than a typical trading company (Stern, 2016: 432). Stern (2016) does not definitively state that there is a linear progression from the EIC to the modern corporation and instead focuses on the difficulty of drawing this conclusion, yet he acknowledges the strength of this argument.

However, his argument disagrees with Talbot (2024), who argues that the quasi-governmental nature of the EIC stops it from being the origin of the modern corporation. Ciepley (2023) presents an analysis of corporations, arguing that they are governmental entities rather than private contractual agreements. Therefore, the EIC's quasi-governmental nature has no impact on whether it is viewed as a corporation or not; instead, it demonstrates the changing corporation position.

Lawson (2015) argues that the modern corporation is out of control due to the associated rights of limited liability and corporate personality. Modern corporations use subsidiaries to avoid tax regulations and to take advantage of limited labour regulations in certain countries (Lawson, 2015: 126). As Talbot (2024) argued that the international aspect of the EIC plays a large part in whether the EIC should be classified as a corporation or a quasi-governmental community. However, the role that the EIC played internationally does appear to reflect modern-day practices. The EIC strategically operated in regions where it could secure favourable terms, which often involved negotiating with local rulers to exploit political divisions and establishing its own political and military control, providing favourable conditions as well as tax breaks (Robins, 2015: 38). Whilst modern corporations do not establish military control, they do seek countries with lower tax rates and less stringent regulations (Lawson, 2015: 126). The EIC's primary goal was to extract resources and maximise profits using local labour, which may have involved coercive means (Chaudhuri, 1968: 484). Modern corporations are often criticised for exploiting cheap labour in developing countries and prioritising profit over ethical considerations (Monshipouri, Welch and Kennedy, 2003: 967). Through these similarities, the EIC does appear to be the root of the modern corporation.

Talbot (2024) argues that the modern corporation arose from private, unincorporated organisations regulated by 19th-century company law.

However, the rights and obligations associated with the corporation position changed with the EIC's positioning as a corporation. Therefore, the rights and obligations that allow the corporation to act as it does today are due to the EIC, suggesting that not only is the EIC the root of the modern corporation, but it fundamentally altered the corporation position from what had come before.

3.3 The Root of the Modern Corporation

The EIC was one of the first entities to operate on a truly global scale as it established trade networks spanning continents (Robins, 2015: 5). This multinationalism prefigures the international reach of modern corporations, which similarly rely on interconnected markets. The EIC was granted a monopoly over British trade in Asia, which was used to eliminate competition and control vast markets (Robins, 2015: 5). The EIC established significant market power, setting a precedent for future corporations. This influence extended to labour markets due to the EIC's reliance on local and global labour forces (Robins, 2015: 23, 179). It shaped cultural exchanges and consumption patterns by introducing tea, spices, and textiles to the British market, much like how global corporations shape cultural trends today (Robins, 2015: xii). This global reach meant the company had to navigate multiple legal jurisdictions and exercise governance in colonial territories (Stern, 2016: 438). Similarly, the EIC played a significant role in British politics (Stern, 2017a: 123). Its activities also influenced the development of the military-fiscal state and, therefore, have an impactful role in the history of British state formation (Stern, 2009: 1152). While modern corporations do not directly wield political power, they exert significant influence through lobbying, campaign financing, and public-private partnerships (Wilks, 2013). By creating new legal frameworks, the EIC has contributed to the evolution of the corporate form. The EIC tightly controlled its supply chains for key commodities through coercion or force (Tran, 2021: 369). Modern corporations achieve similar control through contracts and vertical integration (Ursino, 2015). The company's legacy is its commercial activities as well as its governance and social responsibilities. It was an international actor distinct from other companies of its time, further strengthening the argument that the EIC was the origin of the modern corporation.

As discussed previously, the EIC introduced the joint-stock company model to England, Shareholders were not involved in the day-to-day operations, allowing the managers to oversee operations. Today, corporate boards and executives handle the business operations and strategy, while shareholders remain passive investors (Tosi, Gomez-Mejia and Moody, 1991).

Shares of the EIC were traded in secondary markets, leading to financial separation and booms, just as modern corporations are central to financial markets and are subject to speculative investment (Robins, 2015: 90). Scandals related to corruption and financial instability plagued the EIC, prompting public backlash and government intervention, such as the Regulating Act of 1773 (Robins, 2015: 111). The Bengal Bubble, a financial crisis in 1769 caused by the overvaluation of the company's stock, exposed the EIC's mismanagement (Robins, 2015: 108). Modern corporations face similar issues, leading to regulatory frameworks like antitrust laws and ESG initiatives (de la Cruz and Miller, 2024). The EIC prioritised shareholder returns, focusing on maximising profits through monopolies and territorial expansion (Roukis, 2004: 945). While limited liability was not formally codified during EIC's time, its joint-stock structure limited individual shareholder liability, a precursor to modern limited liability laws (Stern, 2015: 428). Therefore, the groundwork was laid for the administrative process of incorporation that would be codified in the 19th century (Stern, 2015: 432).

The EIC had a governance structure consisting of a Board of Directors in London, which oversaw operations and delegated authority across the regions (Buchan, 2024: 54). The internal governance practices, such as shareholder meetings and voting rights, have influenced corporate law development (Buchan, 2024). Significant autonomy was granted to the local officials, such as the governors in India, despite the central office making any strategic decisions (Smith, 2022: 246). These hierarchical decision-making systems are found in modern corporations today, and the balance between central oversight and local decision-making is an aspect of modern management (Williamson, 1981: 1561). The EIC's structure demonstrated the challenges of managing these global trade networks, such as making decisions across vast distances and dealing with principal-agent problems (Stern, 2016: 430).

These challenges required adaptations to its governance practices, which may resonate with the issues that are faced by modern corporations.

The EIC stands as a crucial link in the evolution of the modern corporation. Its innovations in governance, finance, and global operations, along with its profit-driven behaviour and political influence, shaped the legal and economic frameworks that underpin corporate capitalism today. While its methods and excesses led to critiques and regulatory reforms, the EIC's legacy continues to resonate in the structure of contemporary multinational corporations.

4. The Corporation's Legal Continuity

The legal continuity and evolution of corporate personality and limited liability demonstrate how the corporation has transformed while maintaining core features. The concept of corporate personality can be traced back to medieval times when corporations were seen as legal entities distinct from their members (Mansell and Sison, 2020: 583). These entities could own property and enter into contracts separate from their members (Mansell and Sison, 2020: 583). With the rise of colonial and trade corporations, corporate personality took on a new dimension. These corporations began to assert legal rights akin to individuals, and the idea of the corporation as an artificial legal person became entrenched (Stern, 2017: 25). This concept drew on the medieval legal concepts, inspired by Roman law, and expanded on them to justify profit-driven activities (Stern, 2017: 22; Mansell and Sison, 2020: 582).

By the 19th century, corporate personality had further evolved to serve private enterprise needs. Courts upheld the corporation's distinct legal identity in *Salomon v A Salomon & Co* (1897), ensuring continuity and insulating investors and directors from liabilities (Lawson, 2015: 139). Limited liability similarly saw a gradual shift as in medieval corporations; members often shared collective responsibility for work, obligation and common purpose (Mansell and Sison, 2020: 591, 592). Like the modern corporation, medieval corporations kept their assets and liabilities separate from those of their members, but this was not formally codified (Mansell and Sison, 2020: 592).

The early modern period saw a gradual shift towards the formalisation of limited investor liability, particularly with the formation of JSCs like the EIC, in an attempt to attract broader investment (Stern, 2017: 30). In this form, investors contributed capital but were not fully liable for the company's actions. This concept was formalised in statutes such as the Joint Stock Companies Act of 1844 and 1856, which legally separated shareholders from corporate debts (Stern, 2017: 30, 31).

Lawson (2015) argues that the corporation position has remained relatively stable, other than when the EIC positioned itself as the first profit-driven enterprise, with any changes being the occupants rather than the position. One could argue that despite legal changes, the corporation's fundamental role as a collective entity with legal standing, whether for profit or charity, has remained intact. From medieval churches to modern multinational corporations, they have continuously been recognised as entities that are (to different extents) separate from their members. The core legal principles of corporate personality have remained consistent. This demonstrates that the legal rights associated with the corporation position have remained consistent, and when the EIC became a corporation, it took advantage of these. The function and societal role of the corporation have evolved from one focused on community to the profit-driven form of today. Therefore, the EIC became the first corporation to disregard societal obligations, replacing them with obligations to shareholders, and altering the corporation position.

Conclusion

This paper has demonstrated that the corporation position was stable before the existence of the EIC. The EIC was positioned as a corporation, gaining rights, such as those typically reserved for governments, but with different obligations. The EIC was profit-oriented and acted for shareholders rather than for the public good, which was the previous obligation of the corporation. Through the EIC's global expansion, it became a quasi-governmental entity, gaining rights not intended for corporations, especially not-for-profit corporations. This suggests, using social positioning theory, that the corporation position fundamentally changed when the EIC illegally positioned itself as such.

The rights and obligations associated with the corporation have been fundamentally altered, and the corporation's role within society has changed to reflect this. It does not seem likely, even with corporate social responsibility, that the corporation could revert to the corporation before the EIC, without significant changes.

Following the EIC's change in position, there was no immediate regulatory backlash. When regulatory changes were introduced a century later, they attempted to control the EIC's action as it gained more power and influence; however, by then, the corporation position being occupied by for-profit communities had been accepted. Social positioning theory posits that positions are community-relevant, and as a society accepted the EIC as a corporation, the position changed. This would suggest a significant shift in the history of the corporation, whether this is significant when it comes to the modern corporation depends on whether the legacy of the EIC is visible today. Many of the challenges faced by the EIC are still relevant today, including speculative investment and scandals relating to corruption, which are then addressed by the regulatory framework. The EIC's structure, a joint-stock model, is prevalent today, as well as its hierarchical structure and financial innovations. A similarity between the two forms of the corporation is that they are profit-driven, which, whether it was inevitable due to society embracing capitalism or not, was because of the EIC's actions. Therefore, the EIC is the root of the modern corporation, and it can offer a legacy that provides the modern corporation with lessons and guidance.

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POLITICAL ECONOMY

SECTION INTRODUCTION

Political economy continues to sit at the heart of global debate, and this year has underlined its significance in shaping both domestic and international developments. The tensions of 2025 have made clear that economics cannot be studied in isolation from politics. Trade policies, security concerns, and financial markets are deeply interlinked, and the ripple effects of decisions in one arena are quickly felt across the other. As editors, we see this section as a space to bring together contributions that reflect the complexity of these dynamics and to give readers the opportunity to engage with the ideas that lie behind current events.

The essays included here approach political economy from different but complementary angles. Together, they show how the discipline can offer insight into the competing priorities of states and markets, the challenges of global interdependence, and the behavioural shifts that arise during times of uncertainty. In doing so, they move beyond simple commentary on events and instead provide a framework for understanding the forces that continue to shape our world.

Our role as editors is not only to present these arguments but also to highlight their relevance. Political economy is not just an academic pursuit; it informs decisions that affect trade, growth, and the choices available to households and firms. By reading this section, our audience will come away with a stronger appreciation of how theory and practice intersect and why careful reflection on these issues is essential in the current climate.

Politics and economy go hand in hand. This is especially important in the period of interconnectedness and co-reliance between countries that we currently live in. 2025 has been An incredibly unstable year for the political economy, with geopolitical tensions in Europe continuing to rise due to wars. Furthermore, the implementation of tariffs by the United States caused not only political tensions to rise but also great economic instability with JP Morgan signalling a 60% chance of entering a recession, which has since been reduced to 40% due to the underlying "material headwinds" of tariff implementation.

In the UK, the tariffs has caused a 13.5% decrease of trade with the US compared to the same period last year. The British Chambers of Commerce has referred to the consequence as "the lowest UK exports to the US since the Coronavirus pandemic".

As we think about these events, it's clear that the point where politics and economics meet is no longer just an idea; it affects markets, policies, and people's daily lives. In a world where economic decisions affect politics and politics affect economic choices, it is important to understand these dynamics. By looking into these topics, we hope that readers not only gain new perspectives but also a renewed desire to question, examine, and interact with the forces that shape the global economy today.

Wei Chek & Eshita Soni
Political Economy Section Editors

To what extent have the German mainstream centre-right and far-right parties converged or diverged in their political discourse on X (formerly Twitter) across the federal elections of 2017 and 2025?

Aylina de la Mano Markau

Introduction

In recent years, the European political landscape has witnessed a significant rise in far-right ideas (Green, 2024). The Alternative für Deutschland (AfD) is the national party exemplar of this movement in Germany. AfD advocates for strict immigration controls and national sovereignty, shows pro-Russia tendencies, and is sceptical of climate policies and the European Union (EU). The party was established in 2013 and is now the second-largest party in parliament after the Christian Democratic Union (CDU) (Statista Research Department, 2024). The CDU has publicly declared that it will not cooperate with the AfD's aggressive and uncompromising position on immigration and refugees, which evokes Nazi rhetoric (Chase & Goldenberg, 2019).

However, the CDU has to adapt to the voters to remain popular. Thus, CDU has shifted further to the right in an effort to regain voters, particularly by adopting a harder line on immigration (Krause, Cohen, & Abou-Chadi, 2022). This shift signals convergence between the centre-right and far-right on this policy issue. A similar pattern may also be emerging in political discourse more broadly. In this way, ideas, rhetoric or policies that were once considered fringe or radical can become accepted and normalised as they are adopted by mainstream parties (a phenomenon referred to in the literature as mainstreaming). This could pose deeper challenges to the integrity of democracies.

The purpose of this essay is to determine whether the political discourse of the German mainstream centre-right party CDU and the far-right party AfD on X (formerly Twitter) has converged or diverged over time. The time periods chosen are two election years: 2017 and 2025.

It is important to clarify from the outset that 'political discourse', as used in this study, encompasses rhetorical strategies as well as the policy issues parties discuss or Twitter elements such as hashtags (being more content-based).

Literature Review

The far-right and moderate right differ widely. Pirro (2022) argues that the far-right is anti-individualist and anti-pluralist. This means that neither individuals' interests nor rights supersede ethno-national communities. A comparative analysis of 26 far-right definitions identifies the most repeated elements of far-right organisations as nationalism, racism, xenophobia, anti-democracy, and defence of the strong state (Mudde, 1995, p. 206). In the case of the AfD, it would be plausible to argue that they have embraced some of these tendencies, particularly in their agenda and rhetoric. For example, Alice Weidel (current AfD party leader) openly displayed xenophobia when she stated in the German parliament, "burqas, headscarf girls, publicly supported knife men, and other good-for-nothings will not secure our prosperity, economic growth and the social state" (Hallam, 2024).

In contrast, the moderate right endorses the rule of law, individual rights and checks and balances (Pirro, 2022, pp. 104-105). In the German party system, CDU and FDP occupy the moderate right (Gordon, 1995, p. 265). The CDU, the party of choice in this research, is a centre-right party that supports a free-market economy and social welfare programmes while remaining conservative on social issues. CDU is widely accepted as a mainstream party, but what makes a party mainstream differs between authors. There are various ways to define mainstream parties (see (Meguid, 2005, p. 348); (Pop-Eleches, 2010); (Kallis, 2013, p. 226)). Insightfully, Brown, Mondon and Winter (2023) identify two key points: (i) the mainstream is constructed, contingent and fluid, and (ii) the mainstream is not essentially good, rational or moderate. These characteristics are important for this research to avoid falling into the trap of an uncritical reification of an essentially good and static mainstream against the far-right (Brown, Mondon, & Winter, 2023, p. 166). In the case of the CDU, the party has shifted repeatedly over time: most Germans recall the lack of consensus around Merkel's 2015 refugee open-door policy.

In line with this, mainstreaming is a process by which political actors, discourses and/or attitudes move from marginal positions on the political spectrum or public sphere to more central ones, shifting what is deemed to be acceptable or legitimate in politics, media and public circles (Brown, Mondon, & Winter, 2023, p. 170). Applied to the present case, mainstreaming would require AfD attitudes and strategies to move from a marginal position on the right spectrum to a more central and legitimate one. The shift in political actors, discourses, or attitudes can come from both directions: through the mainstream party, CDU, adopting elements or strategies of the AfD or through AfD adopting CDU strategies. At the same time, one shift in dimension does not entail shifts in others (Brown, Mondon, & Winter, 2023, p. 170). Crucially, mainstreaming suggests convergence, as it implies a process whereby both parties move closer together and become more similar in their positions, policies and speech.

Van Dijk (1997, pp. 12-14), defines political discourse as a political actor carrying out a political action (e.g. to govern, legislate, protest or vote) in an institutional context of communication (e.g. parliamentary debates, public speeches, official addresses). However, this approach excludes other possibly relevant forms of discourse, such as media discourse on political issues (Randour, Perrez, & Reuchamps, 2020). In this essay, I use Van Dijk's definition with Chilton and Schäffner's adjustments. For them, the concept of political discourse can be interpreted narrowly as institutional communication but can also be broader and refer to any form of power negotiation across various contexts (Randour, Perrez, & Reuchamps, 2020, p. 429). My focus will be on political media discourse by party leaders before elections, retaining the 'political actor' and 'action' elements but examining the less institutionalised context of social media (Fairclough & Fairclough, 2012, p. 18).

