The US-China Trade War: Macro Effects of Tariff Shocks in a Two-Country DSGE Model

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Abstract

This thesis analyzes the macroeconomic effects of the U.S.–China trade war—a major bilateral conflict with global implications—focusing on why both countries impose tariffs for perceived economic gains. Therefore, we first address whether high tariffs imposed by the U.S. and China—citing large trade deficits as highlighted by the Trump administration—will improve or worsen those deficits and what macroeconomic consequences will follow. As a second question, we examine whether broadening the motivation beyond the trade deficit—to include domestic jobs, non-economic factors, foreign tariffs, subsidies, and their combinations—better fits the data under indirect inference and reveals which scenario minimizes welfare loss. Finally, we explore whether adding institutional structure—using sovereign ESG as a proxy—and tracing the link from tariffs to ESG to other macro variables improves model efficiency under indirect inference, and whether the best-matched model (via IIW) confirms or statistically rejects certain regression relationships as spurious. This study makes three main contributions to the literature. First, using a two-country DSGE model, we show that higher tariffs—often intended to reduce trade deficits—fail to achieve this goal. Second, applying indirect inference, we demonstrate that although higher tariffs justified by large trade deficits align most closely with the data, the lowest welfare loss arises under zero-tariff scenarios. Third, by incorporating sovereign ESG as a proxy for institutional quality, we improve the model's empirical fit, highlighting the critical role of institutional factors in macroeconomic responses to trade policy.

Keywords: U.S.–China trade war, DSGE model, indirect inference, welfare analysis, sovereign ESG

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Chapter 1

Introduction

The U.S.–China trade war has become one of the most important events in recent global economic history. For many years, economists and policymakers believed that free trade—especially trade without tariffs—brings mutual benefits to all countries involved. This belief has shaped international trade rules and cooperation for decades. The intellectual foundations of this idea can be traced back to classical economists. Smith (2002, originally published in 1776) introduced the concept of the "invisible hand", arguing that an effective market is created through free competition. Following this, David (1971) developed the theory of comparative advantage, showing that countries can achieve maximum benefits by specialising in goods where they hold a production efficiency advantage. Similarly, Bastiat (1873), through his example of the "Candle Makers' Petition," mocked the absurdities of protectionism and strongly advocated for free trade. From the perspective of labour economics, George (2017) argued that protective tariffs harm workers and primarily benefit monopolistic interests.

Beyond academic discussions, practical developments have also demonstrated a clear global trend toward free trade and zero-tariff agreements, especially since the early 21st century, as shown in Figure 1.1. This trend has been most directly reflected in the sharp reduction of tariffs—often by more than 90%—as noted in several key agreements(Office of the United States Trade Representative, 2001). In what follows, we focus on three major events that have had particularly significant effects. The first is China's accession to the WTO, which involved a commitment to substantial tariff cuts and a wider opening of its service sector—key steps that promoted deeper integration into the global trading system. The second is the TPP agreement in 2016, which aimed to establish a free trade area covering 40% of global GDP(Office of the United States Trade Representative, 2016). Although the US withdrew in 2017, many of its high-standard provisions remained and were carried forward into the CPTPP[1]. This weakened US leadership in regional trade and contributed to a shift in the structure of global trade. The third is the

[1] CPTPP: Comprehensive and Progressive Agreement for Trans-Pacific Partnership

signing of the RCEP[2] in 2020, which brought together 15 countries—including ASEAN[3] members, China, Japan, South Korea, Australia, and New Zealand—forming what is now the world's largest free trade pact(Association of Southeast Asian Nations, 2020).

Table 1.1: Timeline of Major Free Trade Agreements Since 2001

Year	Event
2001	China joins the WTO (World Trade Organization), committing to major tariff cuts
2004	China and ASEAN sign ACFTA (ASEAN–China Free Trade Agreement) to eliminate tariffs on 90% of goods
2005	AUSFTA (Australia–United States Free Trade Agreement) comes into effect, removing tariffs on 99% of goods
2006	USBFTA (U.S.–Bahrain Free Trade Agreement) enters into force, eliminating all industrial and consumer tariffs
2007	USCFTA (U.S.–Colombia Free Trade Agreement) is signed to boost bilateral trade
2009	USPTPA (U.S.–Peru Trade Promotion Agreement) comes into force, cutting 80% of tariffs immediately
2010	KOREU FTA (Korea–European Union Free Trade Agreement) signed, removing tariffs on 98.7% of goods
2012	KORUS FTA (U.S.–Korea Free Trade Agreement) enters into force, eliminating 95% of tariffs
2016	TPP (Trans-Pacific Partnership) signed by 12 nations, aiming at a 40% GDP zone (U.S. exits in 2017)
2018	AfCFTA (African Continental Free Trade Area) signed, targeting 90% tariff removal in intra-African trade
2019	EVFTA (European Union–Vietnam Free Trade Agreement) signed, removing 90% of tariffs over 7 years
2020	RCEP (Regional Comprehensive Economic Partnership) signed by 15 countries, aiming to cut 92% of tariffs over 20 years
2021	AfCFTA (African Continental Free Trade Area) officially enters into force
2022	RCEP (Regional Comprehensive Economic Partnership) comes into effect, covering 30% of global population and GDP
2024	CNZFTA (China–New Zealand Free Trade Agreement) upgraded to eliminate tariffs on NZ dairy exports
2024	EUNZFTA (European Union–New Zealand Free Trade Agreement) signed, removing all tariffs within 7 years
2025	China implements zero-tariff policy for 43 LDCs (Least Developed Countries)

However, the implementation of zero-tariff policies is often constrained by factors beyond economics. While the benefits of free trade are well established in theory, actual trade policies are frequently influenced by geopolitical tensions, technological rivalry, and national strategic interests (Drozdz and Miškinis, 2011). These factors help explain episodes such as the U.S.–China trade war, despite the acknowledged economic gains from liberalisation (Chong and Li, 2019). To illustrate how real-world trade policy has increasingly followed a pattern of non-cooperation—despite the continued presence of cooperative efforts—Table 1.2 lists a series of events that reflect the recent turn toward protectionism. In what follows, we focus on a few key events that have been particularly influential. The first is the WTO's ruling against U.S. steel tariffs, which compelled their withdrawal. Although this reinforced the WTO's institutional authority, it also provoked discontent within the U.S., laying the groundwork for future scepticism toward multilateral frameworks (Bown and Kolb, 2022). The second event is the U.S. imposition of safeguard tariffs[4] on Chinese tires in 2009. China responded with retaliatory tariffs on U.S. chicken and auto parts(Grimmett et al., 2011). Although short-lived, these actions renewed attention to the return of protectionist tendencies. The third occurred in 2018, when the U.S. imposed global tariffs of 20% on steel and 10% on aluminum. Widely viewed as the onset of the U.S.–China trade war, this measure signalled a decisive move away from multilateralism, triggering retaliatory tariffs from major trading partners and placing additional pressure on the WTO's dispute settlement mechanism (Bown, 2019).

[2]RCEP: Regional Comprehensive Economic Partnership

[3]ASEAN: Association of Southeast Asian Nations

[4]Safeguard tariffs are typically short-term measures, often lasting around four years. They are not imposed due to unfair trading, but in response to a sharp increase in imports.

Table 1.2: Timeline of Major Trade Protection Events

Year	**Event**
2001	U.S. imposes anti-dumping duties on Vietnamese catfish
2002	U.S. imposes tariffs on imported steel from EU
2003	WTO rules U.S. steel tariffs illegal; U.S. repeals them
2003	WTO Doha Round fails in Cancún due to agricultural disputes
2005	EU imposes import quotas on Chinese textiles
2006	U.S. levies anti-dumping duties on Chinese paper products
2007	WTO Doha talks break down in Potsdam over subsidies
2008	WTO Doha talks fail again in Geneva
2009	U.S. imposes safeguard tariffs on Chinese tires
2010	India raises tariffs on electronics to protect local industry
2012	Argentina enacts non-automatic import licensing system
2013	Russia becomes top user of protectionist measures globally
2014	EU imposes anti-dumping duties on Chinese solar panels
2015	India imposes anti-dumping tariffs on steel products
2016	UK votes to leave EU (Brexit referendum)
2017	U.S. exits TPP under Trump administration
2017	U.S. renegotiates NAFTA, favoring 'America First'
2017	U.S. imposes tariffs on Canadian softwood lumber
2018	U.S. imposes tariffs on solar panels and washing machines
2018	U.S. imposes steel (25%) and aluminum (10%) tariffs globally

These events suggest that tariffs have been used as a tool to break from cooperation. This marked the beginning of the U.S.–China trade conflict, in which tariffs have remained a central feature. We now return to a more fundamental question: why do we study tariff shocks? Ideally, all such motivations would be incorporated into our model. Yet many of these non-economic factors are hard to measure, such as competition over national power. As a result, we focus on the trade deficit. The trade deficit is often given as a reason in official statements. It is easy to measure and appears frequently in government documents, as shown in Table 1.3. Whatever its theoretical validity, it plays a clear role in actual tariff policy, especially in the case of the U.S.–China trade war, where it helped justify both the initial measures and later escalations. Therefore, Chapter 2 starts from the trade deficit. We introduce a two-country DSGE model with symmetric tariffs to study a tariff increase, using a larger deficit as the justification. We also look at non-economic factors, not just economic ones. These are hard to measure. They are not clearly mentioned in U.S. documents. Political reasons, for example, are only guessed. So we turn to this in Chapter 3.

Table 1.3: US-China Trade Actions and Tariff Timeline (2018–2025)

Date	Trade Deficit (USD)	Policy Event	Tariff Action	Stated Reason
2018/3/22	Approx. $375B (high)	Announcement of Section 301 Investigation	Preparing to impose tariffs on Chinese products	Massive trade deficit, technology transfers, etc.
2018/7/6	Approx. $375B (high)	First round of tariffs takes effect	25% tariffs on $34B worth of goods	Punish unfair trade practices by China
2018/9/24	Approx. $375B (high)	Second round of tariffs takes effect	10% tariffs on $200B of goods, rising to 25%	China failed to correct its trade behavior
2019/5/10	Approx. $345B (high)	Tariff rate increase	Tariffs on $200B of goods raised from 10% to 25%	Negotiations failed, China did not make enough concessions
2019/8/1	Approx. $345B (high)	Announcement of tariffs on remaining goods	10% tariffs on remaining $300B worth of goods	Deficit remains, China did not fulfill commitments
2020/1/15	Approx. $310B (high)	Phase One Agreement signed	Tariffs on $250B worth of goods retained as leverage	Pressure tool, deficit not significantly reduced
2025/2/1	Over $400B (very high)	Resumption of China tariffs	10% tariffs on all Chinese goods	Trade deficit continues to expand
2025/3/1	Over $400B (very high)	Tariff rate increase	Tariffs raised to 20% on Chinese goods, 25% on some	Chinese overcapacity, growing surplus
2025/4/5	Over $400B (very high)	Global Unified Tariff Framework	Tariffs on Chinese goods up to 45%	China has the largest trade surplus with the U.S.
2025/4/9	Over $400B (very high)	Special tariff on low-value goods	Up to $100 tax per item	Prevent tariff evasion via postal shipments
2025/4/10	Over $400B (very high)	Comprehensive tariff escalation	Tariffs raised up to 145%, some exemptions granted	Countering Chinese surplus and subsidy practices

Chapter 2 explores how tariffs are used to address trade imbalances, focusing on the U.S.–China trade war. In 2018, the U.S. put tariffs on Chinese goods to deal with the trade deficit, which had reached $419.2 billion. It uses a two-country New Keynesian DSGE model where tariffs respond to trade deficits to study their broader effects. The model has two symmetric countries, the U.S. and China, and includes a rule where tariffs change with trade imbalances. This shows how tariffs affect output, inflation, and trade flows in both countries.

After starting with the trade deficit as the main reason for raising tariffs, we then extend the analysis to look at other possible motives. As noted earlier, we cannot clearly identify reasons that are not often stated. But we still want to see what effects these hidden motives may have. For example, Trump's tariff policy was not only aimed at foreign countries or protecting U.S. manufacturing. It also served a political purpose. Regions that supported him received tariff relief, while others faced greater losses (Kim and Yoon, 2021). Therefore, Chapter 3 looks at other possible reasons for tariffs, such as political factors, protection of domestic jobs, retaliation, and anti-dumping. This is because, in practice, we need to know what caused the trade war from the tariff side. We also want to see which reasons may explain it under different possible cases. We also use a two-country DSGE model with the indirect inference method to estimate parameters. But unlike in Chapter 2, we change the tariff rule to reflect different cases. We also compare welfare loss across models under the same parameters to see which case performs better. Therefore, Chapter 3 finds that using the trade deficit as a reason for high tariffs fits the real data best. This case seems most in line with what happened in practice.

After examining how tariffs affect macroeconomic variables, we now turn to an important issue. How do tariffs affect GDP, inflation, and other macroeconomic variables? We select one variable, the Sovereign ESG index, which reflects a country's performance in environmental, social, and governance (ESG) dimensions. We use it as a mechanism variable to examine whether the effects of tariffs are transmitted through Sovereign ESG, and subsequently affect other macroeconomic variables. The main reason for us choose sovereign ESG, is that, it gradually become more and more important, especially in the context of us-china trade war.

Usually, when we assess a country's performance, we look at economic indicators such as GDP growth, inflation, and debt levels. However, when a country faces problems, the cause may not lie in surface-level economic numbers. Instead, the real reasons may be deeper issues—such as weak institutions, social injustice, or environmental damage. These deeper problems can be seen through the Sovereign ESG index. It shows whether a country protects the environment, if its society is stable, and whether the government is honest or corrupt. Many studies have found that countries with good Sovereign ESG performance are more likely to attract investment. They also tend to have higher credit ratings and can handle emergencies—such as economic crises or the COVID-19 pandemic—more effectively. In this way, Sovereign ESG helps us see a country's true condition. It gives a more complete picture than looking at GDP alone.

Especially in the context of the U.S.–China trade war, both countries have faced greater social pressure and significant changes in government policies due to tariff shocks. So, we want to know whether these shocks have gradually weakened a country's institutions and social foundations. By using the Sovereign ESG index, we can observe these deeper changes over time. In past research, most studies have focused only on the impact of trade shocks on GDP. Very few have explored their deeper effects from the perspective of institutions, society, and the environment. This is also the main innovation of Chapter 4.

The structure of the thesis is as follows: Chapter 2 examines whether tariffs can be an effective tool to correct the U.S.–China trade imbalance. In Chapter 3, building on the analysis in Chapter 2, we explore a wide range of scenarios, each driven by different underlying motivations. Chapter 3 aims to identify the reasons behind the start of the U.S.–China trade war. It divides these reasons into several key motivations, including political factors, the protection of domestic jobs, responses to subsidized foreign goods, and retaliatory tariffs in response to foreign trade measures. Once we identify the reasons for initiating tariffs in the U.S.–China trade war, Chapter 4 focuses on the transmission process—examining how tariff shocks affect the Sovereign ESG index, and how this, in turn, influences other macroeconomic variables.

Chapter 2

Baseline Two-Country DSGE Model of Tariff Adjustment under Trade Deficit

2.1 Introduction

The U.S.–China trade war, which began in 2018 under the Trump administration, was officially tied to concerns over intellectual property and national security. Yet the large trade deficit, which peaked at $419.2 billion in 2018, was often used to justify tariffs (Fajgelbaum and Khandelwal, 2022). Figure2.1.1 shows the sharp rise in the deficit from 2001 to 2017, after which, in 2018, the U.S. imposed high tariffs on Chinese goods, mainly targeting steel, electronics, 5G, and AI (Bown, 2019). These actions were often connected to the trade imbalance. China responded with tariffs on U.S. agricultural goods and domestic policy shifts (Kapustina et al., 2020). In 2020, the Phase One deal[1] was signed. China agreed to buy over $200 billion in U.S. goods. But the tariffs stayed in place. This continued pattern shows that the trade deficit remained central in U.S. trade policy. It also provides the starting point for our model.

Therefore, given this background, it is natural to ask: do tariffs that are justified by trade imbalances actually help reduce them? And what effects do these tariffs have on output, inflation, and trade flows in both countries? Some studies have looked at this from a micro perspective or used other types of DSGE models. But few use a standard two-country New Keynesian model with tariffs that respond to trade deficits. In this paper, we use such a model. We add a rule where tariffs react to the trade balance. This lets us test whether the policy works, and what it does to the main macro variables.

To answer this question, we build a two-country DSGE model. It is used to study how tariffs interact with macroeconomic variables. We estimate the model using the indirect inference method (IIM). We then look at the transmission mechanism through impulse

[1]The Phase One deal was signed to ease tensions. China agreed to increase U.S. imports and improve rules on intellectual property and currency.

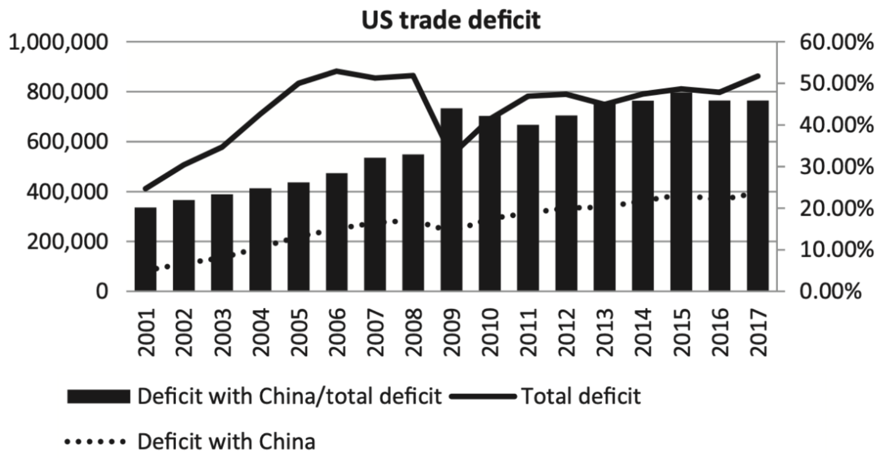

Figure 2.1.1: US trade deficit
Data Source: UN Comtrade database

response functions (IRFs) and forecast error variance decomposition (FEVD). Finally, we use simulated data to do a historical variance decomposition. This helps us find the main drivers of macroeconomic changes from 2001 to 2023Q1.

This paper makes three main contributions. First, we treat tariff shocks as endogenous, not exogenous. We add a tariff rule to the two-country DSGE model so that tariff rates respond to the trade deficit. Second, our results show that domestic supply-side shocks still drive most of the macro variation. Foreign shocks matter too, but their effects are smaller and less direct. Third, we show how tariff shocks affect key macro variables. This helps us track how trade policy moves through the economy.

This chapter is structured as follows. Section 2 reviews the literature and points out the gap. Section 3 sets out the two-country DSGE model. Section 4 explains how we estimate the model using the Indirect Inference Method (IIM). Section 5 shows the dynamic responses with impulse response functions (IRFs) and forecast error variance decomposition (FEVD). Section 6 uses simulated data to run a historical variance decomposition (HVD) and identify the main drivers of macro fluctuations. Section 7 concludes.

2.2 Literature Review

Recently, the US-China trade war has caused economic disruptions across multiple dimensions, including countries, firms, and investors. Firstly, at the national level, bilateral tariff barriers have led to increased import costs and higher living expenses for citizens(Hobijn and Nechio, 2025). As a result, these rising costs have spilled over into innovation expenditures, leading to inefficiencies and delays in global technological advancement(Liang, 2023). Specifically, at the firm level, the US-China trade war has led many multinational companies to restructure their supply chains by shifting production from China and the US to Southeast Asia, thereby increasing overall production costs(Chen, 2021). These effects can spill over into financial markets by lowering investor confidence, as the uncertainty of the US-China trade war slows global investment decisions(Zou et al., 2024). In a more extreme scenario, investor concerns may trigger capital outflows from developing countries, further increasing uncertainty in global financial markets(Jung, 2023). Therefore, tariffs can lead to broader economic disruptions through several mechanisms, including bilateral tariff barriers, technological decoupling, supply chain restructuring by multinational firms, declining investor confidence, and financial market volatility. It is thus important to find a way to quantify these effects.

We therefore consider using tariffs to study the economic disruptions, as they are easily quantifiable and widely used in analyzing the effects of the US-China trade war. On the supply side, Frequent adjustments in tariff policy create uncertainty, making it difficult for firms to predict future market conditions(Sharfaei et al., 2023). This uncertainty can depress capital expenditure, hinder innovation, and reduce productivity(Chae et al., 2019). This uncertainty can be intensified by retaliatory tariffs, leading to lower exports and further exacerbating negative impacts on firms, potentially resulting in layoffs or bankruptcies and creating a vicious cycle(Akcigit et al., 2018). Following the uncertainty, supply chain disruptions can hinder the global flow of materials, leading to higher costs, production delays, and reduced international competitiveness(Lee, 2021). To avoid these negative effects, firms may not only halt current supply chains and rebuild new ones, but also substitute highly efficient products with those from less efficient industries, leading to resource misallocation(Alessandria et al., 2023). Therefore, tariffs can lead to a series of economic disruptions through several mechanisms, including price increases, market uncertainty, retaliatory tariffs, supply chain disruptions, and resource misallocation.

Next, we focus on the macroeconomic effects of tariffs as a lens to understand the broader economic disruptions they cause. We have selected four key macroeconomic variables to analyze the effects of tariffs, as they are strongly related to tariff changes. We first analyze how tariffs affect external economic relations, then turn to internal impacts, following the dimensions of nations, firms, and consumers.

As trade imbalances reflect external economic relations, we begin our analysis with them. Import reduction serves as a potential mechanism through which tariffs, by increasing import costs, may help reduce the trade deficit(Noureen and Mahmood, 2020). Rising import costs may not only reduce import volumes but also trigger imported inflation, thereby increasing domestic prices, as many export-oriented industries rely on imported inputs(Furceri et al., 2020). Additionally, resource allocation may be distorted, as tariffs can protect domestic industries without comparative advantage, leading to resource misallocation and reduced efficiency(Furceri et al., 2020). Furthermore, countries targeted by tariffs may respond with retaliatory measures, leading to a decline in our home country's exports and an exacerbation of the trade deficit(Akcigit et al., 2018). Therefore, one possible mechanism is exchange rate adjustment: higher tariffs reduce import demand, lowering the demand for foreign currency(Furceri et al., 2020). This can appreciate the home currency, making exports more expensive and imports cheaper, partially offsetting tariff effects(Jeanne and Son, 2024). On the other hand, trade diversion can also act as a response mechanism(Fajgelbaum and Khandelwal, 2022). Although tariffs reduce direct imports from China, U.S. firms may turn to third countries for the same goods(Fajgelbaum and Khandelwal, 2022). These third countries, in turn, continue importing from China(Haberkorn et al., 2024). As a result, the overall trade balance between the U.S. and China remains relatively stable, with only a modest shift in direct bilateral trade(Barattieri et al., 2021). Therefore, lower imports, higher domestic prices, resource misallocation, retaliatory tariffs, exchange rate adjustments, and trade diversion are key mechanisms through which tariffs contribute to trade imbalances.

Having examined the external effects of tariffs, we next analyze their internal impacts, starting with their influence on national GDP. We begin by examining the net export mechanism: higher tariffs may reduce imports, improve the trade balance, and ultimately boost GDP(Idris et al., 2019). Additionally, the resource misallocation mechanism may arise, as tariffs can protect low-efficiency industries, diverting resources toward less competitive sectors. This reduces overall economic efficiency, lowers productivity, and ultimately slows GDP growth(Noureen and Mahmood, 2020). Next, the consumption and investment mechanisms—two key components of GDP—are also negatively affected(Barattieri et al., 2021). On the one hand, higher tariffs raise the prices of imported goods, reducing consumers' real purchasing power and thereby lowering consumption expenditure(Noureen and Mahmood, 2020). On the other hand, tariff increases can induce policy uncertainty and trade frictions, causing firms to delay or scale back investment plans—especially in industries that rely on international markets(Ostry, 2019). As a result, investment uncertainty rises. In contrast, tariffs can also serve as a source of fiscal revenue, enabling governments to finance productive expenditures such as infrastructure and education(Barattieri et al., 2021). However, these benefits may only minimally offset the negative effects on firms and consumers(Thompson, 2014). Therefore, the mechanisms through which tariffs affect GDP include changes in net exports, resource misallocation, reduced consumption, increased investment uncertainty, and fiscal revenue effects.

Following the analysis of tariff effects at the national level, particularly on GDP, we next examine their impact at the firm level, focusing on employment. The most direct impact is through the domestic employment protection mechanism(Guo et al., 2024). Higher tariffs raise the prices of imported goods, making domestic products relatively more competitive(Autor et al., 2016). As a result, domestic firms may expand or maintain production, thereby supporting employment(Furceri et al., 2020). The positive direct effect is limited, while the negative effects are multifaceted—such as supply chain disruptions(Kohn, 2006). Higher tariffs increase the cost and reduce the availability of imported components, leading to reduced investment in manufacturing inputs and, consequently, a decline in labor demand(Bagwell et al., 2003). An indirect mechanism is through rising consumer costs(Flaaen and Pierce, 2019). As tariffs increase prices, consumption-related industries—such as retail and services—may be suppressed, thereby indirectly reducing labor demand in these sectors(Flaaen and Pierce, 2019). This negative impact may be amplified by the retaliatory tariff mechanism(Mutambara, 2019). Export-oriented industries facing higher retaliatory tariffs may experience a decline in exports, leading to reduced revenues. As a result, export-oriented firms—particularly in agriculture and manufacturing—may lay off workers or freeze hiring(Mutambara, 2019). In the long term, a key negative effect is the structural employment shift mechanism(Georgescu and Herman, 2019). Higher tariffs may protect low-efficiency industries, suppress economic transformation and innovation, and prevent labor from moving from declining sectors to emerging ones. This results in labor misallocation and contributes to structural unemployment(Georgescu and Herman, 2019). In conclusion, protection of domestic employment, supply chaion disruption, retaliatory tariff, consumping costs, and structural employment shift, can be the mechanisms, showing why tariff can effects the employment.

After examining the firm and industry dimensions, we now turn to the impact on households, which is primarily reflected in inflation. Primarily, the imported inflation mechanism operates as tariffs raise the costs of imported goods—such as food, components, and energy—resulting in a higher Consumer Price Index (CPI)(Kohn, 2006). In addition to goods prices, the cost-passing mechanism also plays a role(Fong and Mohs, 2020). As tariffs raise production costs—particularly through higher prices of intermediate goods—firms may pass these costs on to consumers by increasing the prices of final goods to maintain their profit margins(Fong and Mohs, 2020). This inflationary effect can be further intensified by two mechanisms: exchange rate depreciation and inflation expectations. On the one hand, through the exchange rate channel, higher tariffs may trigger capital outflows, leading to depreciation of the domestic currency(Mishkin, 2009). This makes imported goods more expensive, thereby further accelerating inflation(Mishkin, 2009). On the other hand, tariffs can raise inflation expectations(Okpe and Ikpesu, 2021). Anticipating higher prices, workers may demand higher wages, further fueling inflation through a wage–price spiral(Okpe and Ikpesu, 2021). In response, consumers may shift toward domestic substitutes(Barattieri et al., 2021). As a result, excess demand for domestic goods can drive up prices, further pushing inflation—especially when supply capacity is limited(Barattieri et al., 2021). In conclusion, tariffs can drive inflation through several channels: imported inflation, cost pass-through, exchange rate effects, inflation expectations, and demand substitution.

While many studies examine tariff effects during the US-China trade war, few explore the motivation behind tariffs—specifically, their potential link to rising trade deficits. We then introduce an endogenous tariff adjustment mechanism based on rising trade deficits.

Most trade war models view tariffs as exogenous one-time shocks, which prevents them from capturing the two-way feedback between trade policy and the economy. For example, Tombazos (2003) presents evidence of a two-way feedback mechanism, whereby tariff protection reduces import penetration, which in turn leads to further tariff measures. In addition to imports, Egger and Erhardt (2019) employ a nonparametric approach, allowing tariff and non-tariff barriers to respond endogenously to trade flows, thus capturing a two-way feedback mechanism. While Egger and Erhardt (2019) focus on imports, Karacaovali (2011) highlight that ignoring the two-way feedback between tariffs and productivity leads to an underestimation of trade liberalization effects. Extending this line of evidence to broader economic outcomes, Amiti et al. (2019) also provides evidence of a two-way feedback mechanism between tariffs and economic outcomes: tariffs endogenously trigger supply-chain reallocation, which affects price levels and amplifies welfare losses. Therefore, tariffs should be modelled as endogenous to the economy, due to the presence of a two-way feedback mechanism.

While some existing studies treat tariffs as endogenous variables, few models explicitly incorporate tariff rules—that is, systematic tariff adjustments triggered by trade imbalances. Subramanian et al. (1993) argues that tariff policy is often shaped by complex considerations—including political pressures, strategic concerns, and international negotiations—rather than by explicit rules. Without the clear motivations announced by the Trump administration, such tariff measures would likely not have been implemented. Because of this complexity, most economists view tariffs as a policy tool with a controversial nature and considerable variability in implementation. As a result, tariffs are often handled in a simplified way, such as being modelled as a one-time exogenous shock(York, 2024). In addition to their complexity, tariffs are also limited in their effectiveness at correcting external trade imbalances. As Amiti et al. (2019) show, higher tariffs can reduce exports and lead to an appreciation of the domestic currency, thereby offsetting potential improvements in the trade balance. Beyond their inefficiency, tariff rules—such as those adjusting rates based on trade imbalances—are further hindered by delayed trade data and unpredictable enforcement timelines.Tariff decisions often lack clear criteria, and trade deficits may emerge only after tariffs are announced but before they take effect

(Pal, 2025). Therefore, it is essential to address the fundamental challenges of tariffs: their complexity, contentious nature, inefficiency, and delayed trade data.

To fill this gap, we employ a two-country DSGE model with a tariff rule to examine the effects of raising tariffs in response to trade deficits, with a focus on the U.S.–China trade war. Incorporating a tariff rule—where tariff rates adjust according to trade imbalances—allows the model to abstract from real-world complexity and provides a consistent framework for policy analysis. This setup also captures the dynamic interactions between tariffs, exchange rates, exports, and the trade balance, helping to account for offsetting effects such as currency appreciation or reduced export demand. Furthermore, by accommodating delayed responses, the model enables the formulation of rules in which tariffs increase proportionally with the size of the trade deficit, offering a unified and systematic policy approach.

2.3 Model

This paper develops a two-country DSGE model with nominal rigidities, incomplete financial markets, and independent monetary policy, following Minford et al. (2022). A key feature is that tariffs respond endogenously to trade deficits. In contrast to Yang et al. (2023), which treats tariffs as exogenous shocks, our model allows trade policy to adjust systematically to external imbalances. This mechanism helps replicate observed movements in net exports during the U.S.–China trade conflict and highlights the stabilising potential of rule-based trade policy in open economies.