Social media is of interest for various reasons. Most significantly, it serves as a novel platform for political activity, albeit often distancing itself from formal political procedures and simplifying politics into brief slogans (Wodak, 2015, p. 11). Solovev and Pröllochs (2022, p. 3656) identified three principal advantages of social media: it increases message dissemination, fosters communication between politicians and users, and facilitates extensive political mobilisation irrespective of geographic, scope or content limitations.

Twitter specifically functions as a 'public arena' where political discussions are prominently visible and prompt, mirroring the concerns and debates of political actors (Fuchs, 2014).

The literature on political media discourse indicates significant differences between far-right and mainstream parties in their use of social media. Far-right parties achieve considerable success by effectively utilising media agendas, framing, and communication (Forchtner, Krzyżanowski, & Wodak, 2013). Their discourse typically includes challenging the establishment and referencing in- or out-groups (Haßler, Wurst, & Schlosser, 2021) or, according to Pelinka, 'looking for a culprit', someone to hold (unfairly) responsible from above or abroad (Wodak, 2015, pp. 3-4). In contrast, mainstream programmes and content are often criticised for inefficient communication and poor presentation through the media (Wodak, 2015, p. 12).

Methodology

This research aims to compare the political discourse of the AfD and CDU on X before the elections. To achieve this, I independently collected X posts, providing a stable corpus of textual data that can be systematically analysed. While the texts are fixed and observable, their interpretation is inherently subjective. This duality makes them well-suited for a mixed-methods approach. Through this approach, once the tweets have been collected, a qualitative analysis is conducted to interpret meaning and identify discourse strategies as outlined in a codebook. Then, these categories are quantified and assessed for frequency and distribution across the dataset.

Various criteria were paramount in selecting the corpus for this study. First, as advanced in the introduction, the two federal elections selected are the election of the 24th of September 2017, and the election of the 25th of February 2025. The former was chosen because it marks the first time AfD entered the German parliament.

The latter is relevant due to the party's improved electoral success and recency, thereby underscoring the contemporary relevance of this research. Second, X-accounts were chosen based on two criteria: the X-account had to (i) belong to a party leader holding the role of chair or co-chair at the national level, and (ii) required a reasonable level of activity on X, measured by a time-varying follower count reported from the 1st of March 2025. I focused on individual party leaders' accounts because the AfD's general party account had no available posts for the 2017 elections, making a cross-party comparison of accounts for that year impossible. Moreover, this study examines two periods with different degrees of X's prominence as a social media platform. Selecting tweets based on likes or retweets would be problematic.

In the case of the AfD, both during the federal elections of 2017 and 2025, the party was led by co-chairs. In 2017, the AfD was led by Frauke Petry and Jörg Meuthen. I selected Petry's account, as she assumed leadership earlier (Franzmann, 2017) and had a slightly higher number of followers (85,000 vs. 80,000). In 2025, Alice Weidel and Tino Chrupalla co-chaired the party, but Weidel's account was used due to a significantly greater follower gap (1.1 million vs 187,000 followers). For the CDU, Friedrich Merz was the party leader in 2025, and his account (496,400 followers) was selected. The situation is more complex for the 2017 federal election, as Angela Merkel did not have a Twitter account. However, her spokesperson, Steffen Seibert, tweeted on Merkel's behalf (Schultheis, 2019). Thus, I used archives from his account (900,000 followers), always aware not to talk about Merkel's discourse, but always 'Seibert in the representation of Merkel'.

To collect X-posts from each account in the appropriate time frame, I used Twitter's advanced search function (e.g., posts from the account @FraukePetry between 24/8/2017 and 24/9/2017). Then, I used the browser extension Zeeschuimer to scrape all the available tweets and convert them into an Excel file. To ensure the reliability of this method, I randomly selected posts and verified that the Zeeschuimer dataset accurately reflected the correct number of retweets, hashtags, and others. Then, I transported the relevant tweets and characteristics to my own Excel sheet. Tweets were deemed irrelevant if they responded to another tweet or required additional context, such as watching a video.

The result was 296 tweets for coding. See Table 1 below for an overview of the distribution of posts across accounts and election years. I used DeepL to translate all posts. Next, I manually coded for various (sub-)categories as outlined in a codebook (see Table 2). This method is preferable to automatic coding with software because it presents a deeper level of nuance and specificity. From then on, the results derived from the comparative longitudinal qualitative analysis were illustrated through numerical tables and graphs. But for this essay's purpose, I will only highlight the key findings (next section).

PARTY & ELECTION YEAR	PARTY LEADER	NUMBER OF POSTS/TWEETS
AfD - 2017	Frauke Petry	73
AfD - 2025	Alice Weidel	78
CDU - 2017	Steffen Seibert (representing Angela Merkel)	53
CDU - 2025	Friedrich Merz	92
		SUM= 296

Table 1: Number of X posts collected by party leader in each election year

Table 2: Codebook

CATEGORY	SUBCATEGORY	DESCRIPTION
Policy Issue	Immigration	X-posts refer to a migratory flow of immigrants, refugees, or foreign nationals seeking entry or citizenship. They may highlight migration overload, policy failures, or crimes linked to immigrants.
	Economy	X-posts address Germany's economic situation, including taxes, inflation, growth, EU membership/involvement, climate policy, and education, as they are all linked to the country's financial stability.
	Security	X-posts on the state's actions to ensure security, including military strength, crime reduction, poverty alleviation, and foreign policy or international politics more broadly, such as the Ukraine conflict.
	None	X-posts that do not directly or indirectly relate to any of the above. This category highlights the absence of a clear 'Policy Issue'.
Legitimation strategies	Authorisation	Authorisation is legitimation by referring to authority, be that a person, tradition, custom or law.
	Rationalisation	Rationalisation is legitimation by reference to knowledge claims or arguments. This form of legitimation is often apparent through the use of scientific or statistical data.
	Moral evaluation	Moral evaluation means legitimation by reference to value systems or ideologies.
	Mythopoesis	Mythopoesis is legitimation achieved by narratives, often small stories, anecdotes or fragments of narrative structures about the past or future.

General discourse strategies	Party promotion	Party promotion involves encouraging votes for a specific party or endorsing its leader. It may highlight interviews, proposals, or similar content. Importantly, the promotion appears directly in the message, not just through hashtags.
	Metaphors	A metaphor is a figure of speech that, for rhetorical effect, directly refers to one thing by mentioning another.
	Loaded language	Loaded language refers to strongly connotative words or phrases that shape perception. For example, when talking about protestors, you can call them "rioters" (negative) or "freedom fighters" (positive).
	Emotional appeal	Emotional appeal targets the audience's emotions, such as fear, pride, anger, or guilt. Positive emotions may be evoked through references to children or the elderly, appealing to a nurturing instinct, or exaggerated praise between politicians. Negative emotions may involve urgency via exclamation marks and words like "danger" or the use of irony, ridicule, or mockery.
	Delegitimation	Delegitimation seeks to undermine the credibility, authority, or legitimacy of a person, institution, or system, often portraying them as corrupt, morally wrong, incompetent, or untrustworthy.
Populist discourse strategies	Challenging establishment	Challenging establishment occurs when a political actor opposes established institutions, norms, or systems, such as the government or the EU. Unlike blaming, it critiques structures rather than individuals. It is common during elections as parties compete for power.
	Reference to People	Reference to people involves mentioning individuals or groups within the German community, often using general terms like "us" (the Germans) to emphasise the in-group.
	Othering	Othering makes the out-group explicit. It references a dangerous other, such as an ethnical group. It is often used in immigration speech, but can also be a way to distinguish yourself from less able people.
	Scapegoating	Scapegoating is a form of blaming in which a group or individual is unfairly made to bear responsibility for broader problems. It must be directed at someone in a clear way.
Twitter-specific messaging enhancements	Videos	X-posts include an explanatory video, a recording of a political debate or interview and similar.
	Images	X-posts include an image, such as a campaign advertisement.
	Hashtags	X-posts include hashtags (a word preceded by the sign #) to categorise content.
	Emojis	X-posts include emojis such as hearts or German flags.

**(if an X-post presents two subcategories use the one that is most predominant)*

Each of the categories yields a sub-hypothesis that is occasionally supported by previous literature (see Table 3). All five hypotheses (one for each category) can be summarised via an umbrella hypothesis:

- *H1: The political discourses of CDU and AfD on X exhibit greater convergence than divergence in 2025 than in 2017*

Category	Sub-hypothesis
Policy issue	H1a: The policy issues discussed by CDU and AfD party leaders are overall more similar in 2025 than in 2017
Legitimation strategies	H1b: The legitimation strategies used by CDU and AfD party leaders are overall more similar in 2025 than in 2017
General discourse strategies	H1c: The discursive strategies used by CDU and AfD party leaders are overall more similar in 2025 than in 2017
Populist discourse strategies	H1d: The populist discourse strategies initially adopted by AfD have gradually and increasingly been also adopted by CDU between 2017 and 2025
Twitter-specific messaging enhancements	H1e: CDU and AfD party leaders converge in the usage of Twitter-specific messaging enhancements between 2017 and 2025

Table 3: Sub-hypothesis for each category

Discussion of Results

This study set out to investigate whether the political discourse of the German mainstream (CDU) and far-right (AfD) parties converged or diverged between the elections of 2017 and 2025. The analysis of the tweets confirms the umbrella hypothesis (H1): that the CDU and AfD converged more than they diverged. As shown in Table 4, most subcategories presented convergence between 2017 and 2025. Specifically, 16 out of 22 subcategories exhibited either moderate or significant convergence. Moreover, the data supported all sub-hypotheses except for H1a. H1b and H1d were substantiated across all subcategories, while H1c and H1e exhibited some divergence but were nonetheless partially supported, as the majority of subcategories within showed convergence.

Subcategories that converge significantly	Subcategories that converge moderately	Subcategories that diverge significantly	Subcategories that diverge moderately
No Policy Issue	Security	Immigration	Economy
Authorisation	Rationalisation	Loaded language	No Legitimation Strategy
Moral Evaluation	Party Promotion		Metaphors
Mythopoesis	Challenging establishment		Videos
Emotional appeal	Scapegoating		
Delegitimation	Hashtags		
Othering	Emojis		
Reference to people			
Images			

**A subcategory changes "moderately" when the convergence/divergence comes only from one side or when the change is a very low proportion (between 1-8% points).*

Table 4: Distribution of subcategories between significant and moderate convergence or divergence*

As a result, the main outlier in my results occurs in the category of policy issues. This is due to a significant divergence in Immigration and Economy. The former contradicts Spanje (2010), May & Czymara (2024) and Downes & Loveless (2018), who argued that mainstream parties adopt anti-immigrant positions to regain voters. It is possible that this strategy occurred only temporarily between 2015 and 2018, as proposed by Downes (2020). If this were the case, the present study would not have detected it. Moreover, it can be speculated that the mainstream party adopted more anti-immigrant policies, as Perlmutter (retrieved from Spanje (2010)) suggests they would have regardless of far-right activity, but chose not to discuss them on Twitter or in the days leading up to the election. Regarding the latter, Bardi (2022) noted that Peter Mair observed convergence between mainstream left and right parties on economic interests. However, it remained unclear whether far-right parties engaged with economic issues in the same voter-oriented way as with Immigration (Franzmann, 2017). My findings show that AfD slightly decreased its frequency of economic discourse while CDU increased it.

Moreover, I want to comment on the other cases of divergence. Loaded language was equally employed by mainstream and far-right parties in 2017. Interestingly, AfD usage remained the same while CDU usage increased. Although the fluctuation is minor compared to other subcategories, I classify it as significant due to its proportion to 2017. The CDU's increased use of loaded language may reflect the personalities of different party leaders. If we assume the results indicate a fundamental shift in CDU's methods, this could suggest a heightened perception of scandal or drama in German politics, with CDU seeking to engage with this atmosphere. Next, my results show CDU appealed to emotions more than AfD in 2017 and 2025, despite significant convergence. This contradicts Breeze (2020), who argued that populist actors align with their audience's emotions, implying that far-right parties use emotional appeal more than others, implying divergence. This discrepancy may arise because the coding reflects only mentions, not sentiment. Future research could apply sentiment analysis to distinguish positive from negative emotions. The case for Metaphors is simpler; Chilton (2004) does not specify which party uses them more. My results show that AfD used more metaphors, diverging moderately from CDU over time, aligning with predictions for emotional appeal.

The categories that entirely support the sub-hypothesis are the legitimation strategies and the populist discourse. In the case of legitimation strategies, the CDU increased its usage of Moral evaluation and Mythopoesis. In doing so, CDU has made its political discourse more varied but prioritised some strategies more commonly present in extremist parties, as Wodak (2015) outlined. For the populist discourse strategies, the CDU experienced a decrease in challenging establishments, scapegoating, and references to people between 2017 and 2025. This signals an interest in differentiating themselves from the far-right, consistent with the "Brandmauer" policy around AfD. The only exception is Scapegoating, where CDU usage has increased considerably.

Regarding the direction of convergence/mainstreaming, I cannot identify a clear trend. For instance, with regard to Authorisation, the CDU mostly converges towards the AfD, while in the case of Emoji usage, the AfD converges towards the CDU. There are instances where both parties converge equally or one stagnates while the other progresses (see Table 5). This aligns with Brown, Mondon, and Winter's (2023) analysis but contradicts Downes' (2020) argument that the shift is driven by mainstream centre-right parties instead of far-right parties.

Convergence comes mostly or only from the CDU	Convergence comes mostly or only from AfD	Convergence comes from both
Security Authorisation Mythopoesis Challenging establishment Othering	Rationalisation Party Promotion Scapegoating Hashtags Emojis	No Policy Issue Moral Evaluation Emotional appeal Delegitimation Reference to people Images

Table 5: Directions of CDU or/and AfD convergence

Implications and Limitations

This study has theoretical implications. It contributes to a better understanding of far-right and mainstream usage of social media platforms like X. This emerging area of political debate warrants further study, making any analysis of political actors' use or non-use of social media relevant. Furthermore, the research also developed a codebook that other researchers can adopt to facilitate future work and extend the analysis across time and countries. In addition, this research had a significant temporal aspect that previous dissertations have omitted (e.g. Germann, 2024; Brockmeyer, 2024).

On a practical level, this study offers insights into how various content and discourse strategies shift over time between mainstream and far-right parties. It found that the parties have generally become more similar/converged—a process referred to in the literature as "mainstreaming". Scholars argue that mainstreaming legitimises and normalises potentially dangerous far-right attitudes or discourse strategies (Brown, Mondon, & Winter, 2023). Suppose these developments are further recognised through a voter analysis of what is deemed normal (future research). In that case, it can aid policymakers, media organisations, and civic educators in changing their framings to avoid further polarisation in the political arena. However, the contradictions in Immigration mainstreaming show the importance of a case-by-case study, which is highlighted by many discourse experts such as Van Dijk (1997). Accordingly, the extrapolation of results should be approached with caution.

Last but not least, this research can be used by citizens so they become more aware of the strategies politicians are taking and how to avoid falling for what one does not desire, such as a mainstream party that is copying the far-right or a far-right party that does not have real political aspirations.

In terms of limitations, first, the research focuses exclusively on German political parties. While this allowed for specificity and offered novel insights in a certain respect, it complicates the application of the findings to other countries or parties with different cultural and political backgrounds. Second, focusing only on one leader for each party and year may not fully represent the range of views and strategies within the parties. Moreover, it ignores differences in rhetoric and approach among different members and factions. Third, Twitter has a reputation for producing more divisive and controversial remarks. The platform's dynamic might tilt the representation of discourse towards more radical positions. Consequently, future studies would benefit from including a broader range of members within CDU and AfD, more political parties and possibly more election years. Moreover, it could be interesting to incorporate information from a wider array of sources, such as political speeches, traditional media, or public meetings similar to Germann's (2024) research.

Conclusion

This study focused on CDU and AfD's political discourse in 2017 and 2025. The point of interest was whether they became more similar, i.e. converged across several relevant (sub-)categories. The results indicate that the parties converged more than diverged in key areas, with some caveats. This matters because such convergence may contribute to the legitimation or normalisation of far-right ideas, such as xenophobia and divisive rhetoric, within German politics, posing risks to democratic inclusivity. While my findings do not confirm this normalisation, future research could investigate public responses to assess its broader impact.

See page 206 for references

Borrowing Contest with Limited Liability: The Role of Risk Aversion in Rent-Seeking and Creation

Samen Polishchuk

1. Introduction

Contest theory models how agents expend resources to win a prize, but standard frameworks typically assume risk-neutral contestants with a guaranteed prize. In many real-world contests, including techno- logical races or pharmaceutical trials, a successful firm is not always guaranteed. Participants finance their effort through borrowing and face the possibility of failure under limited liability. Limited liability means losers cannot be forced to repay beyond their assets, implying risk preferences and interest costs are critical to contest outcomes.

Our model introduces financial leverage into conflict settings by linking borrowing decisions to the proba- bility of success. Each firm selects its effort level by taking on debt, subject to an equilibrium interest rate that reflects the firm's endogenous default risk. Lenders operate in a perfectly competitive credit market and thus earn zero expected profits. As a firm reduces its effort, its probability of winning declines, which in turn raises its perceived default risk. This prompts lenders to demand a higher interest rate, tightening the firm's borrowing constraint. A distinctive feature of the model is its mixed system structure, allowing for two types of environments: rent-seeking, where a prize is always awarded to at least one firm, and rent creation, where aggregateeffort can influencethe availability of surplus. By incorporating both types of settings, the model extends standard contest frameworks to capture a wider range of uncertainty in competitive interactions.

The case of pure rent-seeking has been extensively studied in the contest literature, particularly in the contextof Tullock-style frameworks where firms expendeffort to win a fixedprize (Buzila, 2018). In such cases, the prize is awarded to at least one participant regardless of aggregate effort, yet all exerted resourcesare socially unproductive. A well-documented implication is that total expenditure can approach or even exceed the value of the prize, especially under symmetric information and risk- neutrality (Tullock, 1980). This has direct relevance in settings such as government procurement or defence contracting, where firms aggressively compete for indivisible, high-value contracts. The strategic use of debt financing in this context enables firms to scale up effort and improve their comparative advantage. Empirical evidence suggests that firms engaged in government contract bidding often exhibit elevated leverage ratios, a reflection of capital-intensive competition that leads to socially inefficient allocations (Hebous and Zimmermann, 2016).

On the other hand, rent creation contestsallow for socially beneficial effort, in which firms can expand the available surplus (Dickson et al., 2018). In our case, this dynamic is captured by an outcome uncertainty parameter. When there is more uncertainty regarding the abilityto innovate and create surplus,such as overly ambitious R&D projects, firms are less likely to reap any reward for their expenditure. Thus, with higher degrees of uncertainty, we would expect firms to reduce their borrowing given the likelihood of attaining the prize diminishes. This mechanism aligns with observed financing patterns in innovation- driven sectors, as R&D investment coincides with lower reliance on debt and greater use of internal or equity-based financing (Aghion et al., 2004).

Modelling these dynamics, our framework contributes to contest theory by integrating financial leverage, limited liability, and outcome uncertainty into models of conflict. In foundational work, Skaperdas and Gan (1995) analyse contests with risk-averse agents across both rent-seeking and rent-augmenting environments. Their results challenge conventional intuition: the impact of risk aversion on rent-seeking behaviour is ambiguous and context-dependent. Specifically, depending on the contest's structure and the curvature of utility functions, greater risk aversion may either increase or decrease equilibrium effort.

By contrast, in rent-augmenting settings, where expenditures enlarge a shared and uncertain prize, they find that risk aversion uniformly suppresses effort. Because risk-averse participants are more sensitive to uncertainty in payoff realisation, they are less willing to invest in expanding surplus that may not be fully captured.

Further examining the role of risk preferences, Konrad and Schlesinger (1997) also distinguish between rent-seeking and rent-augmenting contests. They find that,in rent-seeking contexts, moderate levels of risk aversion may increase equilibrium effort, particularly when the prize is not excessively large. However, as the prize grows, risk aversion increasingly suppresses effort. In contrast, in rent- augmenting contests,greater risk aversionuniformly reduces effort regardless of prize size or distributional assumptions.

In the context of uncertain outcomes, Deng et al. (2018) analyse lottery contests with the possibility of a draw and show that introducing tie-breaking mechanisms reduces total equilibrium effort.However, they note that the expected effort of the eventual winner may increaseif prize valuations are heterogeneous. In our model, the potential for a "draw" is functionally analogous to aggregate outcome uncertainty, which also depresses total investment incentives and expected return.

Building on this foundation, the paper investigates how risk aversion influences symmetric equilibrium behaviour in contestsinvolving debt financingunder limited liabilityand outcome uncertainty. We emphasise that the study aims to offer theoretical insights into firm behaviour given a profile of risk- preferences, rather than to formulate direct policy recommendations. In Section 2, we begin by formally introducing the contestmodel in which firms competethrough borrowing. In the followingsection, we derive the symmetric Nash equilibrium levels of effort and utility, conditional on the utility feasibility constraint. We then explore these results in a pure rent-seeking settingand discuss their implications for equilibrium welfare. Finally, we contrastthis baseline with a rent creation settingin which surplusis determined by aggregate effort. This extension is less mathematically rigorous, relying instead on comparative staticsacross fixed ratios of the prize value to the number of firms.

In general, we find that greater outcome uncertainty depresses both symmetric equilibrium effort and utility, while increased risk aversion dampens firms' willingness to borrow and exert effort — reducing utility particularly in rent-seeking and certain rent creation cases. However, under conditions of dense competition, the rent creation framework yields a non-monotonic relationship between utility and risk aversion. Counter-intuitively, we find that more risk-averse firms may attain higher expected utility in equilibrium. Moreover, as the number of competitors rises, intensified contest pressure reduces both symmetric equilibrium effort and utility.

In summary, this paper offers a novel theoretical contribution by embedding leverage and financial con- straints within contest theory. By merging contest dynamics with endogenous borrowing under limited liability, we highlighthow contest structure, particularly uncertainty and risk preferences, shape out- comes in conflict. To our knowledge, this is the first exploration of such logic. Our contestframework of debt financing under limited liability lays the groundwork for future extensions, including models with asymmetric firms, endogenous prize structures, and richer representations of aggregate uncertainty within rent creation theory.

2. The Model

Consider a set of identical firms $N = \{1, \ldots, n\}$, where $n \geqslant 2$, competing for a prizeof value $V > 0$ under limited liability. Each firm $i \in N$ can exert effort by borrowing $x_i > 0$ funds at a firm-specific interest rate r_i. The probability that firm i secures the prize is given by

$$p_i = \frac{x_i}{\sum_{j \in N} x_j + \beta},$$

where the parameter $\beta \geqslant 0$ determines the structure of the contest. Setting $\beta = 0$ reflects a rent-seeking environment, where firms compete over a fixed surplus that is guaranteed to be won by a single firm. In contrast, a positive value of β introduces the possibility that no firm succeeds, yielding a rent creation setting. In this contextstructure, investment can directly influence the availability of surplus, as firms must consider the possibility that their efforts yield no value.

We define the utility of firm i ∈ N , which borrows x_i at interest rate r_i under limited liability, as

$$U_i(x_i) = p_i \cdot u(\max\{0, w_i + V - r_i \cdot x_i\}) + (1 - p_i) \cdot u(\max\{0, w_i - r_i \cdot x_i\}),$$

where w_i denotes the firm's initial assets and u(.) is the utility function. For tractability, we assume w_i = o. In line with the literature, we adopt a power utility specification u(z) = $z^{\alpha}$for some coefficient of relativerisk aversion α ∈ (o, ı]. As α increases, the degree of risk aversiondiminishes. When α ‹ı, the firm is risk-averse; the marginal utilityof additional debt-financed investment declines. This intuition can be consistent with the behaviour of managers or shareholders who are cautious about over-leveraging due to the heightened probability of bankruptcy. Conversely, when α = ı, the firm is risk neutral.

Substituting and simplifying, firm i's utility reduces to

$$U_i(x_i) = p_i \cdot (\max\{0, V - r_i \cdot x_i\})^{\alpha} + (1 - p_i) \cdot (\max\{0, -r_i \cdot x_i\})^{\alpha}.$$

Limited liability ensures that a firm incurs no losses if it fails to securethe prize. Under this condition, the firm's utility simplifies to

$$U_i(x_i) = p_i \cdot (V - r_i \cdot x_i)^{\alpha}. \tag{ı}$$

In a perfectly competitive borrowing environment, lenders compete for borrowers until expected returns equate to the risk-freerate, r_f . That is, a firm i that is more risky, captured by a lower probability of successp_i, should be charged a higher rate of interest, r_i. But because of the competitive nature of the market, lenderswill drive the cost of borrowing down to no abnormal profits, where their expected returns match the market risk-free rate. Under symmetric information, this implies $p_i \cdot r_i = r_f$, which we normalise to $p_i \cdot r_i$ = ı throughout the analysis for simplicity. Firm i seeks to maximise its utility (ı)
subject to this constraint:

$$\max_{x_i > 0} U_i = p_i \cdot (V - r_i x_i)^{\alpha}, \quad \text{s.t. } p_i \cdot r_i = 1. \tag{2}$$

Our analysis in the following sections builds on this assumption to assess whether there is an existence of a symmetric equilibrium of effort, where no firm has any incentive to unilaterally deviate.

If no value is produced, no firm receives a reward. Greater total effort across firms lowers the probability that no value is created, thus making the availabilityof surplus endogenous to firm effort rather than simply competingfor a fixed resource.

As such, we interpret β as a parameter governing outcome uncertainty. Intuitively, it captures the probability that aggregate investment, such as in R&D or pharmaceutical trials, fails to generate real economic value. Such failure may stem from overly ambitious projects where innovation does not materialise regulatory disapproval, or other structural impediments that prevent the realisation of surplus. Higher values of β thus represent greater uncertainty that investment translates into a tangible payoff. That is, as β increases, the probability of success decreases for any given level of effort, and the likelihood that any firm secures the prize diminishes, reflecting the increasing difficulty of producing surplus in environments with greater uncertainty.

We define the utility of firm $i \in N$, which borrows x_i at interest rate r_i under limited liability, as

$$U_i(x_i) = p_i \cdot u(\max\{0, w_i + V - r_i \cdot x_i\}) + (1 - p_i) \cdot u(\max\{0, w_i - r_i \cdot x_i\}),$$

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(2)

$$\max_{x_i>0} U_i = p_i \cdot (V - r_i x_i)^{\alpha}, \quad \text{s.t. } p_i \cdot r_i = 1.$$

Our analysis in the following sections builds on this assumption to assess whether there is an existence of a symmetric equilibrium of effort, where no firm has any incentive to unilaterally deviate.

3. Symmetric Nash Equilibrium

In this section, we identify conditions under which a symmetric borrowing level, $x_i = x_s \forall i \in N$, along with the resulting utility, forms a Nash equilibrium under limited liability. This occurs when each firm maximises its individual utility (2):

$$\max_{x_i>0} U_i = p_i \cdot (V - r_i x_i)^{\alpha}, \quad \text{s.t. } p_i \cdot r_i = 1 \quad \text{for all } i \in N.$$

The analysis focuses on the symmetric equilibrium described in Proposition 1, which is tractable and yields clear economic insights. This approach enables the identification of equilibrium responses to changes in the underlying parameters of the contest. A formal proof is provided in Appendix A.

Proposition 1: In a symmetric Nash equilibrium effort takes value

$$x_s = \frac{\sqrt{[V(n-1) - \beta(2n - (1-\alpha))]^2 + 4(V\beta - \beta^2)(n^2 - (1-\alpha)n)} + V(n-1) - \beta(2n - (1-\alpha))}{2n(n - (1-\alpha))}, \tag{3}$$

and each firm's utility takes value

$$U_i(x_s) = \frac{x_s}{nx_s + \beta} \cdot (V - nx_s - \beta)^{\alpha}. \tag{4}$$

Such equilibrium exists if and only if $x_s \in (o, \frac{V-\beta}{n})$.

The utility feasibility condition, $x_s < \frac{V-\beta}{n}$, ensures that the utility of each agent in the market remains strictly greater than zero, $U_i(x_s) > o$. Cases where the equilibrium utility is equal to zero are excluded from consideration, as the analysis focuses on interior solutions in which firms are incentivised to exert strictly positive effort.

Rewriting the condition in terms of aggregate effort, $nx_s < V - \beta$, reveals an implicit (2) cap on total industry-wide borrowing (nx_s) for the existence of a symmetric Nash equilibrium. Because β captures the probability that no firm achieves the desired outcome, V – β may be interpreted as the expected net surplus available to all competitors. Aggregate spending in excess of this threshold would recreate the classic rent-dissipation outcome, whereby collective effort surpass the expected surplus and generate deadweight loss (Harberger, 1954; Tullock, 1980). By contrast, the equilibrium constraint ensures that that the sum of all firms' investments never outpaces the value of the prize adjusted to the rent creation parameter, averting this equilibrium outcome.

Moreover, as the outcome uncertainty parameter β increases, the upper-bound on total permissible borrowing proportionally contracts. Intuitively, higher uncertainty disciplines aggregate effort, as risk- averse firms internalise the chance that the entire contest yields no payoff.

4. Rent-Seeking: $\beta = 0$

In this section, we analyse the benchmark case with no outcome uncertainty (β = o), where the prize is guaranteed to be awardedto one of the firms ($\Sigma i\ p_i$ = ı). This framework aligns with classical models of rent-seeking, where competitors allocateresources to capturean existing surplusrather than to generate new value (Tullock, 1967; Krueger, 1974). It characterises sectors marked by zero sum competition over fixed rewards, such as procurement races or exclusive licensing agreements. In such cases, any effort is regarded as socially wasteful, since firms are merely competing over a fixedprize (e.g. government contracts) without contributing to overall value creation (Wellford, 2009).

Moreover, only one firm ultimately secures the prize, leaving all others with nothing in return for their investment, rendering their efforts as sunk costs. This inefficiency could be mitigated through alternative contest structures in which the surplus is shared in proportion to effort, rather than awarded to a single winner.

As previously discussed, such rent-seeking contests can lead to excessive individual effort, worsening the inefficiency in equilibrium. When all participants expend resources to improve their chances of winning, the total cost can approachor even exceed the value of the prize (Harberger, 1954; Tullock,1980). From a welfare standpoint, the total surplus remains unchanged, but its value is eroded by unproductive competition and duplicated investment.

While the exclusion of outcome uncertainty improves tractability, it abstracts from important real-world frictions. In many settings, firms face the possibility that the prize itself may not materialise due to insufficient investment or external shocks. To establish a foundation, we first derive equilibrium utility and effort in this deterministic, rent-seeking environment. We then examine the implications of such contests for welfare.

4.1 Comparative Statics

We are now ready to characterise the symmetric Nash equilibrium levels of effort and corresponding utility in the absence of uncertainty (Appendix B). This result enables a focused analysis of firm behaviour under a pure rent-seeking environment.

Corollary 1: Suppose $\beta = 0$. Then, under the conditions of Proposition 1, there always exists a symmetric Nash equilibrium in which effort takes value

$$x_s = \frac{V(n-1)}{n(n-(1-\alpha))}, \tag{5}$$

and each firm's utility takes value

$$U_s = \frac{V^\alpha}{n} \cdot \left(\frac{\alpha}{n-(1-\alpha)}\right)^\alpha \tag{6}$$

This formulation yields several comparative static results that illuminate how firms adjust there behaviour in response to changes in the model's parameters under symmetric equilibrium. These results are formalised in Proposition 2 below, with detailed proof provided in Appendix C.

Proposition 2. *Suppose the conditions of Corollary 1 are satisfied. Then, in symmetricNash equilibria- rium:*

1. *The equilibrium borrowing effort x_s and utility U_s are increasing in the outcome value V ;*
2. *Both x_s and U_s are decreasing in the number of competing firms n;*
3. *Effort x_s decreases in the coefficient of relative risk aversion α, whereas utilityU_s increases in α.*

First, both the equilibrium effort x_s and the resulting utility U_s are increasing in the prize value V. With an increase in the prize value, each firm has a stronger incentive to exert greater effort in order to improve its probability of capturing the prize. Because effort translates into a higher probability of success in this setting, the increase in expected payoff justifies the additional borrowing. Moreover, the firms' utility function (1) is directly increasing in the prize value.

Second, it is clear that both equilibrium effort and utility are decreasing in the number of competing firms, n. As more competitors enter the contest, the likelihood that any given firm wins the prize declines, reducing the expected return on borrowing and diminishing the strategic value of effort. Accordingly, each firm responds by reducing its level of effort. From the perspective of utility, this reduction in effort is not fully offset by the potential gains from participation, as the prize must now be contested against a larger pool of rivals. This implies that participation becomes less rewarding overall, thereby decreasing each firm's equilibrium utility.

Third, symmetric equilibrium level of effort decreases, whereas equilibrium utility increases with α. Since the utility function is given by $u(z) = z^{\alpha}$, a greater value of α corresponds to less concaveutility, indicating higher risk neutrality. Thus, as the degree of risk-aversion decreases, firms borrow less and their utilities increase in equilibrium. As firms become more risky andneutral, they are less concernedwith the potential downside of failing to win the prize and less inclined to insure themselves through high effort. Instead, they prefer to accept a lower probability of success in exchange for higher net returns when successful. This tradeoff leads to a decline of equilibrium borrowing effort with increasing α. At the same time, utility rises in symmetricequilibrium as firms become more risk neutral.Because less risk-averse firms discount the negative utility associated with low-payoff outcomes, they extract greater utility from expected gains, even as their likelihood of winning declines. As such, even though effort is reduced and hence the probability of success, firms benefit more from smoother preferences relative to more unlikely outcomes, leading to higher expected utility in symmetric equilibrium.