2.3.1 Households

In our two-country DSGE framework, each economy is populated by a representative, infinitely-lived household that maximises expected lifetime utility by choosing optimal paths for consumption and labour supply, following standard formulations in the monetary economics literature (Galí, 2015). The household's utility function is given by:

$$u_t = E_t \sum_{t=0}^{\infty} \beta^t \epsilon_{jt} \left(\log c_t - \frac{n_t^{1+\psi}}{1+\psi} \right), \tag{2.1}$$

where c_t denotes consumption, n_t denotes hours worked, $\beta \in (0,1)$ is the household's subjective discount factor, and ϵ_{jt} captures preference shocks. The parameter $\psi > 0$ shows how much people change their work when wages change; a higher ψ means people change their work less.

Consumption c_t is a CES aggregate of domestic and imported goods, defined as:

$$c_t = \left((1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}} + \nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \tag{2.2}$$

where $c_{h,t}$ and $c_{f,t}$ denote consumption of home goods and imported goods, respectively. The parameter $\nu \in (0,1)$ reflects the share of imported goods in the consumption basket, meaning how much of what consumers buy comes from foreign products. The parameter $\eta > 0$ governs the elasticity of substitution between domestic and imported goods, which means how easily consumers can switch between them when relative prices change.

Household behaviour is subject to the following budget constraint:

$$\begin{aligned} &c_{h,t} + (1+\tau_t)\, q_t\, c_{f,t} + s_{h,t} + q_t\, s_{f,t} + \frac{\varphi_s}{2}(s_{f,t} - s_f)^2 \\ &= w_t\, n_t + \pi_t + (1+r_{t-1})\, s_{h,t-1} + (1+r^*_{t-1})\, q_t\, s_{f,t-1} - t_t, \end{aligned} \tag{2.3}$$

where $c_{h,t}$ and $c_{f,t}$ denote consumption of domestic and imported goods, respectively. The term τ_t represents the import tariff, and q_t is the real exchange rate. Households allocate savings between domestic bonds $s_{h,t}$ and foreign bonds $s_{f,t}$, where the latter represent foreign bonds purchased by domestic residents. These foreign bond holdings are subject to a quadratic adjustment cost governed by φ_s. The steady-state level of foreign bond holdings is denoted s_f. Following Dongzhou and Mi (2023), we set $\varphi_s = 0.01$ to reflect China's stringent capital controls.

The following optimality condition is derived by maximising the utility function (2.1) subject to the budget constraint (2.3). A full derivation is provided in Appendix A, under the First Order Conditions (FOC).

$$c_{h,t}: \; \left((1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}} + \nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}}\right)^{-1} \cdot (1-\nu)^{\frac{1}{\eta}} \cdot c_{h,t}^{\frac{-1}{\eta}} = \lambda_t \tag{2.4}$$

$$c_{f,t}: \; \left[(1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}} + \nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}}\right]^{-1} \cdot \nu^{\frac{1}{\eta}} \cdot c_{f,t}^{\frac{-1}{\eta}} = \left(1+\tau_t\right) q_t \, \lambda_t \tag{2.5}$$

$$s_{h,t}: \; \lambda_t = \beta \, E_t\left[\lambda_{t+1} \left(1+r_t\right)\right] \tag{2.6}$$

$$s_{f,t}: \; \lambda_t \left(q_t + \varphi_s \, s_{f,t} - \varphi_s \, s_f\right) = \beta \, E_t\left[\lambda_{t+1} \, q_{t+1} \left(1+r_t^*\right)\right] \tag{2.7}$$

$$n_t: \; n_t^{\psi} = \lambda_t \, w_t \tag{2.8}$$

2.3.2 Firms

In this section, we describe firms' production and pricing behaviour, focusing on the Calvo pricing mechanism. We begin by outlining the production technology.

Production Function

Following Minford et al. (2023b), we assume a linear production function with labour as the sole input:

$$y_t = \varepsilon_{z,t} \, n_t, \tag{2.9}$$

Here, y_t denotes output, n_t is labour input measured by working hours, and $\varepsilon_{z,t}$ represents total factor productivity.

Marginal Cost

Marginal cost is defined as the cost of producing an additional unit of output and plays a central role in firms' pricing decisions under monopolistic competition. As in Galí (2015), the firm's total cost is given by:

$$tc_t = w_t \, n_t,$$

where w_t denotes the real wage. Using the production constraint (2.9), and applying standard optimisation techniques, the firm's marginal cost is derived as:

$$mc_t = \frac{w_t}{\varepsilon_{z,t}}.$$

This expression links marginal cost to wages and productivity and serves as a key input into the firm's pricing rule under Calvo rigidity.

Pricing Decision

Following the Calvo (1983) pricing model, each period allows only a fraction of $1-\theta$ firms to adjust their prices, while θ firms keep their prices unchanged from time $t-1$ to time t. As a result, the equation for domestic inflation $\pi_{h,t}$ takes the following form[2]:

$$\pi_{h,t} = \tilde{\kappa} \, \widehat{mc}_t + \beta \, E_t \, \pi_{h,t+1}, \tag{2.10}$$

where

$$\tilde{\kappa} = \frac{(1-\theta)\,(1-\theta\,\beta)}{\theta}.$$

In (2.10), $\widehat{mc}_t$ is the deviation form of marginal cost, $\pi_{h,t}$ is the inflation of domestic goods, and β is the discount factor.

CPI Equation

The Consumer Price Index (CPI) captures the aggregate price level faced by consumers, accounting for both domestic and imported goods. It is defined as:

$$p_t = \left[(1-\nu)\, p_{h,t}^{1-\eta} + \nu \, \left(Q_t(1+\tau_t) p_{h,t}^{*} \right)^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{2.11}$$

where $p_{h,t}$ denotes the price of domestically produced goods, and the domestic currency price of imported goods is given by $Q_t(1+\tau_t)p_{h,t}^{*}$, where $p_{h,t}^{*}$ is the price of foreign goods in foreign currency, Q_t is the nominal exchange rate (defined as the units of domestic currency per unit of foreign currency), and τ_t is the ad valorem import tariff rate. The parameter $\nu \in (0,1)$ reflects the share of imported goods in the consumption basket, and $\eta > 0$ governs the elasticity of substitution between domestic and imported goods.

Following reorganisation, the CPI equation takes the form shown below[3]

[2]For the complete derivation process, refer to appendix B1

[3]For the derivation process, refer to Appendix B2.

$$\hat{\pi}_t = (1-\nu)\,\hat{\pi}_{h,t} + \nu\,\hat{\pi}^*_{h,t} + \nu\,\Delta\hat{Q}_t + \nu\,(\hat{\tau}_t - \hat{\tau}_{t-1}) + \hat{\varepsilon}_{\pi,t} \tag{2.12}$$

This equation represents CPI inflation $\hat{\pi}_t$ as a weighted average of domestic inflation $\hat{\pi}_{h,t}$ and imported inflation $\hat{\pi}^*_{h,t}$, adjusted for changes in the nominal exchange rate $\Delta\hat{Q}_t$ and import tariff variations $\hat{\tau}_t - \hat{\tau}_{t-1}$. The parameter $\nu \in (0,1)$ denotes the share of imported goods in the consumption basket. The term $\hat{\varepsilon}_{\pi,t}$ captures exogenous price-level disturbances, which can be interpreted as a markup shock.[4]

2.3.3 Policies

This section centres on the policy equation in the DSGE model context. The government implements an exogenous fiscal policy, which adheres to an AR(1) process. Subsequently, the analysis moves to the Taylor rule to formulate the equation for tariff policy.

Fiscal Policy

Fiscal policy is conducted by the government, with government spending determined entirely by exogenous fiscal shocks:

$$g_t = \varepsilon_{g,t} \tag{2.13}$$

Here, $\varepsilon_{g,t}$ represents an exogenous fiscal shock. Since no persistence term appears in the equation, government spending follows a purely random process without serial correlation.

Taylor Rule

The Taylor rule offers a guideline for central banks to modify interest rates in response to inflation and economic output fluctuations (Minford et al., 2023b). It translates into:

$$1 + R_t = (1 + R_{t-1})^{\rho_R}\,(1+\pi_t)^{(1-\rho_R)\phi_\pi}\left(\frac{y_t}{y_{t-1}}\right)^{(1-\rho_R)\phi_y}(1+R)^{(1-\rho_R)}\,\varepsilon_{R,t} \tag{2.14}$$

where the nominal interest rate responds to inflation (ϕ_π) and output growth (ϕ_y), with inertia governed by ρ_R[5] and subject to a monetary policy shock ($\varepsilon_{R,t}$). For convenience, output growth y_t/y_{t-1} is used instead of the output gap, which has negligible impact on the model's dynamics.

[4] A markup shock means that firms suddenly change how much extra they charge over their costs. This can happen due to changes in competition, demand conditions, expectations about future costs, or pricing rigidities.

[5] The parameter ρ_R measures how slowly the central bank changes interest rates over time. A higher value means the central bank adjusts rates gradually rather than all at once.

Tariff Policy

Standard Tariff Specifications in the Literature Numerous studies model tariffs as exogenous processes to assess their macroeconomic effects. A common approach is to assume that the tariff rate follows a stationary AR(1) process (Bergin and Corsetti, 2020):

$$\tau_{t+1} = \rho_\tau \tau_t + \varepsilon_{\tau,t} \tag{2.15}$$

where τ_t is the tariff rate, $\rho_\tau \in (0,1)$ denotes its persistence, and $\varepsilon_{\tau,t}$ is an i.i.d. disturbance.

Yang et al. (2023) extend this framework to a two-country setting, specifying separate AR(1) processes for each country's tariffs:

$$\begin{aligned} \tau_{F,t} &= \rho_F \tau_{F,t-1} + \epsilon_{F,t}, \\ \tau_{H,t} &= \rho_H \tau_{H,t-1} + \epsilon_{H,t}, \end{aligned}$$

where ρ_F and ρ_H represent the autocorrelation coefficients for each country's tariff, and $\epsilon_{F,t}, \epsilon_{H,t}$ are country-specific tariff shocks. Their study emphasizes how tariffs affect both final and intermediate imported goods.

In contrast, our model endogenizes the tariff policy. Rather than imposing an exogenous AR(1) rule, we model τ_t as a policy instrument that responds to economic conditions. This allows the government to adjust tariffs strategically to stabilize the domestic economy or achieve specific policy goals.

Setting Up the Endogenous Tariff Equation: Tariff and Trading Surplus The U.S. imposed tariffs on Chinese goods to reduce their competitiveness and address the growing trade deficit. Trump supported this move to protect American manufacturing and respond to unfair Chinese trade practices (Sukar and Ahmed, 2019). Other countries, like Mexico, also used tariffs to manage their own trade deficits (Albertoni and Wise, 2021). Tariffs made Chinese products less attractive in the U.S. market (Wei, 2019). This helped lower the trade imbalance and was seen as an effective policy tool. The shift from traditional tools like quotas to more strategic tariffs marked a change in global trade approaches (Iqbal et al., 2019). In the U.S., the Department of Agriculture introduced support programs to help farmers hurt by China's retaliatory tariffs (Janzen and Hendricks, 2020). However, it also led to economic losses for both countries, highlighting the costs of such measures. Studies show that tariffs caused inefficiencies and reduced overall welfare in both the U.S. and China (Carvalho et al., 2019).

Considering these developments, we treat tariffs as policy instruments for managing trade surpluses. Building on this perspective, we define the trade surplus variable as follows:

$$x_t = C^*_{f,t} - C_{f,t} \tag{2.16}$$

where $C^*_{f,t}$ denotes the home country's exports, and $C_{f,t}$ represents its imports.

We then construct a tariff equation grounded in a rule-based policy logic, focusing on the trade surplus as the core explanatory variable.

$$\tau_t = d_x - \gamma_\tau x_t + \epsilon_{\tau,t} \tag{2.17}$$

Equation 2.17 defines the baseline rule used in this study, capturing the relationship between the key variables and establishing the foundational framework for the model. This equation reflects the core principle that tariff rates are primarily determined by the contemporaneous trade deficit, with the term d_x representing the baseline tariff level, which remains fixed regardless of trade conditions. The variable x_t represents the trade surplus at time t , where a more negative x_t indicates a larger trade deficit and thus a higher likelihood of tariff imposition. The residual term, $\epsilon_{\tau,t}$, encompasses other trade policy tools not directly modeled within the equation but still influencing the tariff decision.

The model assumes that the relationship between the trade deficit and the tariff is contemporaneous: when the current trade deficit increases, the tariff rate responds immediately, with a magnitude of γ_τ. We chose this because it's simple. From a theoretical perspective, in endowment-type open-economy models, the optimal tariff can be proportional to the current trade balance. Therefore, the tariff can be written as a linear function of the trade imbalance(Dávila et al., 2025). In practice, in recent U.S. "reciprocal tariff" acts, the tariff is set as a simple proportion of the bilateral trade deficit(DeBarros, 2025). In addition, a uniform 10% tariff is adjusted each year in proportion to the overall trade deficit, showing that real-world policy also often uses this simple linear rule(American Compass, 2024).

Bascially,the residual term $\epsilon_{\tau,t}$ captures other omitted policy factors that are not tariffs, such as export subsidies, anti-dumping duties, import quotas, and import licensing. Secondly, the residual term $\epsilon_{\tau,t}$ also captures lagged and threshold effects that could, in principle, be modeled explicitly, but in this paper we do not do so and instead absorb them implicitly into the error term. In fact, the lagged effects are already captured by the AR(1) specification of the residual term, since we assume that $\epsilon_{\tau,t}$ follows an AR(1) process. For threshold-type specifications, we consider that they would only affect the magnitude of the tariff shock, whereas the lagged form in tariff equation (2.17) only affects its timing. Therefore, we view both threshold and lagged forms as implicitly absorbed into the residual term, so our main results—namely the welfare-loss ranking and stabil-

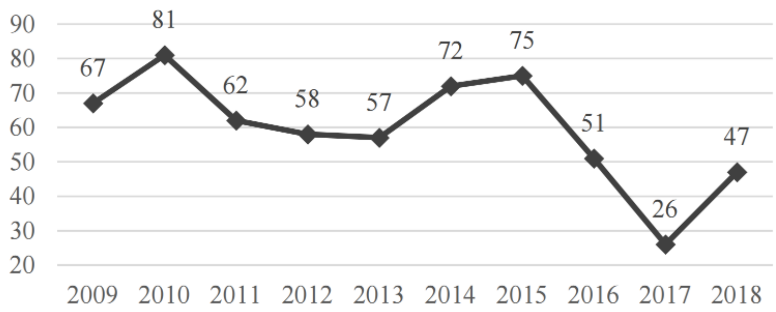

Figure 2.3.1: US industrial subsidy measures from 2009 to 2018 (data source: Global Trade Alert Database)

ity ordering in Chapter 3—are unchanged. Further qualitative assurance is provided in Section 3.5.2.

Balance of Payment

The balance of payments (BOP) is a central indicator of a country's economic conditions, reflecting its competitiveness and the impact of macroeconomic policies. It records all economic transactions between the domestic economy and the rest of the world, including capital flows, trade in goods and services, and financial settlements. In particular, the BOP plays a critical role in determining the equilibrium value of the real exchange rate.

$$q_t \left[s_{f,t} + (1+\tau_t)c_{f,t} - \left(1 + r^*_{t-1}\right) s_{f,t-1}\right] = c^*_{f,t} \tag{2.18}$$

Equation (2.18) ensures the balance between the capital account and the trade balance. The capital account is given by $q_t \left[s_{f,t} - \left(1 + r^*_{t-1}\right) s_{f,t-1}\right]$, while the trade balance is represented by $c^*_{f,t} - q_t(1+\tau_t)c_{f,t}$ where τ_t denotes the ad valorem tariff rate imposed on foreign goods consumed by domestic residents. At equilibrium, the two sides of the BOP identity must be equal.