On the other hand, a smaller value of α corresponds to more concave utility, indicating higher risk aversion. In this setting, risk-averse firms anticipate that more unlikely outcomes are more painful and thus seek to increase their chances of securing the prize by exerting more effort. As a result, equilibrium effort rises despite the firm's greater aversion to risk. However, utility falls in equilibrium as α decreases. Since utility becomes more concave, marginal utility of gains rises, but overall expected utility declines due to the increased weightplaced on lower-probability loss outcomes. This highlights a central tensionin the model: risk-averse firms increase effort to hedge against uncertainty, but the concavity of their utility functions reduces the valuation of expected returns, yielding lower equilibrium utility. Consequently, firms are better-off being risk neutral in equilibrium under a rent-seeking regime.

This finding that equilibrium effort decreases with greater risk neutrality (i.e.as α increases) contrasts with conventional results in the contest literature concerned with rent-seeking. In standard Tullock-style models with risk-averse agents and deterministic prize allocation, increased risk neutrality typically leads to greater effort, as more tolerant agents are willing to accept a lower probability of success in exchange for higher expected returns(Konrad, 2009). Risk-averse agents, by contrast, scale back effortto avoid the downside from investing resources without securing the prize.

The reversal in comparative statics relative to classical contest models stems from the interaction be- tween risk preferences and endogenous winning probabilities within the utility formulation. Rather than inducing caution,risk aversion here generates a strategic responseaimed at avoidingworst-case outcomes, even at the cost of lower expected utility.Our results more closely align with those of Skaperdas and Gan (1995), who show that equilibrium effort may increase or decrease with risk aversion depending on contest structure and the curvature of utility functions.

4.2 Welfare

An important insight into the inefficiencies of rent-seeking contests emerges from the symmetric equilibria- rium expression for effort under certainty.Although individual effort x_s decreases as the number of firms n increases (Proposition 2), aggregate effort in equilibrium nx_s, calculated by rewriting(5) as

$$x_s = \frac{V(n-1)}{n(n-(1-\alpha))},$$

increases in n. This implies that, although each individual firm borrows less in response to intensified competition, the marginal entrant increases total industry borrowing more than the collective reduction by incumbents. In effect, each additional competitor adds disproportionately to the aggregate level of effort, an established rent-seeking characteristic in contest literature. In equilibrium, the pursuit of a fixed prize leads to such excessive duplication of effort : increased competition leads to a finer division of expected payoffs and smaller individual contributions, yet overall effort (i.e. resource expenditure) rises, even when it generates no additional social value.

This inefficient scaling of aggregate effort adversely affects welfare, defined as total equilibrium utility:

$$W = nU_s = V^{\alpha} \cdot \left(\frac{\alpha}{n-(1-\alpha)}\right)^{\alpha}$$

WelfareWis strictly decreasing in the number of firms n. Due to the duplication of effort, as more firms enter the market total effort in the market rises. But since the prize remains fixed, more resources are expended in pursuit of a constant surplus, which only splits the prize more finely. This dilutes the expected payoff and reduces overall welfare. The contest mechanism thus fails to internalise the negative externality imposed by entry, leading to inefficient over-investment and a steady decline in welfare as competition intensifies.

The model's duplication of effort is characteristic of Tullock-style rent-seeking contests, but the degree of dissipation here is comparatively milder.While aggregate effort rises with the number of competitors, the equilibrium does not fully deplete the value of the prize, as the utility feasibility condition is always satisfied when β = o, and firms continue to derive non-zero expected payoffs. The implications of welfare loss in this model and standard Tullock games are also similar in direction. In both cases, unregulated entry leads to over-investment in effort, diminishing the total value realised by society. However, welfare dissipation in this model is bounded due to concave utility and the assurance that some expected payoff remains in equilibrium. This contrasts with the complete erosion of surplus that can occur in traditional rent-seeking settings (Hillman and Samet, 1987; Tullock, 1967).

5. Rent Creation: $\beta > 0$

In this section, we examine whether the model yields analogous features to those established in Proposi- tion 2 when uncertainty is present (β › o). In such environments, a successful outcome is not guaranteed, as the aggregate probability of success satisfies Σi p_i ‹ 1. This marks a departure from our benchmark case of pure rent-seeking, where the prize is always awarded. In contrast, the introduction of outcome uncertainty permits *rent creation*, a process in which firms contribute to the generation of surplus through their efforts rather than merely competing over a fixed resource.

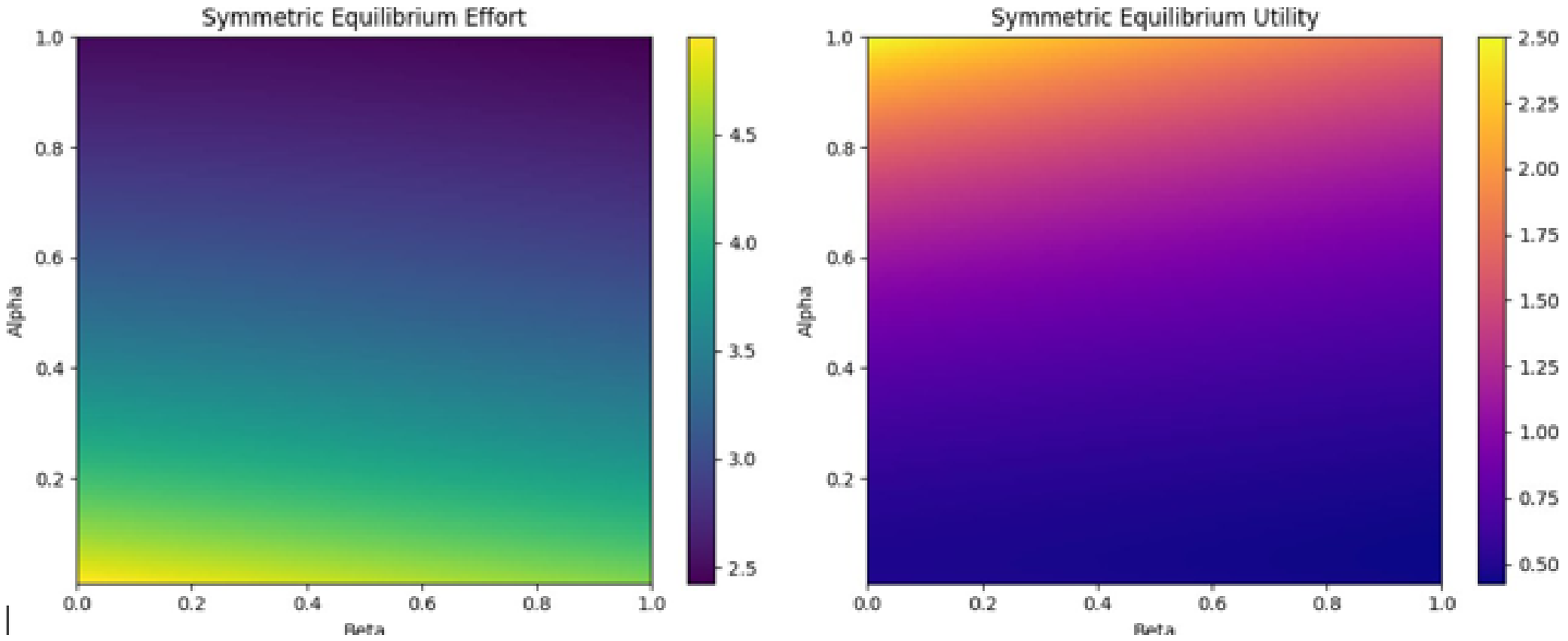
In our model, investment can directly influence whether the prize materialises at all, since by increasing aggregate spending the effect of outcome uncertainty diminishes. This formulation is relevant for a range of economic environments, including R&D races, pharmaceutical trials, and other innovation-driven contests.

Our primary interest lies in the relationship between risk aversion and equilibrium levels of effort and utility under varying degrees of outcome uncertainty. To ensure analytical tractability, we restrict attention to moderate levels of outcome uncertainty, specifically $\beta \in [0, 1]$. Throughout, the value of the prize is fixed at $V = 10$, while the number of firms n is varied to allow meaningful comparison. We refer to the ratio of prize value to the number of firms as competition density: competition is considered less dense when n is low relative to V, and becomes increasingly dense as n approaches or exceeds V.

The analysis begins with a low-density environment ($n < V$), exploring how the symmetric Nash equilibrium responds to changes in both α andβ. This is followed by an intermediate case where the prize is approximately equal to the number of firms ($n \simeq V$), and finally a high-density setting, in which the number of firms exceeds the prize value ($n > V$).

5.1 n < V

First, we consider the case of a fixed number of firms, $n = 2$, competing for a prize of value $V = 10$ in a rent-creating setting. The small number of firms relative to the size of the prize limits competitive pressure, resulting in well-behaved symmetric equilibrium outcomes within our framework. Figure 1 illustrates the resulting symmetric Nash equilibrium outcomes, showing how equilibrium utility (right) and borrowing effort (left) vary with the coefficient of relative risk aversion and the level of outcome uncertainty. These plots highlight how equilibrium behaviour responds to the joint effects of individual risk preferences and the likelihood that no firm secures the prize.



Note: The left panel illustrates the magnitudes of symmetric equilibrium effort, whereas the right panel shows them for equilibrium utility. These magnitudes are derived using the closed-form expressions from Proposition 1. In the visual representation, darker regions correspond to lower values of the respective equilibrium outcome. The vertical axis in both panels represents the coefficient of relative risk aversion, denoted by $\alpha \in (0, 1]$. The horizontal axis indicates the level of
outcome uncertainty, limited to the interval $\beta \in [0, 1]$ to ensure the model remains well-behaved for the purpose of this analysis. The resolution of the simulation is set at 100 by 100, meaning that equilibrium values are computed for 100 evenly spaced points across both the α and β dimensions, starting from $\beta = 0$ and $\alpha = 0.01$.

Figure 1: Heatmap of symmetric equilibrium effort and utility given V = 10 and n = 2.

The low competition density results in relatively high symmetric equilibrium effort levels (left) compared to the available prize, ranging from approximately 2.5 to 5. As observed in the benchmark case where uncertainty was absent ($\beta = 0$), greater risk aversion continues to be associated with higher equilibrium effort across all values of $\beta < 1$. The intuition established in Section 4.1 still applies. Firms that are more risk-averse (lower α) place greater value on securing the prize and therefore exert more effort to minimize the risk of earning nothing.

However, as the degree of outcome uncertainty β increases, equilibrium borrowing levels decline across all values of α. When the likelihood that no firm secures the surplus rises, the expected return on effort falls, diminishing firms' incentives to invest in creating surplus. The risk that even substantial effort may yield no reward weakens the appeal of borrowing. This downward pressure on effort is amplified when combined with greater risk neutrality, resulting in a steeper decline in investment as uncertainty increases and the degree of risk aversion decreases.

In a similar fashion, firms' individual utility measures up to a relatively high magnitude (2.5) since the market is not overlydense with firms.From the right panel of Figure 1, we find that utility decreases with greater degrees of risk aversionfor all levels of β belowone. This mirrorsour results from the base-case when at least one firm was guaranteed success. The logic remains the same: although more risk-averse firms invest greater effort to improve their chances, their expected utility still falls, as their concave preferences place greater emphasis on the possibility of receiving nothing.

Moreover, as outcome uncertainty increases, utility levels decline further across all values of α. The presence of outcome uncertainty reduces the likelihood that any one firm will succeed, diminishing the expected payoff even when excess prize value increases from less effort exerted. This compounds the negative effect of risk aversionon utility. While the panelclearly shows a downward trendin utility as both risk aversion and uncertainty rise, it does not provide definitive visual evidence on whether the marginal impact of risk aversion becomes more severe at higher levels of β.

Hence,the relationship between risk aversion and symmetric borrowing and utility identified in the bench- mark case (Proposition 2) persists under low competition density(n ‹ V) in a rent-creating scenario, even as outcome uncertainty varies. Crucially, this result emerges within a highly controlled setting, where outcome uncertainty remains bounded between zero and one. This ensures that competitive pres- sure does not overwhelm incentives so that equilibrium outcomes remain stable. As we will see, these properties begin to change as we relax the restriction on the ratio between the number of firms and the value of the prize.

5.2 n ≃ V

We now consider the case where the number of firms approaches the prize value, fixed at V = 10, focusing on n = 9 to illustrate the model's behaviour under denser competition. Figure 2 presents a heatmap of symmetric equilibrium effort and utility. Unlike the previous case, the right panel now reveals a non-monotonic relationship between utility and risk aversion.

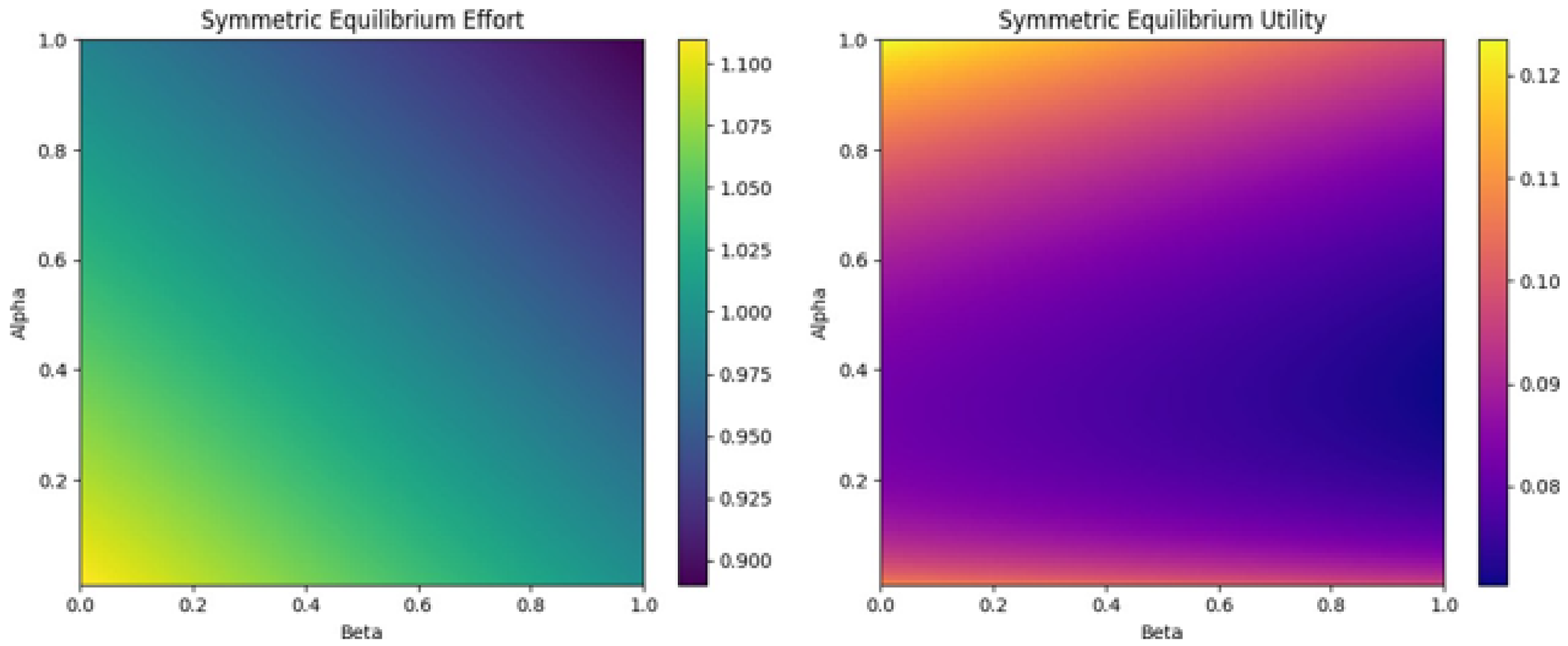


Figure 2: Heatmap of symmetricequilibrium effort and utility given V = 10 and n = 9.

The symmetric equilibrium effort (left) decreases with risk aversion, which is consistent with the bench- mark case. Furthermore, for all values of α and β, equilibrium effort is lower than in the n = 2 case, reflecting the decline in effort as competition becomes denser. Moreover, as in the n < V case, both equilibrium effort and utility decline with greater outcome uncertainty for all levels of α and $\beta \leqslant 1$. To that end, equilibrium borrowing decisions follow similar dynamics to those described in the benchmark case when β = 0. However, a key observation is that the sensitivity of borrowing to changes in α and β has markedly diminished. As shown in the left panel of Figure 2, equilibrium effort remains narrowly confined between approximately 0.9 and 1.1, in sharp contrast to the wider 2.5-unit range observed under lower competition density (n = 2).