The real interest rate is determined by the Fisher equation:

$$r_t = R_t - E_t\pi_{t+1} \tag{2.19}$$

where r_t is the real interest rate, R_t is the nominal interest rate, and π_{t+1} is the expected inflation rate.

The real exchange rate is defined as the relative price of foreign goods in terms of domestic goods:

$$q_t = \frac{Q_t P^*_{h,t}}{P_{h,t}} \tag{2.20}$$

Taking logarithmic changes and incorporating inflation, the evolution of the real exchange rate is described by:

$$\Delta\hat{Q}_t = \Delta\hat{q}_t - \hat{\pi}^*_{h,t} + \hat{\pi}_{h,t} \tag{2.21}$$

2.4 Testing The Model with Indirect Inference Method

Macroeconomic models are often estimated with limited data, which can make standard methods biased and inefficient. This problem is noted in Le et al. (2016). They show that maximum likelihood estimates can be biased in small samples, which is common in macroeconomic work. Therefore, indirect inference is less sensitive to small samples and gives more stable estimates in these cases. The method was first used in this context by Smith Jr (1993), Gourieroux et al. (1993a), and Canova (2007). It was later developed by Minford et al. (2009), Meenagh et al. (2009), and Le et al. (2016), who show that it works well in DSGE simulations. Unlike Bayesian or maximum likelihood methods, it does not need strong distribution assumptions or large samples to work well. This is different from DSGE-VAR methods (Del Negro et al., 2006), which are often used to evaluate models but are sometimes seen as weak on statistical testing.

2.4.1 Indirect Inference Method

Method Overview The indirect inference method (IIM) is used to estimate parameters θ so that the DSGE model matches the statistical behavior of real-world data, for the following reasons. First, the likelihood function is not explicitly available in the DSGE model, as the estimation does not rely on calculating the probability of observing the data. Rather, it evaluates whether the simulated data closely match the actual data. Second, IIM focuses on matching key statistical features—such as the mean, variance, and autocorrelations—rather than requiring the simulated data to exactly replicate the actual data. Third, while the DSGE model can be simulated using tools like Dynare, it cannot be directly estimated, as the parameters cannot be easily derived from actual data. Fourth, an auxiliary model such as VARX simplifies estimation by allowing both actual and simulated data to be compared. This helps identify which parameter set in the DSGE model best matches the data, making it more reliable. Finally, IIM allows for model evaluation through hypothesis testing by comparing simulated and actual data to compute a Wald statistic and corresponding p-value, indicating the model's acceptability. Therefore, IIM is used for parameter estimation because it avoids complex likelihood functions, focuses on matching key statistics, supports simulation via Dynare, employs a simplified auxiliary model (e.g., VARX), and allows for model evaluation using p-values.

Structural Model Definition Given the general structural form of a DSGE model as shown in Equation 2.22:

$$\mathbb{E}_t \left[f(X_{t+1}, X_t, Z_t, \varepsilon_t; \theta) \right] = 0 \tag{2.22}$$

where θ denotes parameters to be estimated (e.g., discount factor, price stickiness), X_t

are endogenous variables (e.g., output, interest rates), Z_t represents exogenous processes, and ε_t are shock terms. Therefore, we solve the model using the following approach. First, we perform log-linearization manually and then input the linearized equations into Dynare for simulation. Then, using the structural parameters θ, we generate time series data for the endogenous variables, denoted as X_t^{sim}.

Auxiliary Model Specification We then introduce auxiliary model, used to draw the statistic characteristics of actual data, using euqation 2.23 :

$$Y_t = AY_{t-1} + X_{t-1} + e_t \tag{2.23}$$

where $Y_t = (y_t, y_t^*)'$,with y_t denotes China's GDP, and y_t^* represents U.S. GDP; $X_t = (t, t)'$, with t denoting a linear time trend (e.g., $1, 2, 3, \ldots$). Unexplained variations are captured by the error term e_t.

This auxiliary model is selected for its co-movement, trend control, compatibility, and simplicity. The auxiliary model captures co-movements by incorporating lagged terms, allowing us to assess how past U.S. economic conditions influence China's current economic outcomes. Furthermore, the auxiliary model controls for trends by including a time trend t, which removes the long-term growth component of GDP and allows us to focus on the short-term dynamics that DSGE models aim to capture. The auxiliary model ensures compatibility by enabling direct comparison between simulated and actual data, focusing on their statistical distributions rather than data format. Finally, the simplicity of the auxiliary model helps avoid overfitting by including only two core variables—the GDP of the two countries—while highlighting the key features of DSGE estimation. Therefore, we not only select the auxiliary model, but also define the corresponding auxiliary statistics as follows:

$$\Phi = \begin{bmatrix} \mathrm{vec}(A) \\ \mathrm{vec}(B) \\ \mathrm{vech}(\Sigma_e) \end{bmatrix} \tag{2.24}$$

where vec(A) stacks all elements of matrix A into a column vector; vec(B) represents the effect of the trend term X_{t-1} (e.g., a linear time trend) on the level of GDP. $\mathrm{vech}(\Sigma_e)$ represents the lower triangular elements of the covariance matrix Σ_e (as it is symmetric), including the variances of U.S. and China's GDP and the covariance capturing the correlation between their error terms.

Simulated Data Generation Thus, with the auxiliary statistics generated each time, we can build the overall statistical profile using the previously defined Φ. The first step is to use the parameters θ to generate simulated data$\{Y_t^{\mathrm{sim}}\}$; Secondly, the simulated data are fitted using the auxiliary VARX model (Equation2.23) to obtain the estimated statistic $\hat{\Phi}^{\text{sim}}(\theta)$. Thirdly, by repeating the simulation N times, we obtain the sample mean of the auxiliary statistics (see 2.25):

$$\bar{\Phi}^{\text{sim}}(\theta) = \frac{1}{N}\sum_{i=1}^{N} \hat{\Phi}^{\text{sim},i}(\theta) \tag{2.25}$$

Based on the mean statistic in 2.25, the covariance of the simulated auxiliary statistics can be computed as shown in 2.26:

$$\Sigma_{\Phi\Phi} = \frac{1}{N-1}\sum_{i=1}^{N} \left(\hat{\Phi}^{\text{sim},i} - \bar{\Phi}^{\text{sim}}\right)\left(\hat{\Phi}^{\text{sim},i} - \bar{\Phi}^{\text{sim}}\right)' \tag{2.26}$$

Discrepancy Measure Then, the actual data are used to estimate $\hat{\Phi}^{\text{act}}$ following the same process. Next, using $\hat{\Phi}^{\text{act}}$ and the simulated covariance matrix $\Sigma_{\Phi\Phi}$, we construct a Wald-type matching function, as shown in 2.27:

$$\text{Wald}(\theta) = \left(\hat{\Phi}^{\text{act}} - \bar{\Phi}^{\text{sim}}(\theta)\right)' \Sigma_{\Phi\Phi}^{-1} \left(\hat{\Phi}^{\text{act}} - \bar{\Phi}^{\text{sim}}(\theta)\right) \tag{2.27}$$

In this way, the optimal structural parameter is obtained as shown in 2.28:

$$\hat{\theta} = \arg\min_{\theta} \text{Wald}(\theta) \tag{2.28}$$

Model Fit & Hypothesis Testing Based on the constructed Wald statistic, we simulate N values: $\{\text{Wald}^{(1)}, \ldots, \text{Wald}^{(N)}\}$. We then compute the p-value to determine the position of the observed Wald statistic within the simulated distribution, as shown in 2.29. Our evaluation criterion is as follows: If $p > 5\%$, the model is not rejected; If $p < 5\%$, the model is considered inconsistent with the data.

$$p = \frac{1}{N}\sum_{i=1}^{N} \left[\text{Wald}^{(i)} > \text{Wald}^{\text{actual}}\right] \tag{2.29}$$

2.4.2 Assessment of Empirical Data: Evaluating Model Fit and Estimation

Our research analyzes simulation outcomes using real economic data, including China's total output Y_t and the U.S. total output Y_t^*, supplemented by bootstrapped simulation data. First, we convert all real variables into per-capita terms and apply natural logarithms to ensure consistency and interpretability across time. Next, we refine this foundation by expressing key variables—such as inflation, nominal interest rates, and real wages—in quarterly rates to align with the time structure of the DSGE model. Finally, to preserve the raw dynamics and fluctuations crucial for accurate identification and analysis of economic shocks, we intentionally avoid applying statistical filters to the data. To enhance the robustness of our analysis, we incorporate additional elements, such as residuals of expected variables in the AR(1) process within the DSGE models for both countries. We examine quarterly economic data from 2000 to 2023, focusing on key indicators, particularly the GDP of China and the U.S. Data sources include the U.S. Bureau of Labor Statistics (BLS), China's National Bureau of Statistics (NBS), World Trade Integration Solutions (WITS), Federal Reserve Economic Data (FRED), the People's Bank of China (PBOC), the World Bank, and the Organisation for Economic Co-operation and Development (OECD). A detailed summary of data construction and processing is provided in AppendixE.

Table 2.1: Adjusted II-Wald Estimates and p-values of the DSGE Model for the US and China

Parameter	Definition	Calibrated Starting Values		Adjusted II Estimates	
		China	US	China	US
β	Time discount factor	0.99	0.99	Fixed at starting values	Fixed at starting values
q	Steady-state real exchange rate	1.00	-	Fixed at starting values	-
C/Y	Steady-state consumption-to-GDP ratio	0.70	0.85	Fixed at starting values	Fixed at starting values
G/Y	Steady-state government expenditure-to-GDP ratio	0.24	0.34	Fixed at starting values	Fixed at starting values
x/Y	Steady-state net exports-to-GDP ratio	0.03	-0.03	Fixed at starting values	Fixed at starting values
S_f/Y	Steady-state foreign bond-to-GDP ratio	0.15	0.08	Fixed at starting values	Fixed at starting values
C_f/Y	Steady-state import-to-GDP ratio	0.12	0.18	Fixed at starting values	Fixed at starting values
C_f^*/Y	Steady-state export-to-GDP ratio	0.16	0.13	Fixed at starting values	Fixed at starting values
ν	Share of imported goods in total goods	0.35	0.30	Fixed at starting values	Fixed at starting values
φ_s	Capital control parameter for China	0.10	-	Fixed at starting values	-
φ	Inverse wage elasticity of labor	3.00	3.00	2.20	3.97
η	Inverse elasticity of substitution between foreign and domestic goods	1.50	1.50	1.85	4.20
θ	Fraction of firms that do not change prices	0.70	0.70	0.66	0.49
ρ_R	Monetary policy inertia	0.80	0.80	0.72	0.71
ϕ_π	Monetary policy response to inflation	1.50	1.50	2.97	2.46
ϕ_Y	Monetary policy response to output growth	0.25	0.25	0.12	0.35
γ_z	Persistence of productivity shocks	0.50	0.50	0.85	0.98
γ_G	Persistence of fiscal shocks	0.50	0.50	0.29	0.71
γ_R	Persistence of interest rate shocks	0.50	0.50	0.29	0.28
γ_τ	Persistence of tariff shocks	0.50	0.50	0.70	0.98
$\phi_{x\tau}$	Coefficient in the tariff equation	0.50	0.50	0.27	0.97
γ_π	Persistence of inflation shocks	0.50	0.50	0.04	0.29
γ_j	Persistence of demanding shocks	0.50	0.50	0.60	0.66
Model p-value		0.00	-	0.065	-

Table 2.1 shows the parameters used in the two-country DSGE model for China and the U.S. Some values are not estimated but fixed based on data or set at initial values from earlier papers. We briefly note here where these initial values come from. The time discount factor ($\beta = 0.99$) is set for both countries, following standard practice in macro models (Smets and Wouters, 2007). The inverse wage elasticity of labor supply ($\varphi = 3.0$) follows typical values used in the literature (Smets and Wouters, 2007). The capital control adjustment cost for China ($\varphi_s = 0.1$) shows moderate investment frictions, based on institutional features (Dongzhou and Mi, 2023). The share of imported goods is set at $\nu = 0.35$ for China and 0.30 for the U.S., based on estimates of trade openness (Du and Gong, 2005). Nominal rigidities are captured through the Calvo parameter, set at $\theta = 0.7$ (Calvo, 1983). Monetary policy behavior follows a standard Taylor rule. This includes interest rate smoothing ($\rho_R = 0.8$) and a response to output ($\phi_Y = 0.25$) (Clarida et al., 2000; Taylor, 1993). In addition, several steady-state ratios are taken from the mean of

real data for China and the U.S. These include the consumption-to-GDP ratio (C/Y), government expenditure ratio (G/Y), net exports (x/Y), foreign bond holdings (S_f/Y), and trade shares (C_f/Y, C_f^*/Y). The steady-state real exchange rate between China and the U.S. is set to 1, following Ca'Zorzi et al. (2017). These values form the base of the model. Some are fixed, and others are used as starting points for estimation.

After setting the initial values and steady states, we move on to examine the key parameters, which are adjusted using indirect inference. Specifically, first, the inverse wage elasticity of labor (φ) is 2.20 for China and 3.97 for the U.S., showing that China has a more elastic labor supply. Chinese workers are more likely to adjust working hours when wages change, especially under trade war uncertainty. Second, the inverse elasticity of substitution (η) is 1.85 in China and 4.20 in the U.S., showing lower substitution in the U.S. So even with higher prices from tariffs, U.S. firms still buy foreign goods. This leads to higher welfare losses. Third, the Calvo parameter (θ) is higher in China (0.66) than in the U.S. (0.49). This means prices adjust less often in China. As a result, China may be less affected by the trade war. This is also seen in the literature, where Chinese consumers face smaller effects from tariffs due to trade diversion.

2.5 Evaluating Shock Impacts Within the Framework

2.5.1 Forecast Variance Decomposition and Impulse Response Functions

Table 2.2: FVD - Variance Decomposition of Shocks

Quarters	Variable	μ_{zt}	μ_{zt}^*	μ_{Gt}	μ_{Gt}^*	μ_{Rt}	μ_{Rt}^*	$\mu_{\tau t}$	$\mu_{\tau t}^*$	$\mu_{\pi t}$	$\mu_{\pi t}^*$	μ_{jt}	μ_{jt}^*
4													
	y_t	26.54	28.92	0.00	0.03	0.14	0.00	0.02	0.02	13.63	27.85	2.43	0.42
	y_t^*	21.07	45.49	0.00	0.02	0.10	0.00	0.01	0.01	9.93	21.42	1.66	0.29
	π_t	24.31	27.99	0.00	0.02	0.58	0.00	0.05	0.01	30.28	14.39	2.07	0.29
	π_t^*	28.97	34.29	0.00	0.03	0.15	0.18	0.02	0.01	15.58	17.96	2.41	0.40
12													
	y_t	27.47	28.52	0.00	0.03	0.14	0.00	0.02	0.02	13.84	27.19	2.36	0.41
	y_t^*	22.12	44.37	0.00	0.02	0.10	0.00	0.01	0.01	10.44	20.87	1.74	0.30
	π_t	24.48	27.94	0.00	0.02	0.58	0.00	0.05	0.01	30.20	14.36	2.06	0.29
	π_t^*	28.91	34.41	0.00	0.03	0.15	0.18	0.02	0.01	15.55	17.93	2.41	0.40
20													
	y_t	27.97	28.31	0.00	0.03	0.14	0.00	0.02	0.02	13.82	26.95	2.33	0.41
	y_t^*	22.66	43.30	0.00	0.02	0.11	0.00	0.01	0.01	10.70	21.09	1.78	0.31
	π_t	24.49	27.94	0.00	0.02	0.58	0.00	0.05	0.01	30.20	14.36	2.06	0.29
	π_t^*	28.87	34.50	0.00	0.03	0.15	0.18	0.02	0.01	15.53	17.91	2.40	0.39
40													
	y_t	28.47	28.12	0.00	0.03	0.14	0.00	0.02	0.02	13.78	26.72	2.31	0.40
	y_t^*	23.66	40.99	0.00	0.02	0.11	0.00	0.01	0.01	11.19	21.81	1.86	0.32
	π_t	24.49	27.94	0.00	0.02	0.58	0.00	0.05	0.01	30.20	14.36	2.06	0.29
	π_t^*	28.82	34.62	0.00	0.03	0.15	0.18	0.02	0.01	15.50	17.88	2.40	0.39

This study employs Forecast Variance Decomposition (FVD) to assess the contribution of shocks to variables. By integrating FVD with Impulse Response Functions (IRFs) and the mathematical framework of the DSGE model, it clarifies the transmission mechanisms of GDP and inflation in China and the United States.