Turning to the right panel, a particularly notable feature is the non-monotonic relationship between equilibrium utility and risk aversion α across all levels of outcome uncertainty. As shown in Figure 2, utility reaches a local maximum over the (β, α) plane when firms are risk neutral (α = 1). Then, they marginally decreases as firms become more risk averse. However, utility magnitudes unexpectedly begin to rise again as α approaches zero for all β values, especially for α < 0.2. To describe this departure from our base-case, we define a phase transition as a shift in the qualitative behaviour of the utility function, particularly in its response to changes in risk preferences. To analyse it analytically, consider the symmetric equilibrium utility from Proposition 1

$$U_i(x_s) = \frac{x_s}{nx_s + \beta} \cdot (V - nx_s - \beta)^{\alpha}.$$

When the number of firms approaches the value of the prize, the term $V - nx_s - \beta$ becomes very small. This occurs because equilibrium effort varies less with changes in α and β, as discussed earlier, which implies that nxs tends closer to V with larger values of n. In particular, when α is close to zero, the term $(V - nx_s - \beta)^{\alpha}$ can become disproportionately large (but bound by one), due to the convexity of fractional exponents near zero. This inflates utility at high levels of risk aversion, creating a non-monotonic profile with peaks both near risk neutrality and extreme risk aversion. Hence, under rent creation ($\beta > 0$), equilibrium utility exhibits a phase transition with respect to risk preferences when competition becomes denser.

The comparative statics established in the benchmark case of Proposition 2 generally continue to hold for $V \simeq n$, particularly for the symmetric equilibrium level of effort. However, we observe a notable deviation from the observed monotonic relationship between equilibrium utility and risk aversion. The heightened competition density induces a phase transition of utility preferences. Instead of a single maximum equilibrium utility over a fixed β and varying α, we observe two distinctive points, when firms are both risk neutral and extremely risk averse. To further investigate the implications of intensified competition, we now turn to a more extreme case in which the number of firms exceeds the value of the prize.

5.3 n > V

Finally, we consider a situation where the market is very dense, fixing the number of firms to $n = 15$. In such a setting, the phase shift remains pervasive as we see a complete reversal of the relationship between equilibrium and risk aversion pictured in Figure 3 (right).

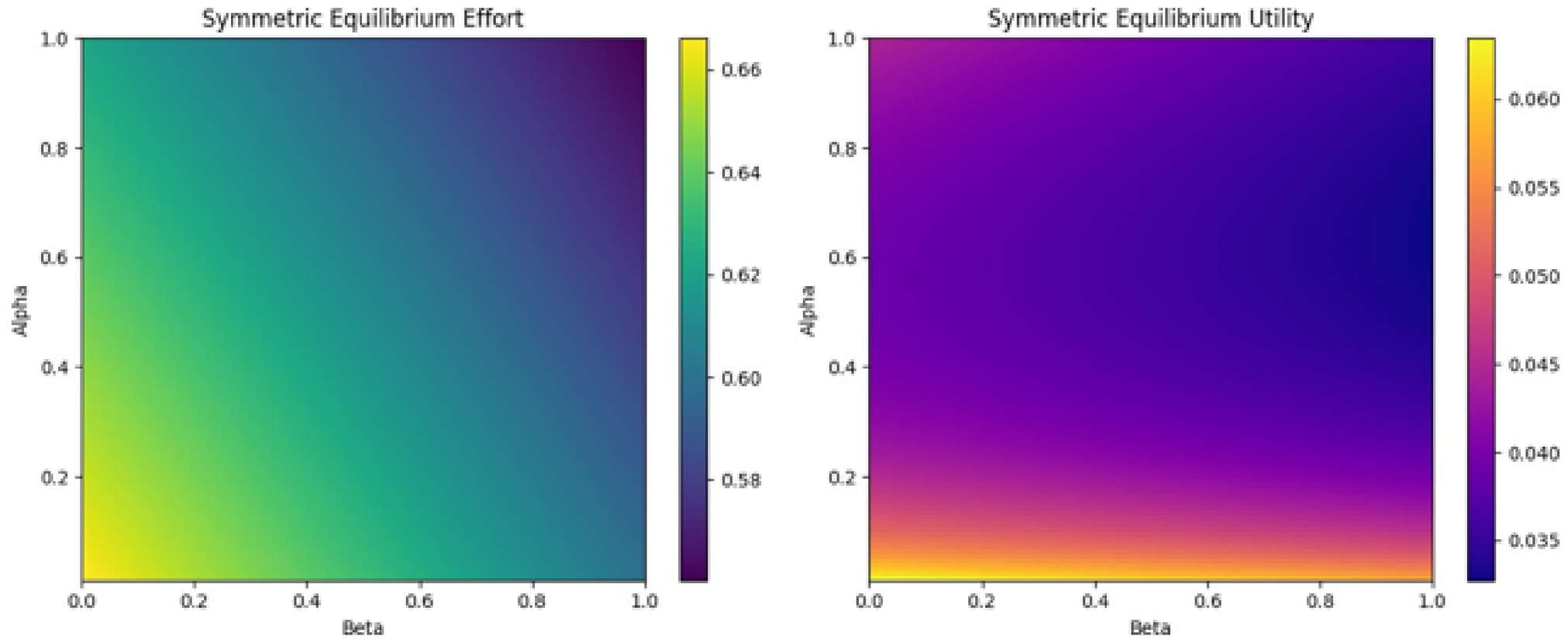


Figure 3: Heatmap of symmetric equilibrium effort and utility given V = 10 and n = 15.

As in the previous comparisons with lower levels of competition density, the symmetric equilibrium effort continues to follow the patterns established in our benchmark case. First, for all values of α and β, equilibrium levels of effort and utility are lower when n = 15 (with a maximum of around 0.66) compared to the earlier case with n = 9. Second, consistent with the benchmark case, borrowing decreases as firms become less risk averse. In addition, in line with earlier scenarios involving fewer firms, both equilibrium effort and utility decline as outcome uncertainty rises ($\beta \leqslant 1$).

However, under highly dense competition, we observe a case that nearly contrasts with the situation described when $n < V$. While the relationship betweenrisk aversion and equilibrium utilityremains non-monotonic, similar to the intermediate case where $n \simeq V$, another phase transition occurs. In this setting, the relationship between equilibrium utility and risk aversion has practically reversed compared to the baseline case of β = 0. Specifically, for any level of outcome uncertainty, the highest levels of equilibrium utility are attained when firms are extremely risk averse ($\alpha \to 0$). This marksa reversal of the typical logic derived from Proposition 2, where greater risk aversion was associated with lower utility.

Therefore, although the behaviour of equilibrium effort continues to align with the findings from the benchmark case, equilibrium utility undergoes a further phase transition. When n › V , firms benefit more from being risk averse in order to increase their utility for any values of outcome uncertainty, a complete reversal of the logic behind our benchmark rent-seeking case. Moreover, across all three rent- creating cases of competition density considered, both equilibrium effort and utility decline as outcome uncertainty increases for all values of α ∈ (0, 1].

However, it is important to remember that we are considering three special cases with fixed number of firms and prize value over a small interval of outcome uncertainty, β ∈ [0, 1]. We want to avoid associating these results with more general aspects of the model, as this would require more rigorous mathematical analysis; for instance, to determine whether lower levels of outcome uncertainty are (indeed) always preferred by firms, or how utility reacts to risk preferences under other competitive densities.

6. Conclusion

This paper introduces a novel model in which firms participate in a contest with debt financing under limited liability. Within both rent-seeking and rent-creating regimes, we derive closed-form expressions for symmetric Nash equilibrium effort and expected utility. A key result is that the relationship between equilibrium utility and risk aversion can become non-monotonic in a rent-creating setting with higher competitive density (what we term a phase transition). Specifically, we find that expected utility attains its highest values when firms are either risk neutral or highly risk averse. This contrasts with our bench- mark rent-seeking case without outcome uncertainty, in which equilibrium utility declines monotonically as risk aversion rises. These findings are consistent with broader contest literature, where equilibrium effort or payoffs may respond non-monotonically to certain parameters (Gama and Rietzke, 2019).

We emphasise that this analysis represents a preliminary theoretical exploration and carries limited policy implications at this stage. The rent creation case, especially, yields rich equilibrium conditions that merit deeper mathematical treatment (for example, rigorous proofs of existence, uniqueness, and comparative statics in more general setups). Our symmetric, static framework lays groundwork but abstracts from many real-world complications. As such, we view our results as a baseline foundation that highlights the interplay between contest incentives and financial constraints.

Future work could extend the framework along several important dimensions. First, allowing for asymmetric firms with heterogeneous risk preferences or initial endowments would offer deeper insight into real-world contest environments. Second, incorporating biased or imperfectly competitive credit markets, where lenders possess market power or asymmetric information, could generate endogenous interest rate distortions and more realistic credit constraints. Ultimately, our results, when paired with more rigorous extensions, could inform policy design aimed at mitigating excessive risk-taking or socially inefficient contest expenditure in leveraged markets.

See page 209 for references and appendix

Can Economic Nationalism Win in a Globalized World? The Wider Implications of the US-China Tariff War

Eshita Soni

Introduction

In an era of growing global interconnectedness, the resurgence of economic nationalism presents a profound challenge to the prevailing world order. In recent days, the ongoing tariff dispute between the world's two largest economies, the United States and China is facing growing tensions. It is challenging the foundations of the global economic system that has shaped international relations since the end of the Cold War (Chow, 2021). This essay will analyse the challenges of economic nationalism in an increasingly globalised world and the wider implications of the US-China Tariff War since the Trump Administration.

Economic nationalism prioritises domestic interests over international cooperation, seeking to protect national industries and employment from foreign competition. This perspective assumes that economic prosperity is fundamentally zero-sum - that nations can only prosper at the expense of others and that they can exclude others from their markets while still enjoying access to theirs (Emegha & Offor, 2019). This stands in stark contrast to globalization's promise of mutual benefit through comparative advantage and integrated markets. The current wave of economic nationalism has not emerged in isolation, but has happened alongside other significant backlashes against globalization including Brexit and the US withdrawal from the Trans-Pacific Partnership (Emegha & Offor, 2019). These developments have materialized against a backdrop of growing inequality related, among other forces, to China's ascent in the world economy and labour-saving technological change.

Nationalism has gained traction across the political spectrum, appealing to both left and right-leaning constituencies in Europe and the United States (Emegha & Offor, 2019). This broad appeal lies in its promise to address persistent economic problems regarding job losses, wage stagnation, and perceived declines in national sovereignty. However, the relationship between economic nationalism and globalization is more complex than it is often portrayed. These forces are not necessarily in conflict; rather, they can coexist in dynamic and context-dependent ways. Research suggests that economic nationalism is not a rejection of globalization, but a reconfiguration of it, adapted to different socio-economic and political environments (Emegha & Offor, 2019).

The US-China Trade War: Economic Nationalism in Practice

The ongoing trade conflict between the United States and China is the most prominent contemporary example of economic nationalism in action. With tariffs imposed on approximately 67% of traded intermediate and capital goods by both countries, the scale of the dispute is considerable (Fajgelbaum et al., 2021). Recent developments have only deepened the divide: In 2025, the reimposition of tariffs under the Trump administration reached levels of 125%, prompting symmetrical retaliatory measures from China (Coface, 2025). This escalation has placed immense strain on global supply chains and increased costs for manufacturers and consumers alike.

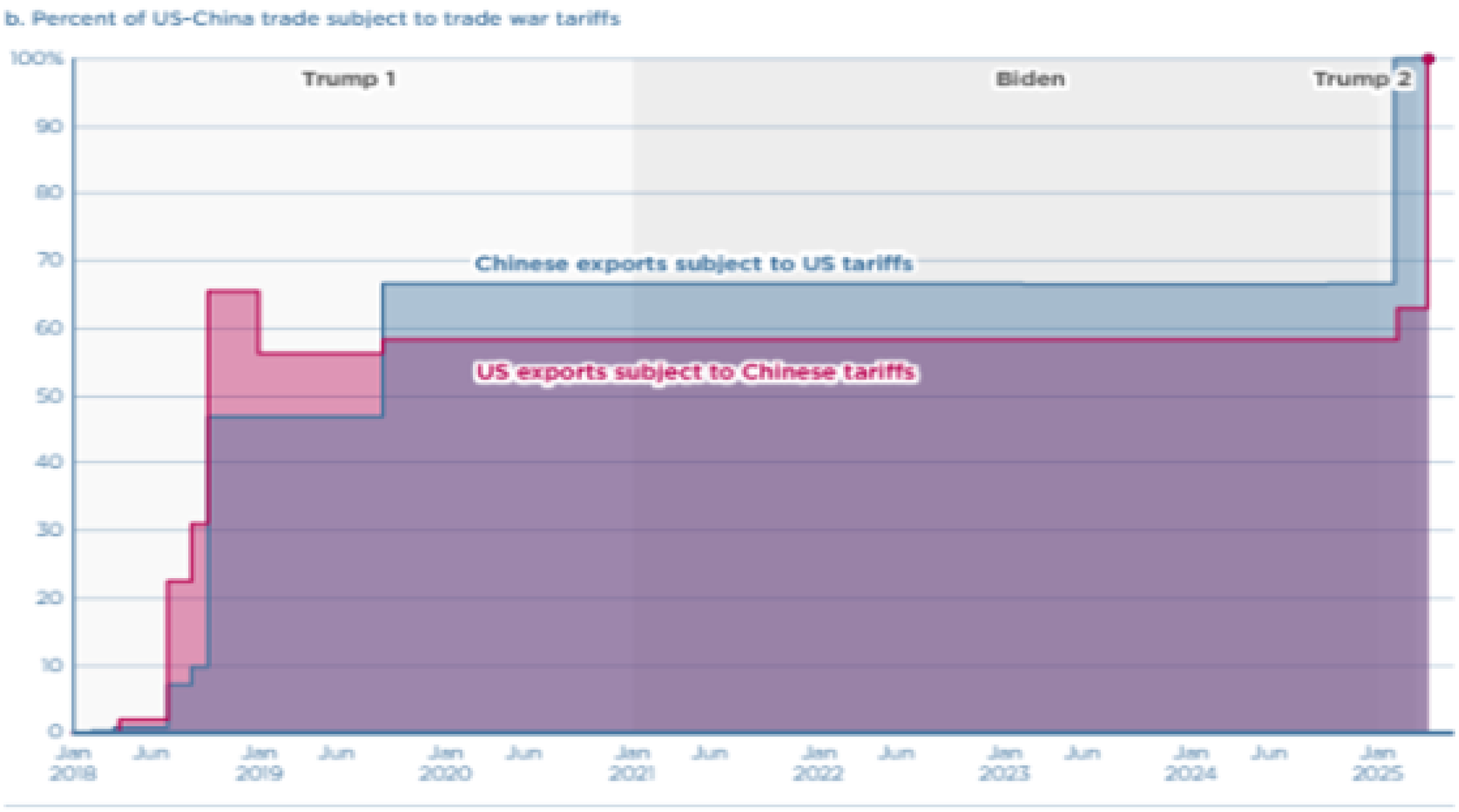


Figure 1 - US–China tariff rates on bilateral trade and rest of world, 2018–2025

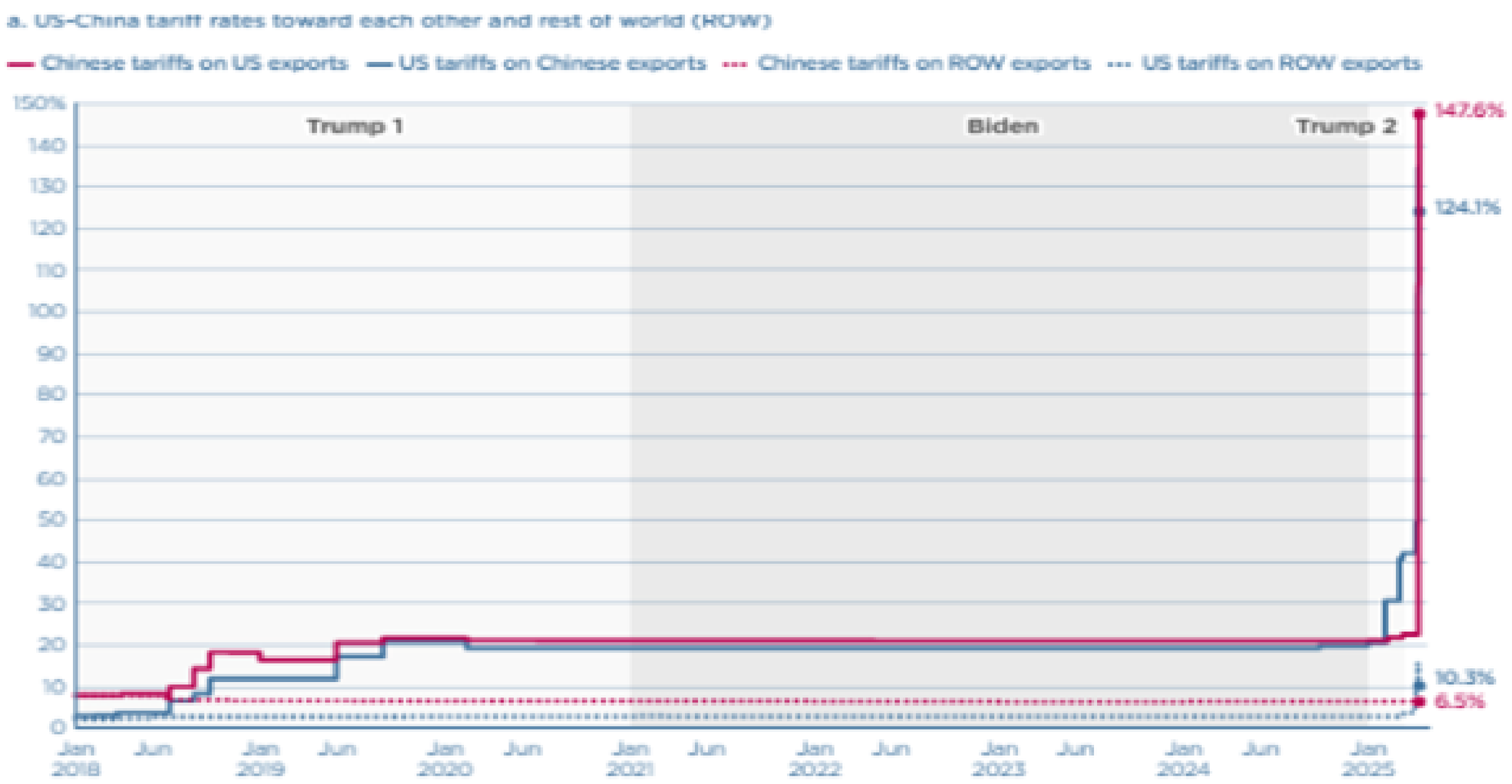


Figure 2 - Share of US–China trade subject to tariffs, 2018–2025

The charts show that US-China tariffs rose sharply during Trump's first term, stabilized under Biden, and then skyrocketed to unprecedented levels at the start of Trump's second term in 2025 (over 124% for US tariffs on China, and 147% for Chinese tariffs on the US). Meanwhile, tariffs on the rest of the world remained low.