We begin by analyzing the impact of domestic shocks on China's GDP, followed by an assessment of spillover effects from the U.S. Since GDP is a key indicator of economic activity, it reflects whether an economy is expanding or contracting (Bryniuk, 2023). Next, we apply the same approach to the U.S., examining the impact of both domestic shocks and spillovers from China on U.S. GDP. After analyzing GDP, we proceed to inflation, following the same steps to examine its dynamics in both countries. Since inflation reflects changes in the value of money, it serves as a key indicator of price stability and purchasing power (Dreger and Zhang, 2011). Therefore, studying GDP and inflation enables us to evaluate both output and price stability.

Our analysis starts with examining the impact of China's domestic shocks on its GDP volatility. As shown in Table 2.2, production shocks explain 27%–28% of China's GDP fluctuations, underscoring the importance of production efficiency in economic growth.

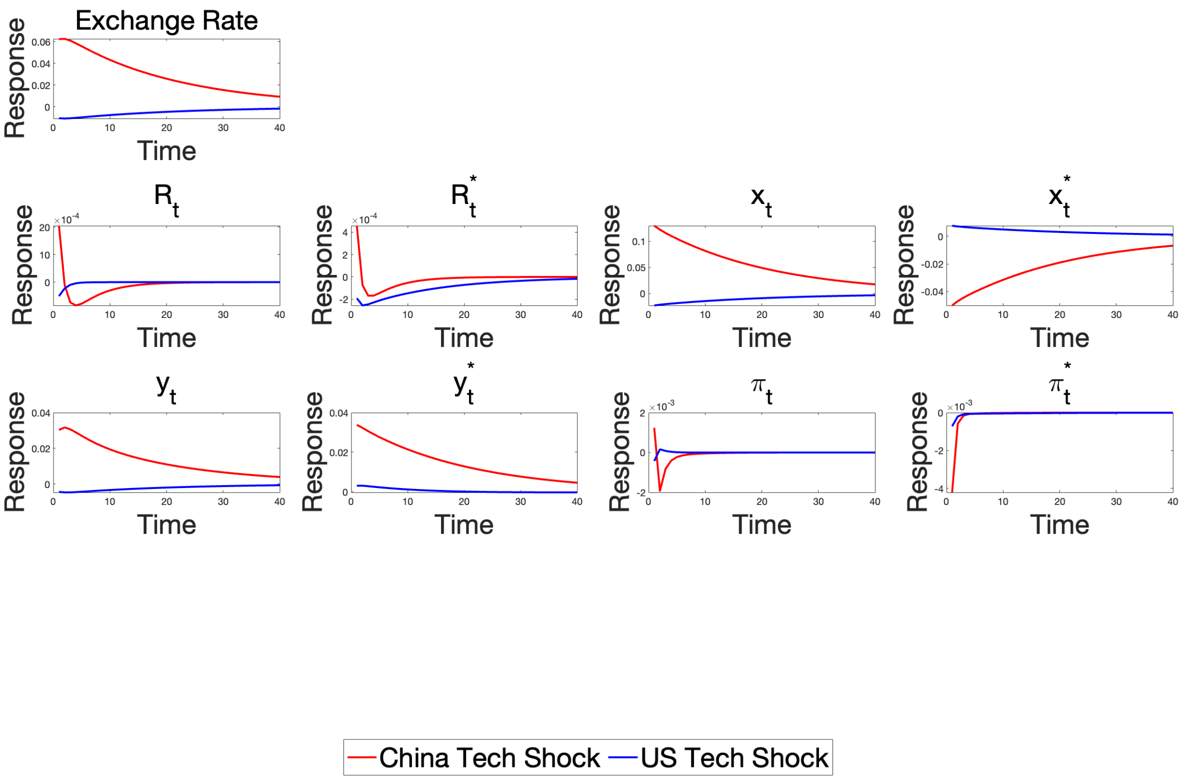

Figure 2.5.1: Impulse Responses to Technology Shocks

The mechanism is that productivity shocks raise China's GDP through supply-side improvements, as shown in Figure 2.5.1. Next, domestic inflation shocks are the second-largest contributor, accounting for 13.6%–13.8% of the fluctuations. The mechanism is: higher inflation leads to higher interest rates, lower consumption, and reduced GDP (Figure 2.5.2). Additionally, fiscal and tariff shocks have near-zero effects, while interest rate shocks explain only about 0.14% of GDP fluctuations Demand shocks account for just 2.3%–2.4%, indicating limited influence.

Next, Table 2.2 also shows that China's GDP fluctuations are significantly driven by spillover effects from U.S. economic shocks. For example, Over 40 quarters, U.S. technology shocks explain about 28% of China's output fluctuations. This underscores the strong economic interdependence between the two countries. The mechanism works as follows: a positive U.S. productivity shock lowers U.S. inflation, which transmits to lower inflation in China via the CPI equation. This reduces China's interest rate, boosts domestic consumption, and ultimately raises GDP. Similarly, U.S. inflation shocks account for 26%–27% of China's GDP fluctuations, as shown in Table 2.2—a greater impact than that of China's own inflation shocks. As shown in Figure 2.5.2, U.S. inflation shocks raise China's GDP through a spillover mechanism: higher U.S. inflation leads to higher U.S. nominal interest rates, causing dollar appreciation (i.e., RMB depreciation), which

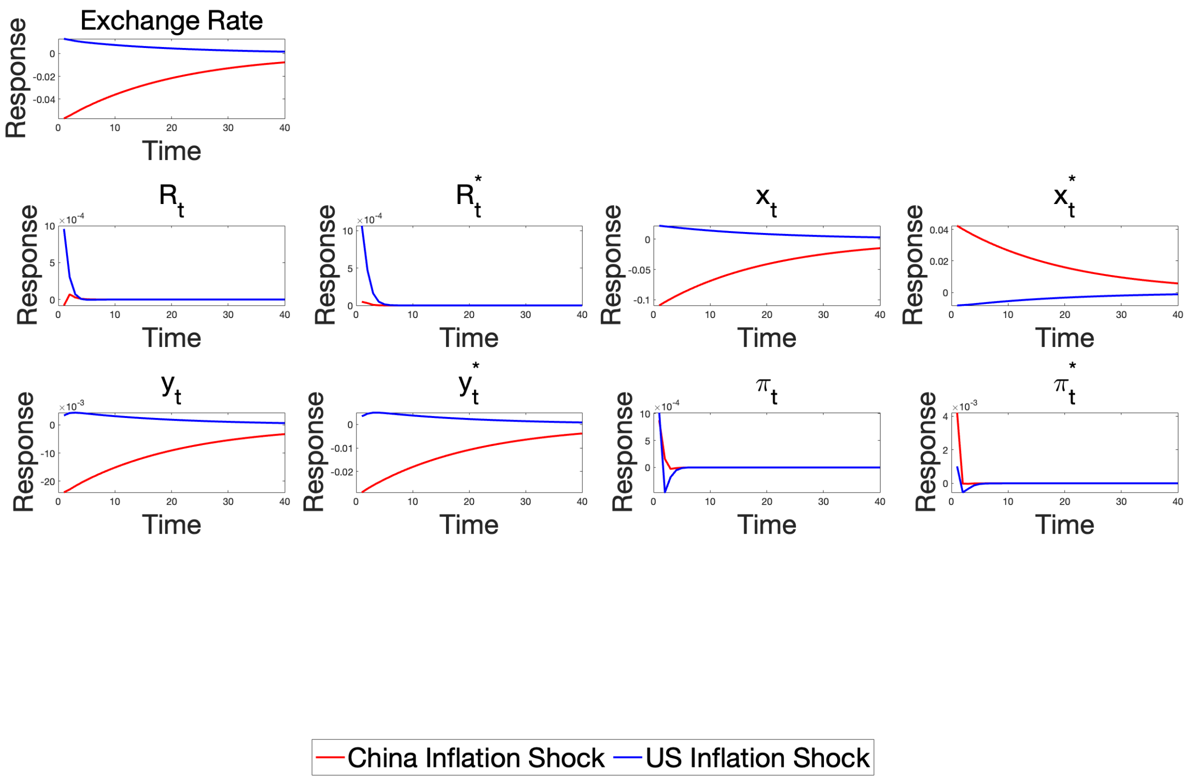

Figure 2.5.2: Impulse Responses to Inflation Shocks

boosts China's exports and trade surplus, thereby slightly increasing GDP growth.

After analyzing China's GDP, we now examine which shocks primarily contribute to U.S. GDP fluctuations. As shown in Table 2.2, U.S. GDP is mainly driven by domestic shocks—production (41%–45%) and inflation (20%–22%), with mechanisms similar to China (Figures 2.5.1, 2.5.2). In contrast, fiscal, tariff, and interest rate shocks have minimal impact. Spillover effects from China also play a secondary role. As shown in Table 2.2, China's production and inflation shocks explain 20%–23% and 10%–11% of U.S. GDP fluctuations, respectively, with mechanisms similar to those in China's case (Figures 2.5.1 and 2.5.2).

Similarly, we proceed to identify the key shocks driving fluctuations in China's inflation. As shown in Table 2.2, domestic inflation shocks are the main driver (30%) of China's inflation, as higher inflation shocks directly raise CPI through the domestic inflation channel (Figure 2.5.2). Domestic production shocks for 24%–25% of China's inflation, as higher productivity reduces marginal costs and lowers price pressures (Figure 2.5.1). Meanwhile, U.S. spillover effects are also significant, with U.S. production shocks contributing around 28% to China's inflation. U.S. inflation shocks raise China's CPI by increasing U.S. interest rates and exchange rates, leading to exchange rate pass-through (Figure 2.5.2).

Like in China, U.S. inflation is primarily shaped by domestic shocks and spillovers from China. U.S. production shocks contribute the most to domestic inflation, accounting for 34%–35% (Table 2.2). Figure 2.5.2 shows that higher production raises marginal costs, pushing up U.S. inflation via the CPI. The second-largest contributor is U.S. domestic inflation shocks, accounting for 17%–18% (Table 2.2). By contrast, fiscal and tariff shocks are virtually insignificant, and interest rate shocks account for less than 0.2%. Spillover effects from China are also significant. As shown in Table 2.2, China's production shocks contribute 28%–29% to U.S. inflation. Figure 2.5.1 shows that China's tech shocks reduce domestic inflation, which lowers U.S. inflation via CPI transmission. Similarly, China's inflation shocks account for approximately 15% of U.S. inflation (Table 2.2). As shown in Figure 2.5.2, higher inflation in China leads to higher U.S. inflation through the CPI transmission channel.

By analogy, the following conclusions can be drawn:

1. Production shocks and inflation shocks are the primary factors driving fluctuations in domestic GDP and inflation.

2. The spillover effects between China and the United States are significant.

Therefore, the FVD analysis first focuses on the two most impactful shocks. However, some shocks have smaller contributions but remain economically important. In particular, tariff and interest rate shocks warrant further attention. Next, we examine the IRFs of these lower-impact shocks.

Initially, we examine how tariff changes between China and the U.S. influence their respective GDP, as shown in Figure 2.5.4. Higher China tariff shocks (red lines) raise CPI inflation, increasing overall inflation in China. As inflation rises, China's nominal interest rate increases according to the Taylor rule. However, if inflation expectations rise faster than the nominal interest rate, the real interest rate may decline. A lower real interest rate can lead to currency depreciation. Meanwhile, higher tariffs reduce imports, increasing the trade surplus. This higher trade surplus, in turn, can boost China's GDP. Following this, higher tariffs can reduce U.S. exports, lowering its trade surplus. This may raise domestic consumption and output, eventually leading to a higher nominal interest rate, while exhcange rate, can lead to a lower us inflation based on CPI of US.

Although theory suggests that tariffs play a significant role in the U.S.-China trade war, the FVD results in Table 2.2 show that tariff shocks exert only a modest influence on GDP and inflation in both countries. This is also consistent with findings in previous studies. Jeanne and Son (2024) attributes this to renminbi depreciation, which offsets higher export prices. nother factor is the U.S.'s weak pricing power, as Magee and Magee (2008) shows: a 10% steel tariff reduced global prices by just 0.12%. Similarly, Jaravel and Sager (2019) and Irwin (2010) argue that low Chinese prices and stable global consumption patterns limited the impact. Eichengreen (2020) highlights dollar appreciation, production shifts, and Federal Reserve rate cuts as key factors mitigating the shocks. Similarly, Cavallo et al. (2021) finds that importers absorbed the costs, limiting consumer price increases.

Following the discussion of tariff shocks, we now consider interest rate shocks, which are generally expected to have a larger effect. However, our study finds a smaller impact. Accordingly, we focus on underlying factors instead of the IRFs, given the consistent methodology.

Although interest rate shocks contribute little in our model, they remain important due to their effects on GDP, inflation, exchange rates, and capital flows through changes in borrowing costs and economic uncertainty. When interest rates rise, borrowing becomes more expensive. Firms must raise prices or cut production. This adds to inflation and slows economic growth (Chowdhury et al., 2006). Higher interest rates also affect exchange rates. They make the USD stronger and weaken other currencies. This makes inflation and other macro factors worse (Özdemir, 2015). Rising interest rates also create uncertainty. This leads to lower consumption and investment. Over time, these effects may stabilize (Lukmanova and Rabitsch, 2023). However, forward guidance from the Federal Reserve can make people more pessimistic. This reduces spending and makes GDP fall more (Acosta, 2022). Higher interest rates also reduce household wealth. They lower asset prices, which weakens consumption and investment (Roache and Attie, 2009). In emerging economies, rising interest rates often cause capital outflows and currency depreciation. This makes inflation worse and GDP fall more than in developed countries (Iacoviello and Navarro, 2019).

The unexpectedly small effects of interest rate shocks in our model suggest that interest rate policies are becoming less effective. This may be due to trade war uncertainty, supply chain problems, strong economic performance, and central bank communication. Analytica (2019) explains that the U.S.–China trade war makes businesses more cautious. They react less to changes in interest rates. As a result, lower interest rates do not boost investment and spending as much as before. Eichengreen (2020) adds that trade wars disrupt supply chains. This forces companies to focus on handling tariffs instead of reacting to central bank policies. Sinha and Smolyansky (2022) finds that even when interest rates rise a lot, the economy still performs well. This shows that businesses and consumers are less affected by these changes. Tanahara et al. (2023) argues that central banks can influence the economy through positive messages about the future. This may reduce the impact of interest rate changes. While trade war uncertainty seems to be the main reason for this weaker effect, strong economic conditions and central bank messaging may also play a role.