By 2025, nearly all bilateral trade is subject to these high tariffs, marking a dramatic escalation in the trade war and isolating the conflict to just US-China trade. Beyond tariffs, the conflict has extended into the realm of critical resources and technology. China, a key player in the global supply of strategic minerals, has restricted exports of materials like germanium and gallium, vital for defence and high-tech industries (CSIS, 2025). In response, the US has expanded export controls on advanced semiconductors crucial to AI and other frontier technologies. These policies are deeply political. Trade measures have become powerful tools in electoral politics, employed to signal resolve and protect domestic constituencies (Chow, 2021). Economic nationalism thus serves political ends as much as economic objectives.

Short and Long-term Implications

Economic nationalism offers policymakers a compelling narrative: defending national industries and jobs from foreign competition. This message resonates strongly, especially in times of economic uncertainty. Strategic sectors such as defence, technology, and infrastructure are often seen as requiring protection to maintain national security and long-term resilience (Chow, 2021). In China's case, a large domestic market provides some buffer against external shocks. The state has mobilized policy tools to support small and medium-sized enterprises and export-oriented firms, highlighting how economic nationalism may also be expressed through industrial policy rather than only through border measures (Henley & Partners, 2022).

Despite its short-term political utility, economic nationalism presents serious long-term economic challenges. Disruptions to global supply chains raises production costs and reduces efficiency. Tariffs ultimately burden domestic consumers and businesses, either through higher prices or reduced margins (Fajgelbaum et al., 2021). The tit-for-tat nature of trade disputes undermines the idea of a one-sided economic advantage. Retaliatory tariffs from China have increased the cost of US goods, dampening demand and creating uncertainty. This volatility affects investment decisions, distorts capital allocation, and slows economic growth (Coface, 2025). Moreover, insulating industries from international competition can reduce innovation and productivity over time. Historical evidence indicates that sustained protectionism tends to stifle economic dynamism and limit exposure to global best practices (Emegha & Offor, 2019).

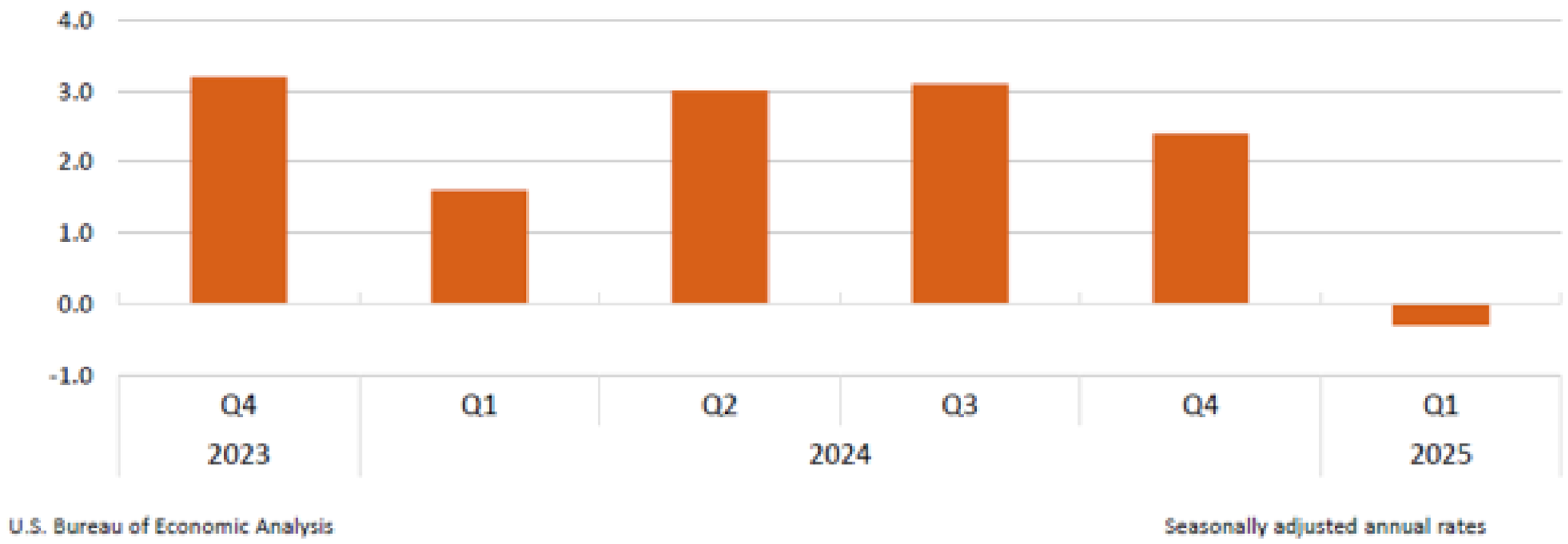


Figure 3 - Real GDP, Percent Change from Preceding Quarter

The chart shows that US real GDP growth was strong in late 2023 and most of 2024, but slowed sharply in early 2025, turning slightly negative in Q1 2025. This suggests the economy lost momentum at the start of 2025. Many say that the negative growth was due to Trump's re-election and the implications of the tariffs however Trump claimed it all to be his predecessor. Consequently, as mentioned in BBC News huge retailers like Walmart, Home Depot and Target have told White House shelves will be empty due to tariffs against China. 60% of fresh fruit, 30% of fresh veg and 70% of toys are imported. Therefore, the increased tariffs has led to an increase in consumer prices. This has damaging economic implications due to rising inflation and a fall in economic growth (the first time since 2022). It also has negative political implications. For example, a major promise Trump made was that he would cut inflation. However, the opposite is happening, leaving voters unhappy.

Global Ramifications and the Erosion of Multilateralism

The consequences of the US-China trade war has reached beyond bilateral relations. Given that their combined economic activity accounts for roughly 43% of global GDP, disruptions in their economic engagement reverberate across the international system. Therefore, prolonged conflict risks inducing broader slowdowns in trade and investment, with particularly severe impacts on emerging markets (BBC, 2025). Third countries increasingly find themselves navigating a fragmented global economy as many face pressure to align with one power or the other or to adjust their trade policies to shield domestic industries. The result is a shift from multilateral cooperation to more fragmented bilateral arrangements (Henley & Partners, 2022). This fragmentation undermines the global trade system. Institutions such as the WTO have been weakened, notably by the US blocking appointments to its Appellate Body, thereby reducing the capacity for coordinated, rule-based dispute resolution (Chow, 2021).

However, Trump argues that tariffs in the longer term bring back jobs to us which will stimulate the economy. The US-China trade war has accelerated the trend of reshoring, as American firms reassess the risks of overreliance on Chinese manufacturing. Tariffs imposed by both countries since 2018 have increased production costs, prompting companies to explore relocating supply chains back to the United States or to third countries such as Vietnam and Mexico (Bown, 2021). Beyond tariffs, growing geopolitical tensions and the experience of COVID-19 have highlighted the strategic vulnerability of globally dispersed supply chains, especially in critical sectors like semiconductors and pharmaceuticals (Lund et al., 2020). The U.S. government has also supported reshoring through policy incentives such as the CHIPS and Science Act, reflecting a broader push toward economic nationalism. However, while reshoring appeals politically, it faces practical barriers including higher labor costs, limited industrial capacity, and workforce shortages in the U.S. (Sirkin et al., 2022). Therefore, although the trade war has catalysed interest in reshoring, its long-term viability as a large-scale strategy remains uncertain. The chart shows that after US tariffs on China were implemented in 2018, US companies with high sales to China (blue line) saw their stock prices drop significantly more than US companies with high sales to other international markets (red line). This underperformance highlights how firms exposed to China were hit hardest by the trade war.

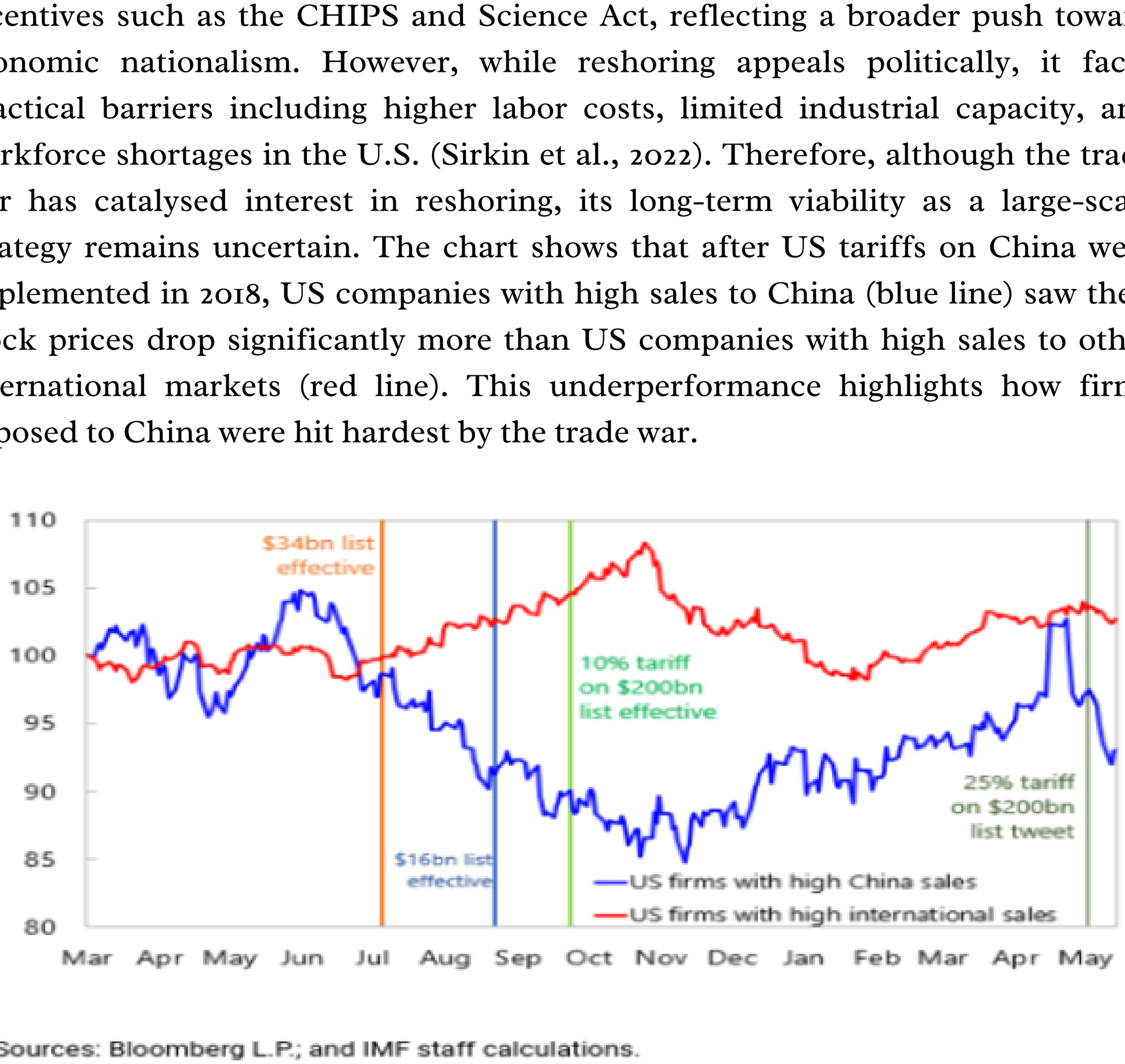


Figure 4 - Stock performance of US firms with high China sales vs. high international sales, 2018–2019

On the contrary, many industries which require low skilled labour are done in countries like Vietnam and China. Consequently, Trump's imposition of tariffs has not only increased prices for the US people but also has brought forward a form of demodernisation since weaker industries which require low skill would be brought to the US (as well as high skilled). This leads to higher wages increasing the overall cost for businesses. In addition, his approach juxtaposes the theory of comparative advantage. Being independent is good for the long term.

However, in the short term, small firms can struggle significantly due to these rising costs. The US has raised tariffs to 245% on China which China has replied with 125% on the US. These tit-for-tat tariffs in the long-term are not beneficial for either country. Therefore, 90 days of a -115% mutual reduction in tariffs aims to create discussions and prevent embargoes. This importance is exarcebated by the current volatility in the global economy due to external shock along with China's property and youth unemployment crises.

Conclusion

Rather than viewing economic nationalism and globalization as incompatible, it is more productive to understand them as points on a continuum. States have long sought to reconcile domestic priorities with international openness. What is emerging today is not deglobalization, but recalibration. China's dual approach illustrates this shift. While fortifying domestic capabilities, it continues to engage with global markets selectively, especially with export-oriented partners that favour multilateralism (Henley & Partners, 2022). This suggests that strategic economic nationalism can coexist with a degree of global integration. Looking ahead, global institutions must adapt. Reforms to the WTO and similar bodies are necessary to accommodate concerns over intellectual property, digital trade, and state subsidies while preserving the benefits of a rules-based system (Chow, 2021). An inclusive approach to globalization—which balances openness with safeguards for national interests—may offer a more stable path forward. This would acknowledge that economic nationalism and globalization are not inherently opposing forces, but rather tools that can be deployed together, depending on national circumstances and strategic goals (Emegha & Offor, 2019).

Economic nationalism, as illustrated by the US-China tariff war, offers both political traction and strategic focus. However, in a deeply interconnected global economy, its limitations are clear. The costs of disengagement through inefficiency, volatility, and reduced growth are substantial. The key challenge is not to choose between economic nationalism and globalization, but to find a viable balance. States that can integrate nationalist priorities with pragmatic engagement in the global economy are more likely to navigate future disruptions effectively. As current dynamics suggest, the global economic order is not collapsing, but evolving. The outcome will depend on how flexibly nations respond to these overlapping pressures and opportunities.

See page 216 for references

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Appendix: Tables and Figures

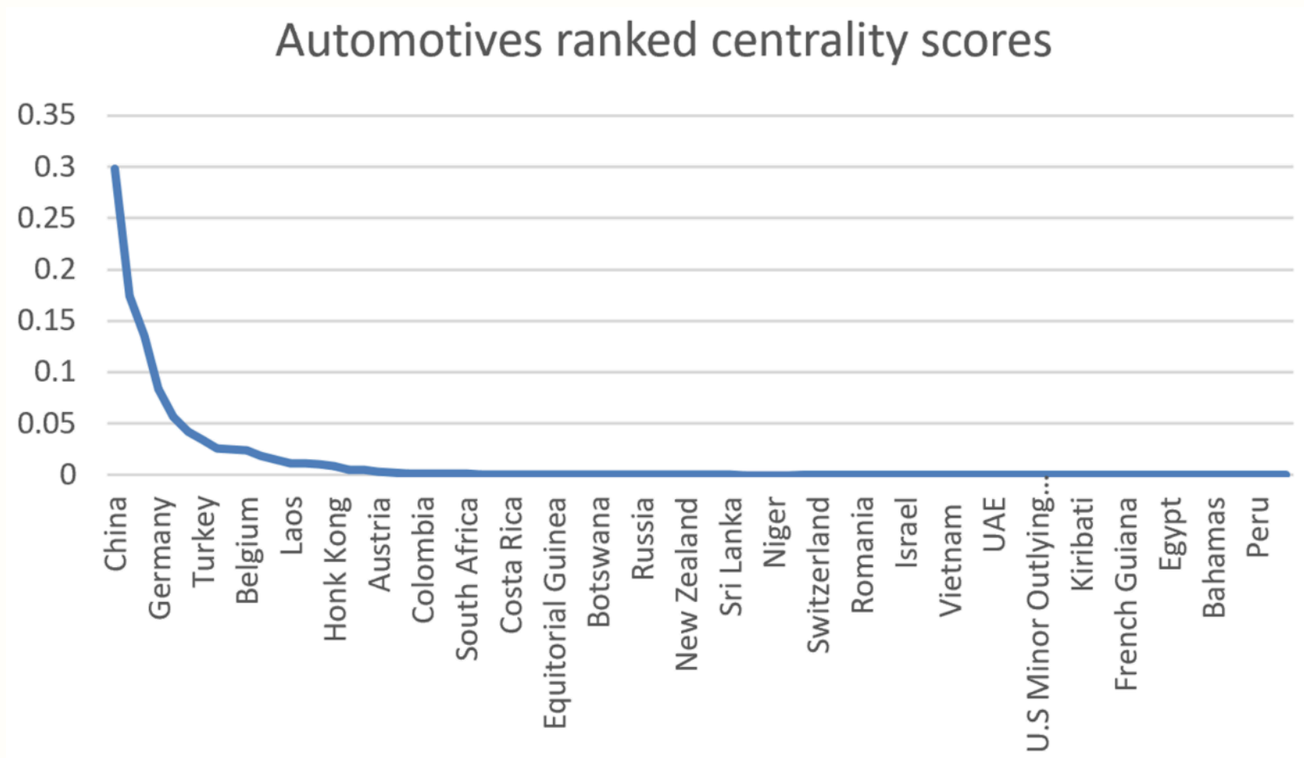

Figure 6: Automotive supplier degree centrality

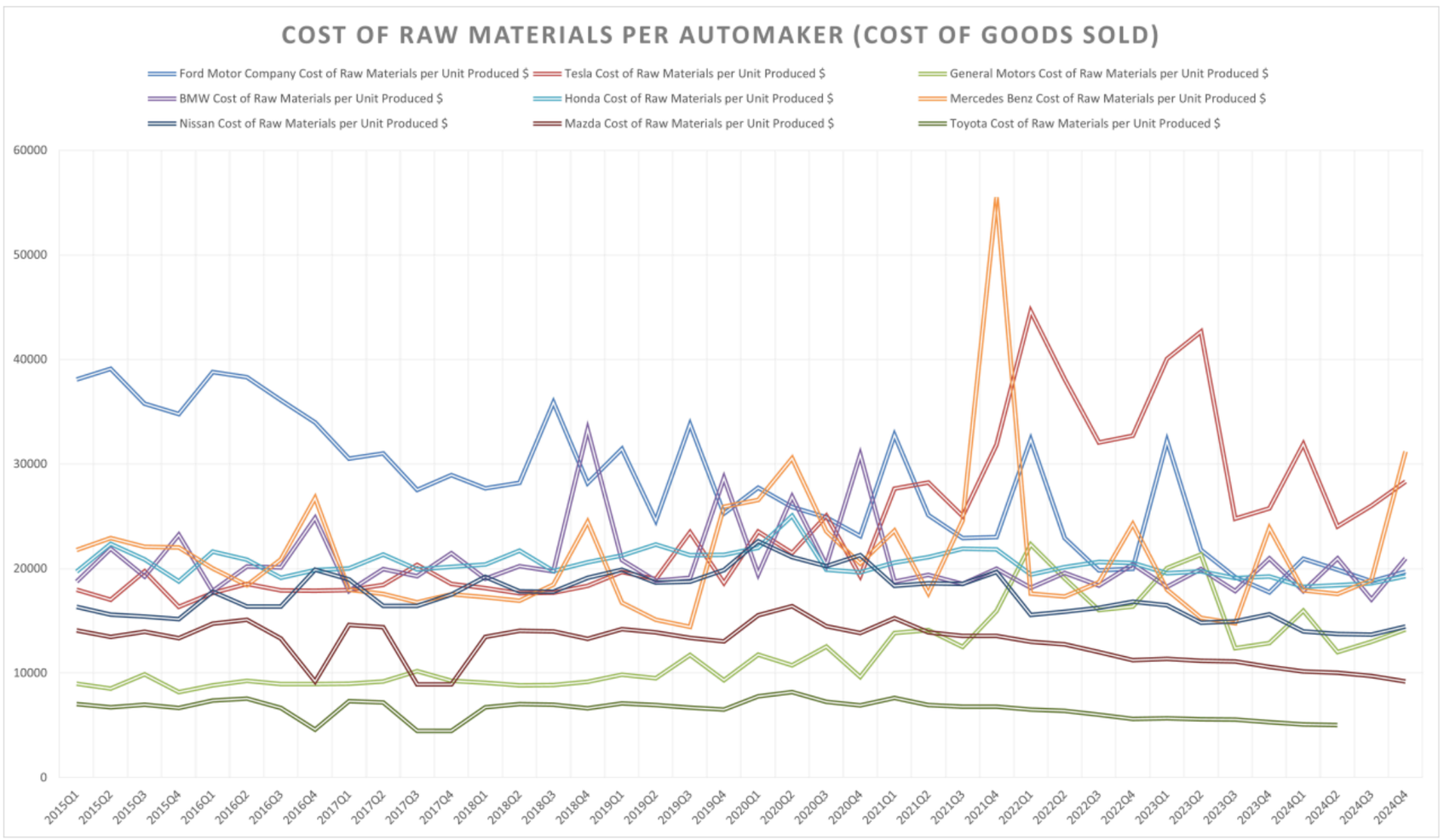

Figure 7: COGS per automaker for period 2015-2024

	(4)
	unit_cost
Xit	-6096.117*
	(3019.525)
dit	26.861
	(16.872)
BMW	0.000
	(.)
FordMotorCompany	6828.593***
	(327.234)
GeneralMotors	-8333.995***
	(153.154)
Honda	-993.182**
	(317.546)
Mazda	-8440.752***
	(261.958)
MercedesBenz	-38.767
	(293.809)
Nissan	-3127.216***
	(88.335)
Tesla	4140.470***
	(429.785)
Toyota	-14402.483***
	(70.433)
Constant	23846.442***
	(1418.068)
Observations	356

Standard errors in parentheses
Standard errors in parentheses, clustered by company_id.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 8: Regression specification (4) Quarter and Firm FE

	(1)
_bs_1	-6096.117***
	(2099.390)
_bs_2	26.861**
	(13.509)
_bs_3	1754.315***
	(182.532)
_bs_4	11.080***
	(1.601)
Observations	356

Standard errors in parentheses
Bootstrap SEs in parentheses; 1,000 reps, seed=12345.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 9: Regression specification (6) Bootstrapping estimation with 1000 replications

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Appendix: Tables and Figures

9.1 A

FOMC Date	Time	Decision	Average Estimates	Median Estimates
1/29/20	19:00	1.75	1.75	1.75
3/3/20	15:00	1.25	1.39	1.5
4/29/20	19:00	0.25	0.25	0.25
6/10/20	19:00	0.25	0.25	0.25
7/29/20	19:00	0.25	0.25	0.25
8/27/20	19:00	0.25	0.25	0.25
9/16/20	19:00	0.25	0.25	0.25
11/5/20	19:00	0.25	0.25	0.25
12/16/20	19:00	0.25	0.25	0.25
1/27/21	19:00	0.25	0.25	0.25
3/17/21	19:00	0.25	0.25	0.25
4/28/21	19:00	0.25	0.25	0.25
6/16/21	19:00	0.25	0.25	0.25
7/28/21	19:00	0.25	0.25	0.25
10/22/21	19:00	0.25	0.25	0.25
11/3/21	19:00	0.25	0.25	0.25
12/15/21	19:00	0.25	0.25	0.25
1/26/22	19:00	0.25	0.25	0.25
3/16/22	19:00	0.50	0.51	0.50
5/4/22	19:00	1.00	0.98	0.10
6/15/22	19:00	1.75	1.59	1.50
7/27/22	19:00	2.50	2.50	2.50
9/21/22	19:00	3.25	3.25	3.25
11/2/22	19:00	4.00	3.99	4.00
12/14/22	19:00	4.50	4.50	4.50
2/1/23	19:00	4.75	4.75	4.75
3/22/23	19:00	5.00	4.97	5.00
5/3/23	19:00	5.25	5.23	5.25
6/15/23	19:00	5.25	5.27	5.25
7/26/23	19:00	5.50	5.49	5.50
9/20/23	19:00	5.50	5.51	5.50
11/1/23	19:00	5.50	5.50	5.50
12/13/23	19:00	5.50	5.50	5.50
1/31/24	19:00	5.50	5.50	5.50
3/20/24	19:00	5.50	5.50	5.50
5/1/24	19:00	5.50	5.50	5.50
6/12/24	19:00	5.50	5.50	5.50
7/31/24	19:00	5.50	5.50	5.50
9/18/24	19:00	5.00	5.23	5.25
11/7/24	19:00	4.75	4.74	4.75
12/18/24	19:00	4.50	4.52	4.50
1/29/25	19:00	4.50	4.50	4.50

Table 3: FOMC meeting decisions and market estimates

9.2 B

Date	$\hat{c}$	$\hat{\phi}$	$\hat{\beta}$	$\hat{\sigma}_\eta$	R^2	t-value ϕ	p-value ϕ	t-value β	p-value β	N
2025-01-07	-0.03180	-0.07711	0.00006	0.03254	0.00629	-0.38480	0.70378	0.08385	0.93387	27
2025-01-08	-0.09772	-0.23775	0.00018	0.03564	0.08241	-1.35389	0.18952	0.24065	0.81206	25
2025-01-10	0.05755	-0.45311	-0.00012	0.03592	0.20511	-2.57675	0.01600	-0.16007	0.87406	29
2025-01-13	0.31044	-0.38660	-0.00072	0.02942	0.16160	-2.21939	0.03474	-1.19351	0.24268	31
2025-01-14	-0.14269	-0.66654	0.00036	0.02046	0.47155	-4.76239	0.00006	0.87046	0.39172	30
2025-01-15	-0.16554	-0.40366	0.00046	0.03558	0.17669	-2.25651	0.03303	0.63312	0.53240	28
2025-01-16	-0.01568	-0.43880	0.00006	0.02589	0.18589	-2.52564	0.01749	0.11161	0.91193	31
2025-01-17	0.04434	-0.21884	-0.00014	0.02008	0.07061	-1.45591	0.15654	-0.34758	0.73076	31
2025-01-21	-0.01245	-0.30652	0.00008	0.01666	0.14712	-2.13445	0.04170	0.23281	0.81760	31
2025-01-22	-0.03370	-0.11808	0.00019	0.01336	0.02323	-0.59646	0.55566	0.67493	0.50526	31
2025-01-23	-0.02833	-0.63318	0.00018	0.01702	0.41299	-4.43728	0.00013	0.52063	0.60672	31
2025-01-24	0.00630	-0.39528	-0.00002	0.01259	0.15639	-2.27734	0.03060	-0.06129	0.95156	31
2025-01-27	0.07501	-0.35810	-0.00060	0.03916	0.13984	-2.09726	0.04512	-0.75093	0.45896	31
2025-01-28	-0.03705	-0.33982	0.00060	0.03984	0.14130	-2.11436	0.04352	0.74052	0.46515	31

Table 4: AR(1) Parameter Estimates by Date (rounded to 5 dp)

9.2 C

Ticker	Metric	mean chg N1	mean chg N2	mean chg N3	mean nchg N1	mean nchg N2	mean nchg N3	pval N1	pval N2	pval N3
AAPL	MAE	0.4356	0.4356	0.4356	0.161	0.161	0.161	0.267	0.267	0.267
AAPL	MAPE	4.469	4.469	4.469	4.626	4.626	4.626	0.9336	0.9336	0.9336
AAPL	RMSE	0.4356	0.4356	0.4356	0.161	0.161	0.161	0.267	0.267	0.267
AMD	MAE	0.7454	0.7454	0.7454	0.9682	0.9682	0.9682	0.7101	0.7101	0.7101
AMD	MAPE	3.784	3.784	3.784	2.65	2.65	2.65	0.3353	0.3353	0.3353
AMD	RMSE	0.7454	0.7454	0.7454	0.9682	0.9682	0.9682	0.7101	0.7101	0.7101
AMZN	MAE	1.023	1.023	1.023	2.453	2.453	2.453	0.03892	0.03892	0.03892
AMZN	MAPE	4.754	4.754	4.754	5.044	5.044	5.044	0.8809	0.8809	0.8809
AMZN	RMSE	1.023	1.023	1.023	2.453	2.453	2.453	0.03892	0.03892	0.03892
BA	MAE	0.4174	0.4174	0.4174	0.1909	0.1909	0.1909	0.07393	0.07393	0.07393
BA	MAPE	3.636	3.636	3.636	3.858	3.858	3.858	0.8951	0.8951	0.8951
BA	RMSE	0.4174	0.4174	0.4174	0.1909	0.1909	0.1909	0.07393	0.07393	0.07393
BAC	MAE	0.3488	0.3488	0.3488	0.3866	0.3866	0.3866	0.8626	0.8626	0.8626
BAC	RMSE	0.3488	0.3488	0.3488	0.3866	0.3866	0.3866	0.8626	0.8626	0.8626
DIS	MAE	0.6523	0.6523	0.6523	0.07492	0.07492	0.07492	0.2871	0.2871	0.2871
DIS	RMSE	0.6523	0.6523	0.6523	0.07492	0.07492	0.07492	0.2871	0.2871	0.2871
F	MAE	0.2775	0.2775	0.2775	0.223	0.223	0.223	0.8069	0.8069	0.8069
F	RMSE	0.2775	0.2775	0.2775	0.223	0.223	0.223	0.8069	0.8069	0.8069
INTC	MAE	0.05078	0.05078	0.05078	0.08181	0.08181	0.08181	0.3012	0.3012	0.3012
INTC	MAPE	5.473	5.473	5.473	5.511	5.511	5.511	0.9752	0.9752	0.9752
INTC	RMSE	0.05078	0.05078	0.05078	0.08181	0.08181	0.08181	0.3012	0.3012	0.3012
JPM	MAE	0.8852	0.8852	0.8852	1.966	1.966	1.966	0.4513	0.4513	0.4513

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Table 5: Per-ticker error metrics and mean changes for N1–N3 intervals

Ticker	Metric	mean chg N1	mean chg N2	mean chg N3	mean nchg N1	mean nchg N2	mean nchg N3	pval N1	pval N2	pval N3
JPM	RMSE	0.8852	0.8852	0.8852	1.966	1.966	1.966	0.4513	0.4513	0.4513
MSFT	MAE	0.4136	0.4136	0.4136	0.2815	0.2815	0.2815	0.1012	0.1012	0.1012
MSFT	MAPE	3.887	3.887	3.887	5.802	5.802	5.802	0.04533	0.04533	0.04533
MSFT	RMSE	0.4136	0.4136	0.4136	0.2815	0.2815	0.2815	0.1012	0.1012	0.1012
MU	MAE	0.09634	0.09634	0.09634	0.7577	0.7577	0.7577	0.03309	0.03309	0.03309
MU	MAPE	5.798	5.798	5.798	6.896	6.896	6.896	0.6989	0.6989	0.6989
MU	RMSE	0.09634	0.09634	0.09634	0.7577	0.7577	0.7577	0.03309	0.03309	0.03309
NFLX	MAE	0.5994	0.5994	0.5994	0.4836	0.4836	0.4836	0.5383	0.5383	0.5383
NFLX	MAPE	6.835	6.835	6.835	4.168	4.168	4.168	0.2194	0.2194	0.2194
NFLX	RMSE	0.5994	0.5994	0.5994	0.4836	0.4836	0.4836	0.5383	0.5383	0.5383
NVDA	MAE	0.564	0.564	0.564	0.5723	0.5723	0.5723	0.968	0.968	0.968
NVDA	MAPE	2.817	2.817	2.817	6.335	6.335	6.335	0.06137	0.06137	0.06137
NVDA	RMSE	0.564	0.564	0.564	0.5723	0.5723	0.5723	0.968	0.968	0.968
PFE	MAE	0.283	0.283	0.283	0.03912	0.03912	0.03912	0.2186	0.2186	0.2186
PFE	RMSE	0.283	0.283	0.283	0.03912	0.03912	0.03912	0.2186	0.2186	0.2186
PYPL	MAE	0.6718	0.6718	0.6718	0.3819	0.3819	0.3819	0.5187	0.5187	0.5187
PYPL	RMSE	0.6718	0.6718	0.6718	0.3819	0.3819	0.3819	0.5187	0.5187	0.5187
SBUX	MAE	1.873	1.873	1.873	0.3872	0.3872	0.3872	0.2356	0.2356	0.2356
SBUX	RMSE	1.873	1.873	1.873	0.3872	0.3872	0.3872	0.2356	0.2356	0.2356
SPY	MAE	1.626	1.626	1.626	0.966	0.966	0.966	0.01713	0.01713	0.01713
SPY	RMSE	1.626	1.626	1.626	0.966	0.966	0.966	0.01713	0.01713	0.01713
T	MAE	0.111	0.111	0.111	0.1587	0.1587	0.1587	0.7186	0.7186	0.7186
T	MAPE	5.276	5.276	5.276	2.333	2.333	2.333	0.556	0.556	0.556