In summary, a policy that does not significantly affect GDP or inflation cannot be considered an effective macroeconomic tool. GDP and inflation are central targets of macroeconomic policy. A policy that fails to influence GDP or inflation has limited prac-

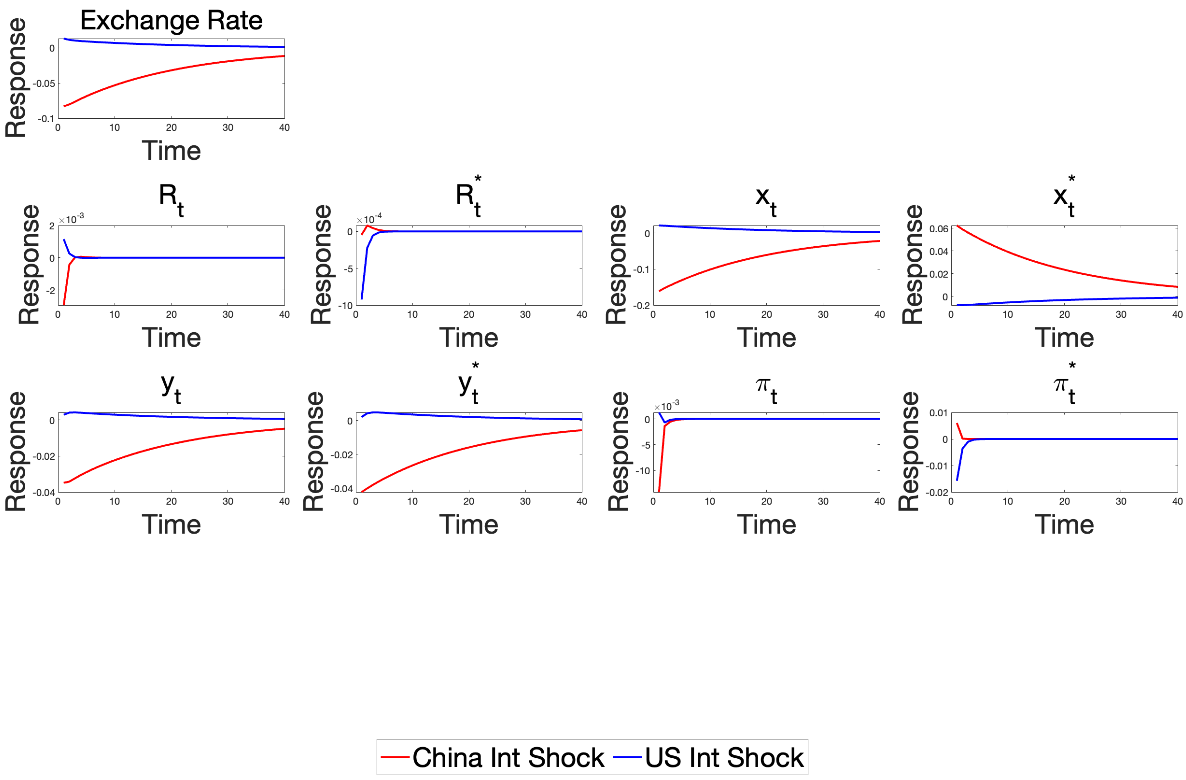

Figure 2.5.3: Impulse Responses to Interest Shocks

tical significance. Our FVD results indicate that both tariff and interest rate shocks have limited effects on GDP and inflation. This is consistent with Jaravel and Sager (2019) and Eichengreen (2020), who find that firms absorb most costs or adjust via exchange rates. The limited impact of interest rate shocks may reflect trade war uncertainty, strong fundamentals, or weaker monetary transmission, as noted earlier. Thus, neither tariffs nor interest rates serve as effective instruments for managing the economy in this setting.

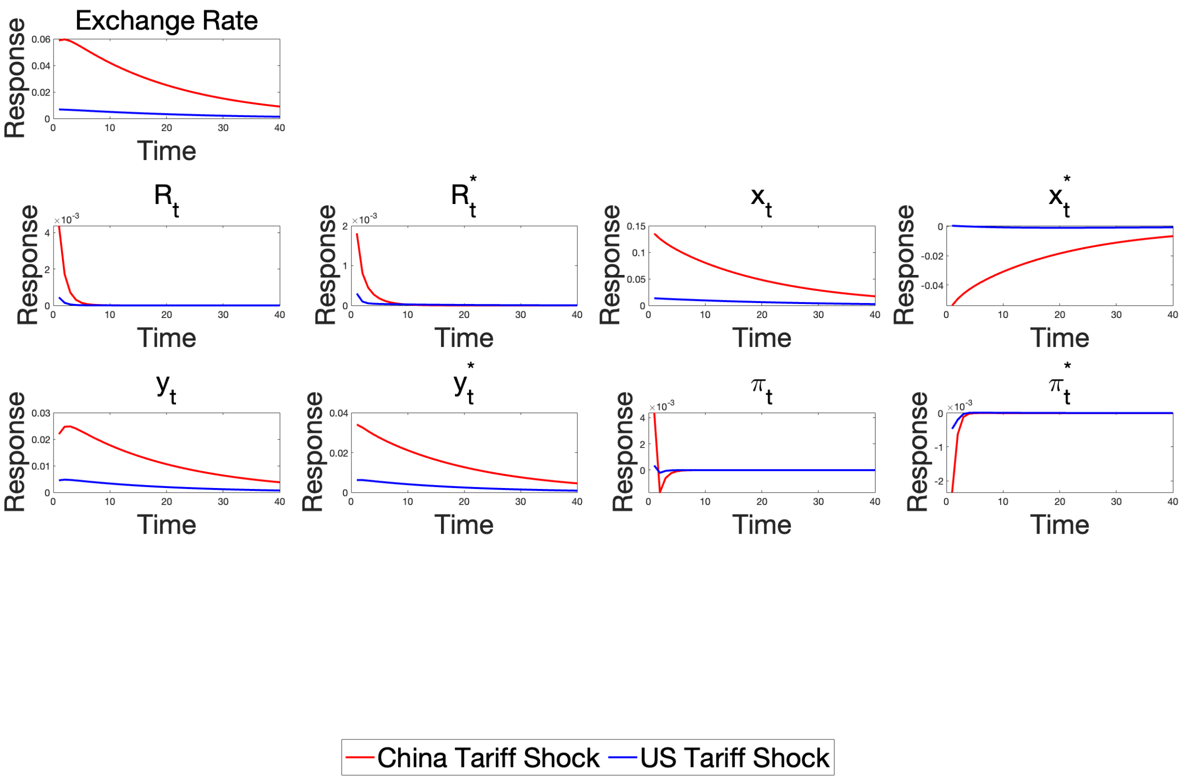

Figure 2.5.4: Impulse Responses to Tariff Shocks

2.5.2 Historical Variance Decomposition

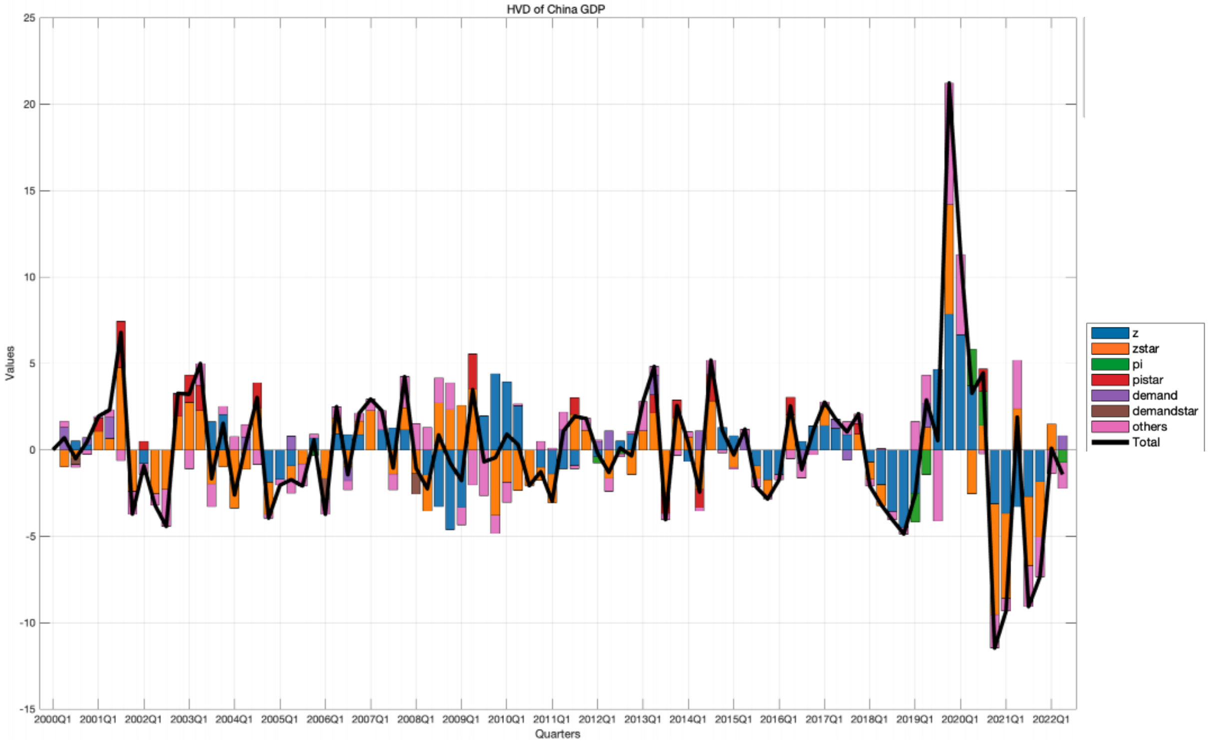

Figure 2.5.5: HVD of China's GDP

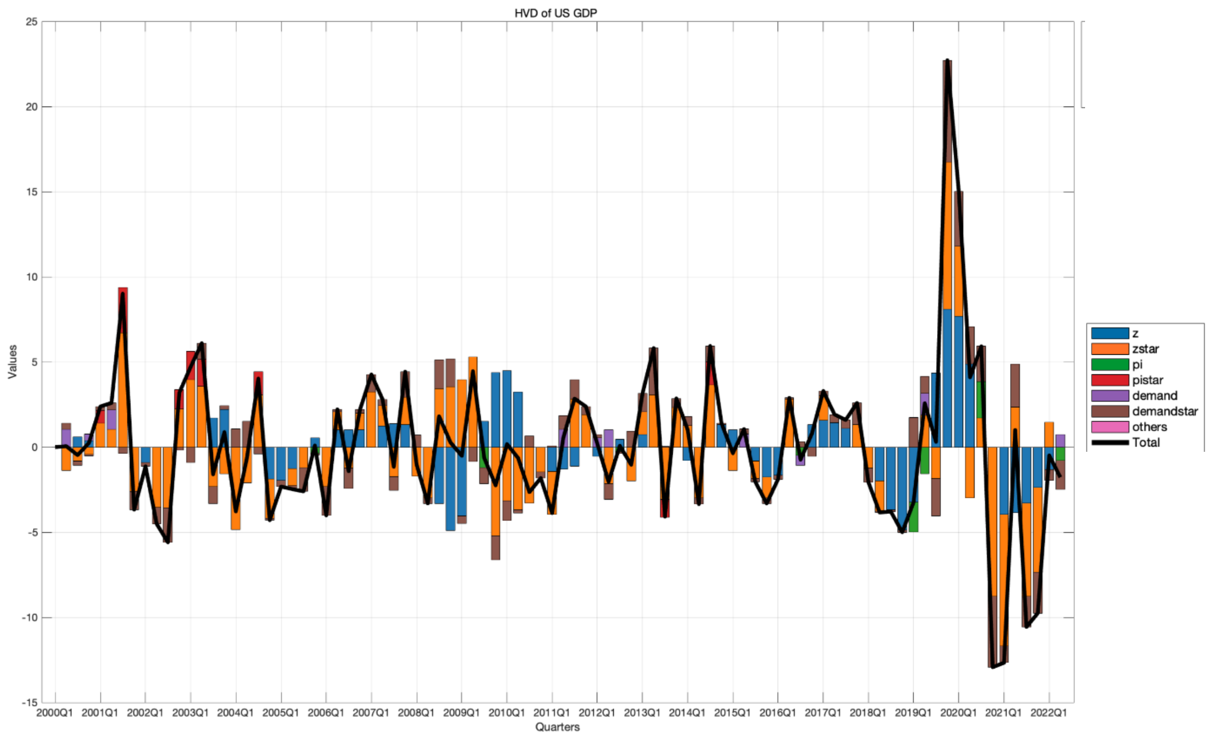

Figure 2.5.6: HVD of US GDP

We analyze several important past events using the HVD of GDP to see how they developed. The most recent event is COVID-19 in 2019, followed closely by the US-China trade war in 2018. In Figure 2.5.5 and Figure 2.5.6, both figures show GDP trends. We observe a sharp decline in 2019. This decline is caused by technological shocks from foreign countries. In 2020, GDP increases sharply. This rise is due to technological progress from both domestic and foreign sources. Later in 2020, GDP shifts from growth to decline. After that, GDP experiences another sharp decrease. There are lasting effects that continue until the first quarter of 2022, caused by the COVID-19 pandemic and the ongoing US-China trade war. Back in 2008 Q1, during the financial crisis, both GDP trends show only a small decrease. This may seem unclear or unexpected. We suggest that this is because the scale of COVID-19 was much larger. As a result, the relative negative impact of the 2008 crisis appears much smaller in comparison. In summary, this is consistent with our findings in the FVD. The main factor driving GDP in both countries is still productivity shocks.