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Table 5 – continued from previous page

Ticker	Metric	mean chg N1	mean chg N2	mean chg N3	mean nchg N1	mean nchg N2	mean nchg N3	pval N1	pval N2	pval N3
T	RMSE	0.111	0.111	0.111	0.1587	0.1587	0.1587	0.7186	0.7186	0.7186
TSLA	MAE	0.7231	0.7231	0.7231	0.8826	0.8826	0.8826	0.7646	0.7646	0.7646
TSLA	MAPE	5.762	5.762	5.762	5.786	5.786	5.786	0.9844	0.9844	0.9844
TSLA	RMSE	0.7231	0.7231	0.7231	0.8826	0.8826	0.8826	0.7646	0.7646	0.7646
UBER	MAE	0.09382	0.09382	0.09382	0.1295	0.1295	0.1295	0.5915	0.5915	0.5915
UBER	MAPE	5.473	5.473	5.473	3.97	3.97	3.97	0.7862	0.7862	0.7862
UBER	RMSE	0.09382	0.09382	0.09382	0.1295	0.1295	0.1295	0.5915	0.5915	0.5915
WMT	MAE	0.2102	0.2102	0.2102	0.2265	0.2265	0.2265	0.9265	0.9265	0.9265
WMT	MAPE	4.767	4.767	4.767	4.755	4.755	4.755	0.9958	0.9958	0.9958
WMT	RMSE	0.2102	0.2102	0.2102	0.2265	0.2265	0.2265	0.9265	0.9265	0.9265
XOM	MAE	0.0372	0.0372	0.0372	0.07929	0.07929	0.07929	0.1198	0.1198	0.1198
XOM	MAPE	4.25	4.25	4.25	3.698	3.698	3.698	0.8387	0.8387	0.8387
XOM	RMSE	0.0372	0.0372	0.0372	0.07929	0.07929	0.07929	0.1198	0.1198	0.1198

Table 5 - continued from previous page

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Appendix: Tables and Figures

A Proof of Proposition 1

In this appendix, we investigate the existence of a symmetric Nash equilibrium level of borrowing and utility. Starting with the rewritten interest rate constraint derived from Equation (2), $r_i = \frac{1}{p_i}$, we substitute this into the firm's utility maximisation problem to obtain:

$$\max_{x_i} U_i = p_i \left(V - \frac{x_i}{p_i} \right)^{\alpha}.$$

Taking the derivative with respect to x_s, we obtain the first-order condition:

$$\frac{\partial U_i}{\partial x_i} = p_i' \left(V - \frac{x_i}{p_i} \right)^{\alpha} + p_i \cdot \alpha \left(V - \frac{x_i}{p_i} \right)^{\alpha-1} \cdot \left(-\frac{1}{p_i} + \frac{x_i}{p_i^2} p_i' \right) = 0,$$

$$\Rightarrow p_i \cdot \frac{\left(V - \frac{x_i}{p_i} \right)^{\alpha}}{\alpha \left(V - \frac{x_i}{p_i} \right)^{\alpha-1}} + x_i = \frac{p_i}{p_i'} \Rightarrow \frac{p_i V}{\alpha} - \frac{x_i}{\alpha} + x_i = \frac{p_i}{p_i'},$$

where $p_i' = \frac{d}{dx_i} \left(\frac{x_i}{\sum x_j + \beta} \right) = \frac{\sum x_j + \beta - x_i}{(\sum x_j + \beta)^2}$. In a symmetric equilibrium, each firm exerts the same level of effort, $x_i = x_s$ for all $i \in N$. Accordingly, $\sum_{j \in N} x_j = n x_s$, and each firm has an identical probability of success:

$$p = \frac{x_s}{n x_s + \beta}, \quad p' = \frac{(n-1)x_s + \beta}{(n x_s + \beta)^2}.$$

Substituting these into the first-order condition we obtain:

$$\frac{x_s V}{\alpha(n x_s + \beta)} + (1 - \frac{1}{\alpha}) x_s = \frac{(n x_s + \beta)^2}{(n-1)x_s + \beta} \cdot \frac{x_s}{n x_s + \beta} = \frac{x_s (n x_s + \beta)}{(n-1)x_s + \beta},$$

$$\Rightarrow x_s [V((n-1)x_s + \beta) + (\alpha - 1)((n-1)x_s + \beta)(n x_s + \beta) - \alpha(n x_s + \beta)^2] = 0.$$

Since $x_s > 0$, zero borrowing does not constitute a symmetric equilibrium. Dividing by x_s and expanding yields:

$$V(n-1)x_s + V\beta + (\alpha - 1)((n-1)n x_s^2 + (2n-1)x_s \beta + \beta^2) - \alpha(n^2 x_s^2 + 2n x_s \beta + \beta^2) = 0.$$

This simplifies to:

$$V(n-1)x_s + V\beta + [(\alpha - 1)(n^2 x_s^2 + 2n x_s \beta + \beta^2) - (\alpha - 1)(n x_s^2 + x_s \beta)] - \alpha(n^2 x_s^2 + 2n x_s \beta + \beta^2) = 0,$$

$$\Rightarrow V(n-1)x_s + V\beta - (n^2 x_s^2 + 2n x_s \beta + \beta^2) + (1 - \alpha)(n x_s^2 + x_s \beta) = 0.$$

Rewriting in terms of x_s gives the quadratic equation:

$$[(1-\alpha)n - n^2] x_s^2 + [V(n-1) - \beta(2n - (1-\alpha))] x_s + V\beta - \beta^2 = 0$$

Solving the first-order condition using the quadratic formula yields a bi-modal expression for the candidate equilibrium borrowing level x_s:

$$x_s = \frac{V(n-1) - \beta(2n - (1-\alpha)) \pm \sqrt{(V(n-1) - \beta(2n - (1-\alpha)))^2 + 4n(V\beta - \beta^2)(n - (1-\alpha))}}{2n(n - (1-\alpha))}.$$

Observe that the square root term in the numerator is strictly greater than the linear term it is added to:

$$\sqrt{(V(n-1) - \beta(2n - (1-\alpha)))^2 + 4n(V\beta - \beta^2)(n - (1-\alpha))} > V(n-1) - \beta(2n - (1-\alpha)).$$

As such, only the solution with the positive square root term yields a feasible solution for $x_s > 0$. Therefore, the candidate symmetric Nash equilibrium borrowing level is:

$$x_s = \frac{\sqrt{[V(n-1) - \beta(2n - (1-\alpha))]^2 + 4n\beta(V - \beta)(n - (1-\alpha))} + V(n-1) - \beta(2n - (1-\alpha))}{2n(n - (1-\alpha))}.$$

However, for this interior solution to constitute a Nash equilibrium, two conditions must be satisfied: (i) the resulting utility must be strictly positive, and (ii) the firm's best-response problem must be strictly concave in its own choice of borrowing.

The first condition (i) ensures that each firm has an incentive to participate in the contest. Given the functional form of firm i's utility from (1)

$$U_i(x_i) = p_i \cdot (V - r_i \cdot x_i)^\alpha,$$

substituting in the candidate equilibrium x_s, where $p_i(x_s) = \frac{x_s}{nx_s + \beta}$ and $r_i = \frac{1}{p_i}$, the expected payoff of each firm in symmetric equilibrium is:

$$U_i(x_s) = \frac{x_s}{nx_s + \beta} \cdot \left(V - \left(\frac{x_s(nx_s + \beta)}{x_s}\right)\right)^\alpha = \frac{x_s}{nx_s + \beta} \cdot (V - nx_s - \beta)^\alpha.$$

Noting that the first fraction is strictly positive for all $x_s > 0$, we require that the term $(V - nx_s - \beta)$ be strictly positive to ensure well-defined, positive utility. This implies the following *utility feasibility condition*:

$$x_s < \frac{V - \beta}{n}, \tag{7}$$

This constraint is necessary for the candidate solution x_s to constitute an equilibrium with strictly positive utility, $U_i(x_s) > 0$.

Next (ii), to verify that the candidate solution indeed represents a global maximum of each firm's payoff function, we must verify that each firm's utility function is strictly concave in its own choice variable, conditional on the others playing the symmetric strategy x_s. Formally, this entails that the second derivative of firm i's utility function with respect to x_i, evaluated at $x_{-i} = x_s$, is strictly negative:

$$\frac{\partial^2 U_i(x_i | x_{-i} = x_s)}{\partial x_i^2} < 0.$$

Consider the utility of firm i when all other firms exert effort x_s:

$$U_i(x_i | x_{-i} = x_s) = \frac{x_i}{(n-1)x_s + x_i + \beta} \cdot [V - ((n-1)x_s + x_i + \beta]^\alpha.$$

The first derivative with respect to x_i is:

$$\frac{\partial U_i(x_i|x_{-i}=x_s)}{\partial x_i} = \frac{(n-1)x_s+\beta}{((n-1)x_s+x_i+\beta)^2}\cdot[V-((n-1)x_s+x_i+\beta)]^{\alpha} - \frac{x_i}{(n-1)x_s+x_i+\beta}\cdot\alpha[V-((n-1)x_s+x_i+\beta)]^{\alpha-1}.$$

Differentiating once more yields:

$$\frac{\partial^2 U_i(x_i|x_{-i}=x_s)}{\partial x_i^2} = -\frac{2(n-1)x_s+\beta}{((n-1)x_s+x_i+\beta)^3}\cdot[V-((n-1)x_s+x_i+\beta)]^{\alpha} - \frac{2((n-1)x_s+\beta)}{((n-1)x_s+x_i+\beta)^2}\cdot\alpha[V-((n-1)x_s+x_i+\beta)]^{\alpha-1} + \frac{x_i}{(n-1)x_s+x_i+\beta}\cdot\alpha(\alpha-1)[V-((n-1)x_s+x_i+\beta)]^{\alpha-2}.$$

For $x_i, x_s > 0$, the first two terms are strictly negative due to the positivity of all components. The third term is also non-positive, being zero when $\alpha = 1$ and strictly negative for $\alpha \in (0,1)$. Therefore, the utility function is strictly concave in x_i, confirming that the first-order condition characterises a global maximum.

Given the concavity of the best-response problem, the utility feasibility condition (7) is both necessary and sufficient to establish that effort x_s and utility $U_i(x_s)$ form a symmetric (pure-strategy) Nash equilibrium. □

B Proof of Corollary 1

Using Proposition 1, we derive the symmetric Nash equilibrium levels of borrowing and utility under the condition for existence. Setting $\beta = 0$ in the closed-form expression for the symmetric equilibrium borrowing level in (3), we obtain:

$$x_s = \frac{\sqrt{[V(n-1)]^2}+V(n-1)}{2n(n-(1-\alpha))} = \frac{2V(n-1)}{2n(n-(1-\alpha))} = \frac{V(n-1)}{n(n-(1-\alpha))}.$$

To verify that this expression satisfies the utility feasibility condition $x_s < \frac{V-\beta}{n}$, $\beta = 0$ yields the requirement:

$$\frac{V(n-1)}{n(n-(1-\alpha))} < \frac{V}{n}.$$

Simplifying, this becomes:

$$\frac{n-1}{n-(1-\alpha)} < 1 \Leftrightarrow \frac{n-1}{n-(1+\alpha)} < 1,$$

which clearly holds for all $\alpha \in (0,1]$, as assumed. Hence, the feasibility condition is always satisfied when $\beta = 0$, and an interior symmetric Nash equilibrium exists for all $n \geq 2$ and $\alpha \in (0,1]$ in the absence of aggregate or systematic risk.

The corresponding equilibrium utility for each firm in this special case simplifies considerably. Using the general utility form in symmetric equilibrium:

$$U_i(x_s) = \frac{x_s}{nx_s+\beta}\cdot(V-nx_s-\beta)^{\alpha} = \frac{1}{n}\cdot(V-nx_s)^{\alpha},$$

and substituting the equilibrium value of x_s, we obtain:

$$U_s = \frac{1}{n} \cdot \left(V - \frac{V(n-1)}{(n-(1-\alpha))} \right)^{\alpha} = \frac{1}{n} \cdot \left(\frac{\alpha V}{n-(1-\alpha)} \right)^{\alpha}.$$

Therefore, equilibrium utility simplifies to:

$$U_s = \frac{V^{\alpha}}{n} \cdot \left(\frac{\alpha}{n-(1-\alpha)} \right)^{\alpha}.$$

This confirms that when the risk of no winner emerging is eliminated, the symmetric equilibrium exists unconditionally and admits a tractable closed-form expression for individual effort and utility. □

C Proof of Proposition 2

This appendix characterises how equilibrium borrowing and utility vary with key parameters of the model. In particular, we focus on the relationship between equilibrium utility and the risk preference parameter $\alpha \in (0, 1]$. As shown in Corollary 1, when the possibility of no winner is excluded by setting $\beta = 0$, the symmetric Nash equilibrium borrowing effort and utility are given by:

$$x_s = \frac{V(n-1)}{n(n-(1-\alpha))}, \quad U_s = \frac{V^{\alpha}}{n} \cdot \left(\frac{\alpha}{n-(1-\alpha)} \right)^{\alpha}.$$

It is immediate from inspection that x_s increases in V and decreases in both n and α. Similarly, equilibrium utility is strictly increasing in V and decreasing in n.

To investigate how U_s varies with α, we define:

$$z(\alpha) := \frac{\alpha}{n-(1-\alpha)}.$$

This allows the utility expression to be written compactly as:

$$U_s = \frac{V^{\alpha}}{n} \cdot z(\alpha)^{\alpha}.$$

Applying the product and chain rules, the derivative of $U_i(x_s)$ with respect to α is:

$$\frac{\partial U_s}{\partial \alpha} = \frac{1}{n} \left(V^{\alpha} \cdot \frac{dz(\alpha)^{\alpha}}{d\alpha} + z(\alpha)^{\alpha} \cdot \frac{dV^{\alpha}}{d\alpha} \right).$$

Proceeding to compute each term separately, the derivative of V^{α} is:

$$\frac{dV^{\alpha}}{d\alpha} = V^{\alpha} \ln V.$$

Next, the derivative of $z(\alpha)^{\alpha}$ satisfies:

$$\frac{dz(\alpha)^{\alpha}}{d\alpha} = z(\alpha)^{\alpha} \left(\ln z(\alpha) + \frac{\alpha}{z(\alpha)} \cdot \frac{dz(\alpha)}{d\alpha} \right).$$

Since $z(\alpha) = \frac{\alpha}{n-1+\alpha}$, the derivative of $z(\alpha)$ with respect to α is:

$$\frac{dz(\alpha)}{d\alpha} = \frac{(n-1+\alpha) \cdot 1 - \alpha \cdot 1}{(n-1+\alpha)^2} = \frac{n-1}{(n-1+\alpha)^2},$$

which is strictly positive for all $n \geq 2$ and $\alpha \in (0, 1]$.

Substituting these expressions, the total derivative becomes:

$$\frac{\partial U_s}{\partial \alpha} = \frac{1}{n}\left[V^\alpha \cdot z(\alpha)^\alpha \left(\ln z(\alpha) + \frac{\alpha}{z(\alpha)} \cdot \frac{n-1}{(n-1+\alpha)^2}\right) + z(\alpha)^\alpha \cdot V^\alpha \ln V\right].$$

All components of this expression are strictly positive under the maintained restrictions that $V > 0$, $n \geq 2$, and $\alpha \in (0, 1]$. In particular, $z(\alpha) > 0$ and all logarithmic and rational terms are well-defined and positive. It follows that the derivative is strictly positive:

$$\frac{\partial U_s}{\partial \alpha} > 0.$$

Therefore, holding all other parameters fixed, equilibrium utility is strictly increasing in α. □

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