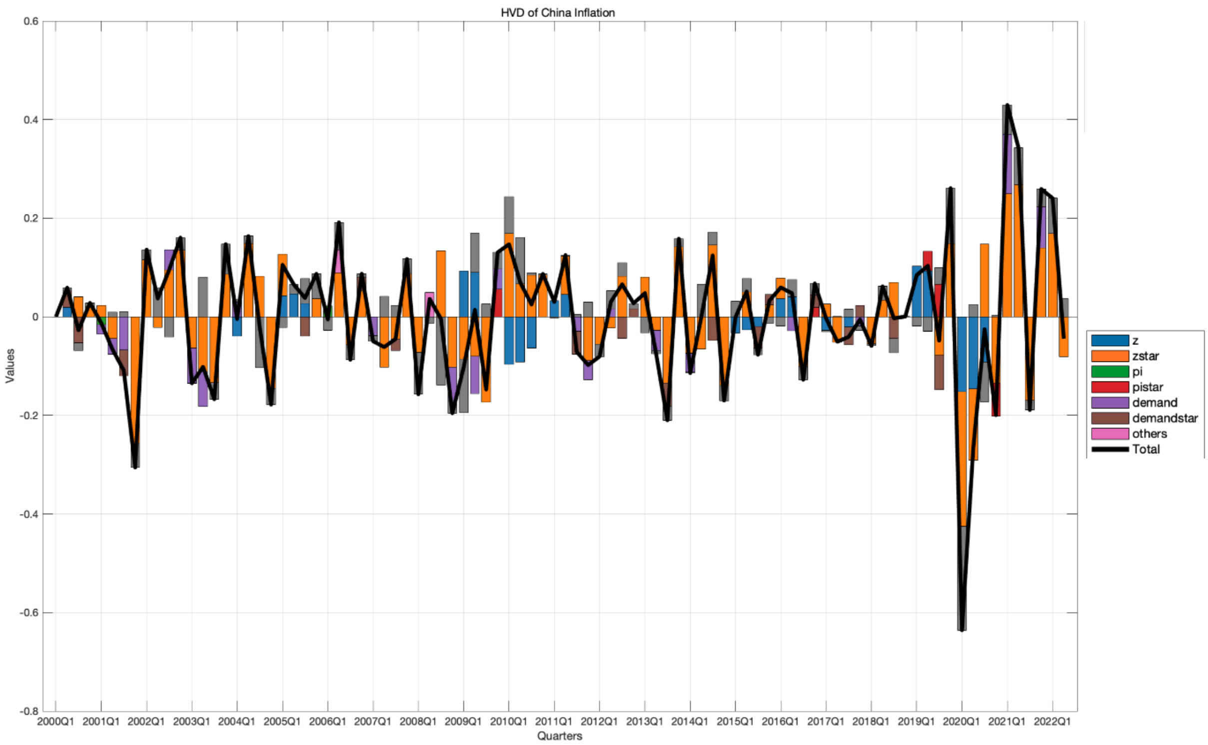

Figure 2.5.7: HVD of China's Inflation

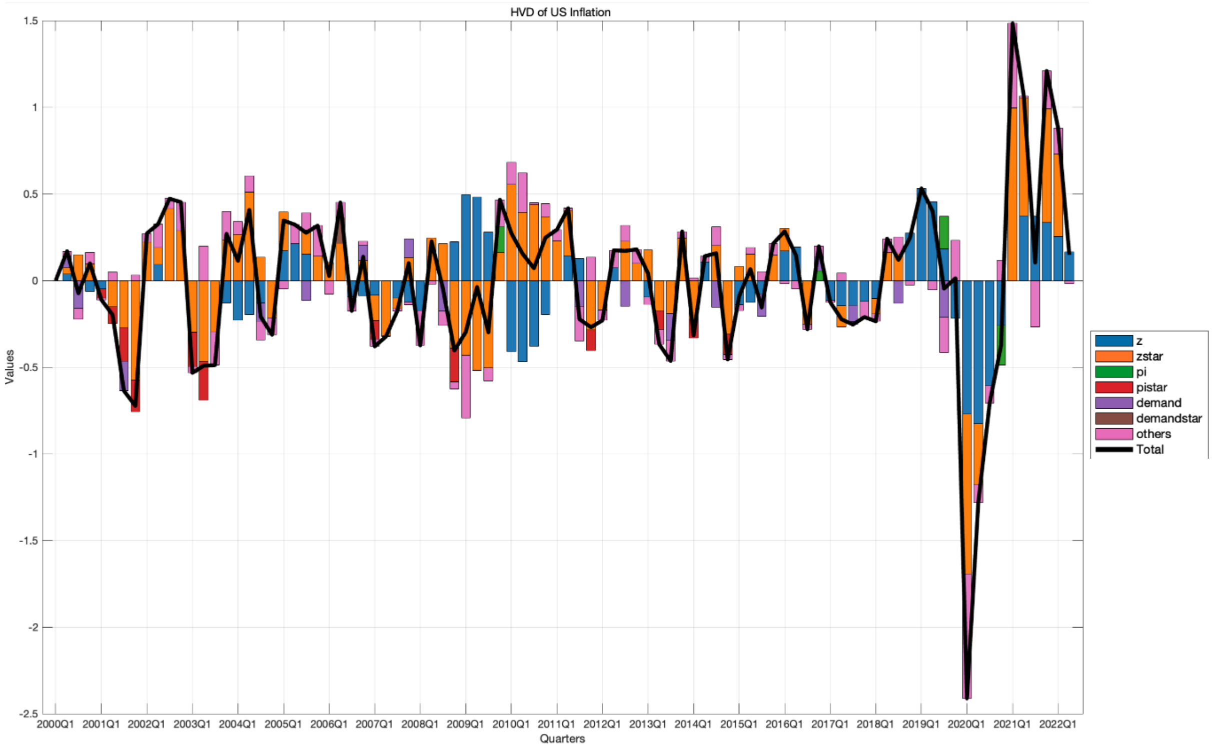

Figure 2.5.8: HVD of US Inflation

Except for the HVD of GDP in China and the US, we also consider the HVD of inflation. This is shown in Figure 2.5.7 and Figure 2.5.8. We first examine the COVID-19 event in 2019 Q1. There is a medium-scale increase in inflation, followed by a larger decrease in 2020. Technological development has supported GDP growth in both countries and helped reduce the cost of goods. In particular, the real-world progress in artificial intelligence (AI) played a key role during the pandemic. Driven by COVID-19 in 2020, AI technologies advanced rapidly, especially in areas such as remote work. In 2021 Q1 and 2022 Q1, we begin to observe a rise in the price level. This is due to the prolonged negative impact of the COVID-19 pandemic and the ongoing US-China trade war. Then, looking back to 2008, we observe fluctuations in inflation in both the US and China. However, these changes do not appear very significant. This is likely due to the negative impacts of the global financial crisis. A similar pattern is seen in the HVD of GDP. Compared to the larger scale of the US-China trade war and the COVID-19 pandemic, the effects of the 2008 financial crisis appear less severe. In summary, the HVD of inflation in both countries is also mainly driven by supply-side shocks, such as technological shocks. This is supported by the results from the FVD.

Furthermore, the HVD results highlight broader macroeconomic spillovers. These findings suggest that the U.S.–China economic relationship operates through multiple policy channels. These channels can weaken or even cancel out the intended effects of unilateral tariff actions. Therefore, tariffs may be too simple and ineffective to be used as reliable tools for structural rebalancing.

2.6 Conclusion

First, the FVD and IRFs show that tariff shocks have very little impact on GDP and inflation in both China and the U.S. This means that tariffs are not an effective tool for managing the overall economy. This result matches other studies that find costs are often absorbed, exchange rates adjust, and there is limited change in trade patterns. Second, the HVD analysis shows that U.S. tariffs during the trade war reduced China's GDP for a short time, but did not bring long-term benefits to the U.S. economy or fix the trade imbalance. This shows that while tariffs can hurt other countries, they do not always help the country that imposes them. Therefore, even if tariffs are used for political or strategic reasons, they do not work well as tools for managing the economy. A good policy tool should be able to affect key outcomes like GDP and inflation, but tariffs do not do this effectively.

Chapter 3

Scenario Analysis of the US-China Trade War: Causes and Welfare Loss Comparison

3.1 Introduction

The U.S.–China trade war has been one of the most closely followed trade disputes in recent years. Trade policies between the two countries have fluctuated over time, with tensions gradually rising in the recent period. Tariffs, a key instrument in international trade, have played a central role in this conflict (Malawer, 2018). They are used to protect domestic industries, reduce unemployment, manage trade balances, and pursue broader political or economic goals. Depending on their purpose, tariffs can be classified into types such as protective tariffs, anti-dumping tariffs, and retaliatory tariffs (Kashyap and Bothra, 2019). In the U.S.–China trade war, the high tariffs imposed by both sides have had significant effects on global supply chains and trade relationships.

In studying the U.S.–China trade war, we treat tariffs as the main variable of interest and have explained their effects in detail in Chapter 2. We now divide tariff shocks into three types: stationary exogenous shocks, non-stationary exogenous shocks, and endogenous shocks. The reason for dividing tariff shocks in this way is to identify two key aspects: First, whether the shock comes from outside or inside the economy. Second, whether the shock fades away on its own, which helps us understand if it is a short-term or long-term effect. In detail, stationary exogenous shocks refer to sudden changes caused by external events or government policies. These shocks tend to fade over time and return to their original level. Non-stationary exogenous shocks also originate outside the economy, but their effects are long-lasting and do not return to the original level. Endogenous shocks are different because they originate within the economy. They can be caused by changes in production, consumption, interest rates, or government policies. For example, a slowdown in economic activity that reduces consumer demand, or a change in tax or trade policy, can lead to tariff changes generated from within the system.

To study the macroeconomic effects of the U.S.–China trade war, we use DSGE models for both countries and estimate the key parameters using indirect inference. We add seven types of tariff equations to the models to examine how different kinds of tariff shocks affect the economy over time. We use impulse response functions to trace how changes in tariff policies affect economic growth, trade flows, and living standards in both countries.

The DSGE model results provide a clear picture of how the U.S.–China trade war has affected both countries and the global economy. Different types of tariff policies have different effects on each country. When tariffs are high, trade barriers increase and supply chains are disrupted. This slows down trade between countries and weakens global trade growth. Over time, high tariffs reduce productivity and lead to lower consumption and investment, which limits global economic growth.

To better understand the deeper effects of tariffs and the reasons why governments introduce tariff shocks, this chapter examines different forms of tariff equations. The structure of the chapter is as follows. First, we review the existing literature on tariff equations. Next, we estimate the parameters of tariff shocks. Then, we use welfare-loss analysis to assess their effects. Finally, we summarize the main findings.

3.2 Literature Review

The literature review starts with the scenario presented in Chapter 2, where a trade war between China and the U.S. is assumed to be caused by trade deficits.

Baseline Scenario: Trade Balance

When a country runs a large trade deficit—that is, its imports are much greater than its exports—it may raise tariffs to reduce imports and ease the trade imbalance. The goal is to limit imports and lower external payments in order to improve the trade balance. In this case, tariff policy is adjusted in response to trade deficits, suggesting that changes in trade balances can lead to changes in tariffs.

He et al. (2019), using a multi-country numerical general equilibrium model, found that in cases of trade imbalance, the optimal tariff levels would fall significantly for both surplus and deficit countries. In their simulation, the global average optimal tariff dropped by 26%. This result suggests that trade imbalances create incentives to reduce tariffs, which in turn supports global trade liberalization by lowering overall tariff levels. In this context, trade deficits may lead to downward tariff adjustments as a way to help restore trade balance.

Gardner and Kimbrough (1990) found that during economic recessions, trade deficits may lead governments to impose high tariffs in an effort to reduce imports and improve the trade balance. However, if these tariffs remain in place when the economy recovers, they may continue to restrict imports even when they are no longer needed, which can instead worsen the trade balance. This shows that while tariff increases may help reduce trade deficits in a downturn, they may have unintended negative effects during periods of growth. Taken together, these findings point to a close relationship between trade balances and tariff policy decisions.

Lastly, Nawaz (2019) found that trade deficits can affect the domestic economy and may lead to broader changes in tariff policy. When setting tariffs, governments need to consider not only market supply and demand, but also the regulatory costs and welfare losses that may result from tariff adjustments. This means that trade deficits influence tariff decisions not just by affecting trade flows, but also by shaping their wider economic consequences. In this way, trade deficits can impact both tariff levels and the overall health of the national economy.

3.2.1 Exogenous Tariff Shock

What is An Exogenous Tariff Shock Exogenous shocks refer to variables that influence endogenous variables but are not themselves influenced by them (Fisher, 1953). This definition involves two key conditions. First, the variable—in this case, tariffs—must affect other economic variables in the model. Second, it must be shown that tariffs are not influenced by those economic variables in return. The first condition is straightforward, as Chapter Two has already demonstrated how tariffs impact other parts of the economy. We now focus on the second condition: that tariffs are set independently of other economic outcomes. To support this assumption, we treat tariff decisions as independent of the behavior of other economic variables. In the next section, we examine this idea further by exploring non-economic factors that may influence tariff policy.

Political Factors Political factors play an important role in shaping tariff decisions. For example, Kim and Margalit (2021) found that during the U.S.–China trade war, China increased tariffs on goods from regions in the U.S. that were strongholds of the Republican Party. This action was viewed as a strategic move aimed at influencing U.S. domestic politics, especially during election periods. Such cases demonstrate that political motives can directly affect how tariff policies are designed and implemented.

Epstein and O'Halloran (1996) examined how the U.S. political system influenced foreign economic policy, particularly through tariffs, as a way to reflect the interests of competing political groups. Their study showed that between 1877 and 1934, changes in party control had a significant effect on tariff levels, with tariff policy often used to balance the interests of different producer groups. This highlights how shifts in political power can shape tariff decisions to reflect broader economic and political priorities.

Finally, Ludema et al. (2018) found that companies can influence tariff policies by affecting political decisions. They showed that when more companies oppose removing tariffs, the government is less likely to remove them. This shows that firms' views can play an important role in how tariff decisions are made. It also shows how political decisions and business interests often work together to shape trade policy.

International Trade Agreements Conybeare (1983) examined how transnational tariff levels changed over the 20th century. They found that in earlier periods, powerful countries often used trade agreements to pressure weaker countries into lowering their tariffs. Over time, however, domestic political and economic changes in these weaker countries began to play a bigger role. As a result, governments in these countries started to focus more on their own development goals rather than foreign demands. This shift shows how the influence on tariff policy moved from international pressure toward domestic priorities. It also suggests that both diplomatic and internal factors can shape how tariff policies are set.

On the other hand, there is often a tension between promoting free trade through agreements and taking protectionist measures during trade conflicts. For example, Bagwell and Staiger (1999) studied how preferential trade agreements affect multilateral tariff cooperation. They found that different agreements can lead to different tariff outcomes.

In some cases, bilateral agreements create a complementarity effect on tariffs. But countries that are not included in these agreements may face unfair treatment. This shows that international trade relations can shape tariff policies. Countries may adjust their tariffs based on both their own interests and the need to cooperate with others.

Olarreaga (1998) studied how foreign investment affects tariff reform. They pointed out that even when tariffs are reduced, foreign investment may still lower overall national welfare. As a result, some countries may keep a certain level of tariffs to protect local industries and reduce the negative impact of foreign capital. This shows that tariff policy is shaped not only by trade agreements but also by foreign investment. Countries often need to balance the goal of opening their markets with the need to protect domestic interests. This suggests that international factors, such as investment flows and trade deals, can lead to changes in tariff policy.

Technical Barriers According to Ghodsi (2015), national security and technology are important factors in setting tariff policies. Governments use tariffs not only to protect key technologies but also to support innovation. When setting tariffs, they consider whether products meet technical standards and whether they may harm human health or the environment. This means that in building technical trade barriers, governments look at both the technical features of products and their broader social impact. Tariff policies are often designed to encourage safe technology while also protecting public welfare. This shows that technical standards can influence tariff decisions, as governments adjust tariffs to reflect safety, health, and innovation goals.

Ederington and McCalman (2013) and Crowley (2006) showed that tariff policies are linked to technological progress and firms' ability to improve their technology. They pointed out that while tariffs do not directly spread technology, governments can help domestic use of global technologies by adjusting non-tariff tools such as quotas[1]. For example, they may lower tariffs on certain tech products or replace some non-tariff rules with clear tariffs. These steps can make it easier for new technologies to enter and grow in the domestic market. This shows that tariff and non-tariff policies can support technology goals. Governments often adjust them to help local firms adopt and apply new technologies.

Tariff adjustments—such as anti-dumping duties—are often influenced by more than just economic factors. Anti-dumping duties are tariffs imposed when a foreign firm sells goods below cost and harms domestic industries.[2] Governments may also use technical barriers to trade, such as product standards or safety rules, to justify higher tariffs. Although these measures appear neutral, they can be used to limit foreign competition

[1] A quota system limits the import quantity of specific goods to protect the domestic market.

[2] For example, if a firm from Country A sells products in Country B below cost, harming local industries, Country B may impose anti-dumping duties to protect its domestic producers.

or protect strategic industries. This shows that non-economic factors, such as regulation or national security, can make trade shocks partly endogenous.

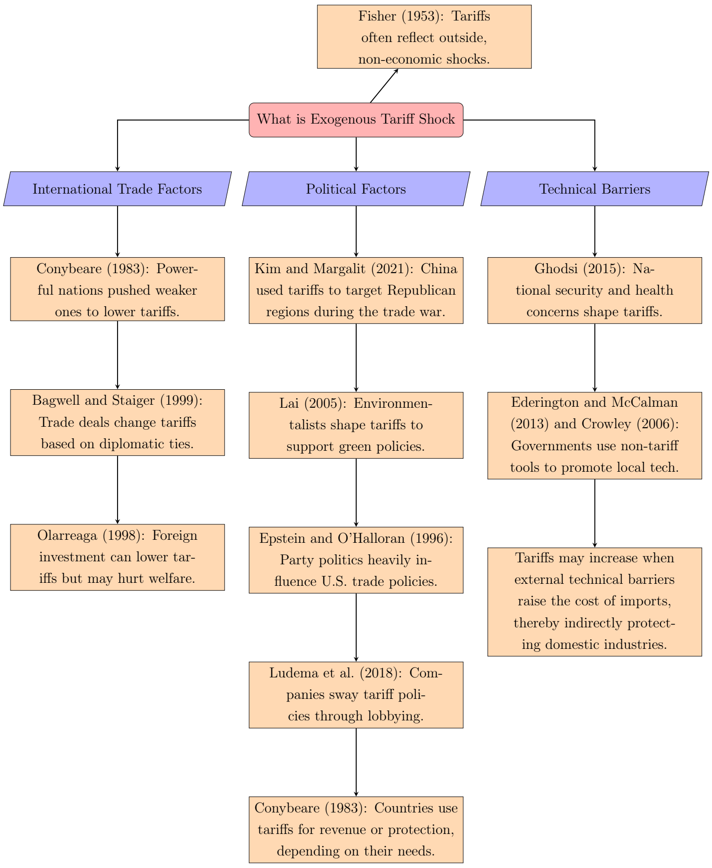

Figure 3.2.1: Description of Exogenous Tariff

To make the above content easier to understand, Figure 3.2.1 shows the views of each party and gives a clear summary of the discussion.

We divide tariff changes into two types: stationary and non-stationary changes. Stationary tariff shocks refer to cases where tariffs rise or fall for a time but later return to their original levels. These changes follow a regular pattern and do not cause lasting effects. In short, the change is temporary and can be expected. In contrast, non-stationary tariff shocks refer to changes that do not return to the original level or become too large and unpredictable. This may happen when the government adjusts tariffs often or when external events like trade disputes or economic crises cause sudden changes. In these cases, tariff changes are harder to control and may have long-term effects.

Exogenous Stationary Tariff Shock

In this section, we explain why tariffs might change for a short time and then return to their original levels.

Policy adjustments Policy adjustment is often used as a short-term measure by governments to deal with economic problems and protect domestic industries. As noted by Clemens and Williamson (2004), many countries in the past raised tariffs to support domestic economic activity. But as global trade has expanded, the long-term benefits of such policies have become less certain. Even so, in some cases, governments still raise tariffs for a short time when facing external shocks or the risk of retaliation. This shows that such tariff increases are usually temporary and are often reversed when external conditions improve.

From another angle, Aaronson (1996) and Abe (1992) discussed other goals of tariff adjustment, such as raising government revenue and improving public welfare. Some countries may lower tariffs to support tourism or reduce production costs, while at the same time increasing indirect taxes to fund public services and promote growth. Whether this strategy works depends on how well the government can provide public goods. This must be taken into account when deciding whether tariff reform can help long-term development. For this reason, after short-term changes, tariff levels often return to a level that fits the country's long-term goals.

Spearot (2013) studied ad valorem tariff reductions during the Uruguay Round in the United States and found that, due to demand elasticity, lower-income groups gained more from tariff liberalisation. This suggests that tariff changes can be used, at least temporarily, to lower the cost of goods mainly consumed by low-income households. As tariff liberalisation tends to make goods for higher-income groups relatively more expensive, goods for lower-income groups become cheaper by comparison. This shows that tariff policy can be directed at specific social groups and later returned to previous levels to restore the balance between market conditions and social aims.

Gallarotti (1985) examined tariff changes in the United States, Britain, and Germany during the 19th and early 20th centuries using an interest group framework. They found that tariff changes often followed the business cycle. In times of economic growth, governments tended to lower tariffs to allow more imports and meet domestic demand. In contrast, during downturns, they often raised tariffs to protect domestic industries by limiting imports. This pattern shows that governments adjust tariffs in response to economic conditions, often raising or lowering them for a time before returning to previous levels as the economy stabilises.

Another way governments adjust tariff policy is by responding to changes in the trade balance. As noted by Gardner and Kimbrough (1990), when a trade deficit becomes large, governments may raise tariffs to limit imports and reduce the deficit. But during periods of strong growth, the trade deficit may shrink, and governments may lower tariffs to allow more imports. This can lead to a worsening trade balance if imports rise too quickly. Such cases show that tariff rates are often adjusted in response to short-term economic conditions, but tend to return to levels that support longer-term economic goals.

Lastly, Irwin (1996) found that changes in the prices of imported goods played an important role in U.S. tariff policy between 1865 and 1973. By examining the ad valorem equivalent[3], they showed that when import prices rise, the ad valorem equivalent of a specific tariff falls, increasing the share of tariffs in the final price. When import prices fall, the ad valorem equivalent rises, which lowers the share of tariffs paid. This suggests that governments take changes in import prices into account when setting tariffs. Tariff levels are adjusted as needed but tend to return to a level that reflects broader economic conditions.

Negative Impact Of Trade Disputes Trade disputes[4] refer to conflicts between countries arising from trade policies, barriers, or related measures. In the current regulatory setting, if countries impose trade restrictions and retaliate in turn, disputes may escalate and develop into trade wars (Gordeeva, 2013). The US–China dispute has had a range of negative effects, leading both governments to consider reducing tariffs after a temporary rise in order to ease tensions and limit economic damage.

Cigna et al. (2022) found that the tariffs imposed by the US on Chinese imports had a clear negative effect on the US economy, without causing short-term trade diversion to third countries. This direct loss may lead both the US and Chinese governments to reconsider and reduce tariffs to their earlier levels. It suggests that once the economic costs of tariffs become evident, governments may adjust trade policies and return tariffs to a more sustainable level.

Freund et al. (2018) noted that the US–China trade dispute not only increased tensions in global trade but also raised uncertainty around investment expectations in developing countries, leading to a fall in foreign investment. The study further found that global exports declined by around 3% and global income by about 1.7%, as rising tariffs disrupted global supply chains. These outcomes suggest that, once the economic costs become sufficiently large, governments may lower tariffs to ease pressure on global trade and reduce uncertainty.

Grossman and Helpman (2020) further explained that the US–China trade dispute prompted American firms to seek alternative suppliers in other countries to avoid higher costs from China's retaliatory tariffs. However, switching suppliers involves time and cost, and often leads to disruptions and adjustments in the supply chain. These changes can affect production, requiring new contracts and revised delivery schedules. This was especially evident in mid-2018, when tariff tensions between the US and China escalated, and the US also saw shifts in trade relations with the European Union and Mexico. These developments suggest that continued changes in trade policy may lead governments

[3]The ratio between tariffs and the prices of imported goods

[4]For example, the US–China trade dispute began with tariffs and other restrictions imposed by the US in response to concerns over unfair trade practices by China, such as intellectual property violations and limited market access, which were seen as contributing to trade imbalances and job losses.

to return tariffs to previous levels in an effort to stabilise markets and limit economic disruption (Galbraith, 2018).

Lastly, Zheng et al. (2023) found that the US–China trade dispute increased costs, reduced profits, and caused job losses for firms in both countries. In agriculture, the dispute led China to raise tariffs on selected US products. Removing these tariffs could improve access for US agricultural exporters and allow Chinese consumers to purchase these goods at lower prices. Such a policy shift would bring clear gains for both sides. This illustrates that tariff adjustments often aim to ease economic pressure and promote trade, and may return to earlier levels once trade conditions improve.

Global Economy Outlook Dieterle (2020) argued that the global economy forms a complex system reflecting the combined output of all countries. Changes in this system have become an important factor behind temporary tariff shifts between China and the United States. For example, when international preferences differ sharply, temporary US tariffs on imported cars can raise their prices and reduce consumer demand. If demand for these imports is inelastic, such tariffs may worsen the US trade deficit. Foreign preferences for American goods also influence the trade balance. In response to these factors, policymakers may adjust tariffs temporarily and later return them to previous levels to help manage trade imbalances as global conditions evolve (Gardner and Kimbrough, 1989).

In a historical context, Clemens and Williamson (2004) used data from before and after World War II to show that high tariffs before the war were mainly aimed at supporting domestic industry. After the war, trade policies became more open, reflecting greater reliance on international trade. This shift highlights how major global events can lead to sharp changes in tariff policy. Such changes suggest that tariff adjustments are often temporary, with governments raising or lowering tariffs in response to global conditions and later returning them to earlier levels as circumstances allow.

Rieber (1981) argued that world prices play an important role in setting tariffs, particularly when there is only one domestic producer of a given product. In such cases, a tariff would raise domestic prices, reduce consumer demand, and encourage the local producer to expand output. While this may increase profits for producers and generate revenue for the government, it also lowers consumer welfare, as higher prices reduce real purchasing power. As a result, although tariffs may offer short-term gains for certain industries, they can reduce overall domestic welfare in the long run. This helps explain why tariff changes are often temporary and may be reversed once their broader effects become clear.

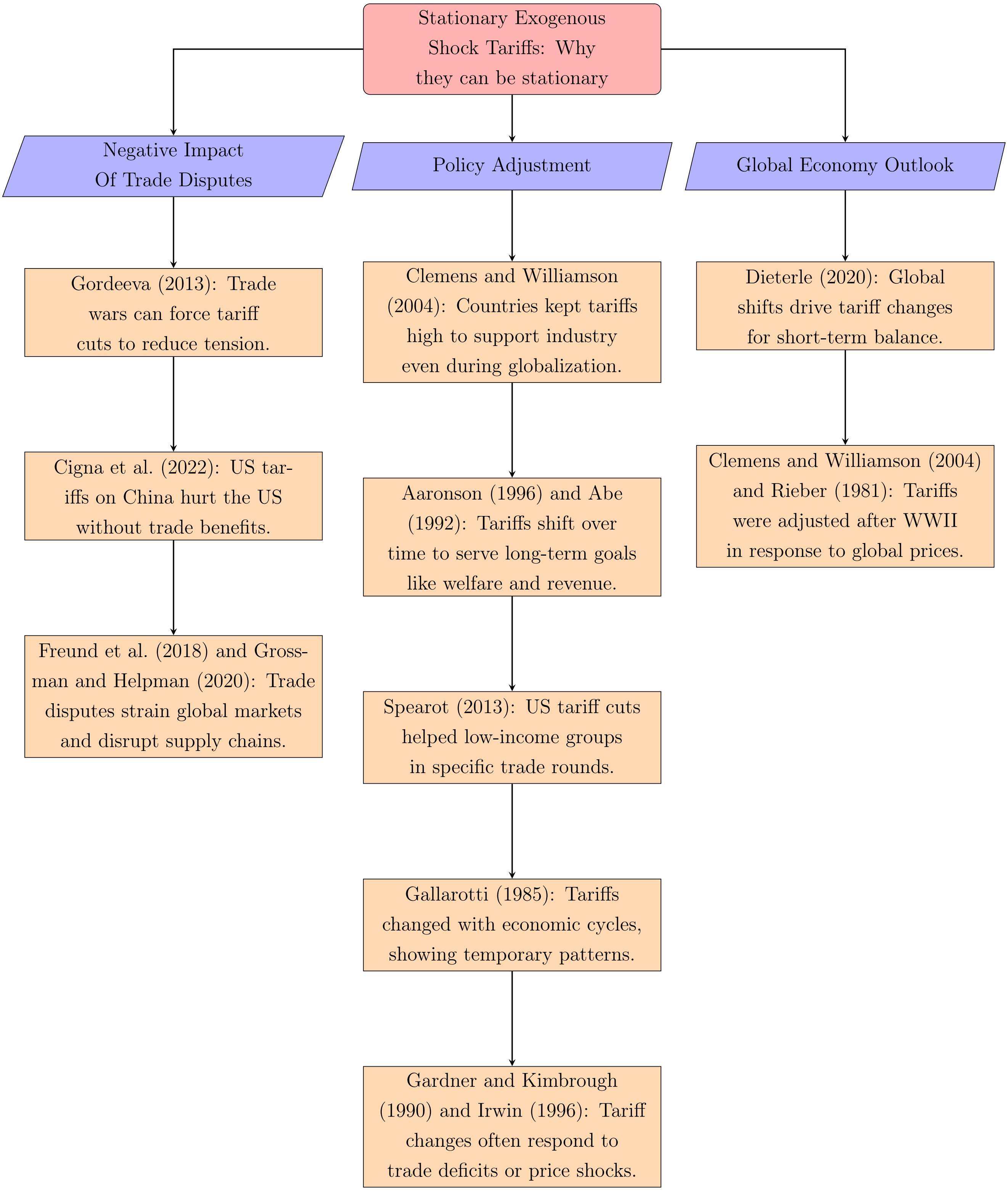

Figure 3.2.2: Stationary Exogenous Shock Tariffs: Why they can be stationary

In summary, Figure 3.2.2 provides a detailed overview of the points discussed above.

Exogenous Non-Stationary Tariff Shock

The previous section explained why tariff changes are often temporary and tend to return to earlier levels. This section turns to cases where tariffs do not return to their original levels, focusing on patterns of non-stationary tariff changes.

Policy Objectives Staiger and Tabellini (1987) argued that governments may raise tariffs in response to short-term pressures to protect domestic industries. However, this may delay longer-term goals such as lowering tariffs to improve consumer welfare and support growth. Political or economic pressures in the short run can shift trade policy toward stronger protection, which may result in high tariffs being kept in place over time. In such cases, a temporary adjustment in tariffs can turn into a lasting policy change. This suggests that tariffs may take on a more central role in trade policy, even replacing subsidies as the main policy instrument.

Following this, Pecorino (1997) offered an explanation for why tariff increases may become permanent by focusing on lobbying. When an industry grows under tariff protection, more capital enters the sector, increasing the political influence of both the industry and its associated interest groups. If the costs of organising these groups are low[5], the government may face pressure to raise tariffs to limit imports. This can create a cycle: as the industry becomes more profitable, it attracts more capital, which strengthens lobbying efforts and increases the push for continued protection. In this way, an initially temporary tariff increase may turn into a lasting policy change.

Finally, Diewert et al. (1989) examined how tariff changes affect productivity. They found that achieving long-term productivity gains may require permanent changes in tariffs. According to the Weymark condition[6], if a combination of tariff and tax adjustments improves Pareto efficiency[7], the government may choose to adopt it. This suggests that when such policies raise productivity and benefit some groups without harming others, temporary tariff changes may become permanent.

Trade Patterns Trade patterns often reflect changes in a country's economic structure. When policymakers seek to influence this structure, they may introduce permanent tariff changes. Such adjustments are common when governments aim to shift production or trade priorities in the long term. For example, Rieber (1981) noted that if a country wants to promote exports of a particular product but domestic producers struggle to compete with imports, the government may raise tariffs on those imports to support

[5]The free-rider problem refers to a situation where some interest groups benefit from a policy without bearing any cost.

[6]The Weymark condition is a standard used to evaluate whether a policy change can improve social welfare.

[7]Pareto efficiency refers to a situation where at least one person is better off without making anyone worse off.

local production. In these cases, tariff changes are not short-term responses but part of a broader strategy to reshape trade patterns and the national economy.

Tariff adjustments are sometimes used to respond to rapid changes in specific industries. Between 1965 and 1990, the structure of international trade shifted quickly, especially in sectors with high R&D spending, such as electronics. This shift benefited large and wealthy countries like the United States and Japan, which had the capacity to adapt. In contrast, smaller or low-income countries lacked the resources to adjust as effectively (Fagerberg and Srholec*, 2004). In such cases, governments may raise or lower tariffs to support or limit the growth of certain industries. These changes are often based on long-term goals and may result in lasting shifts in the structure of trade and production.

Finally, Federico and Tena-Junguito (2019) found that global trade growth during 1830–1870 and 1972–2007 was closely linked to trade openness, driven by falling trade costs and the rise of international supply chains. When policymakers seek to lower trade costs and promote integration, they may implement permanent tariff changes. Such changes affect trade flows in the short term but can also reshape trade patterns and economic structures over time. This suggests that even if tariff changes begin as temporary measures, they may lead to lasting effects.

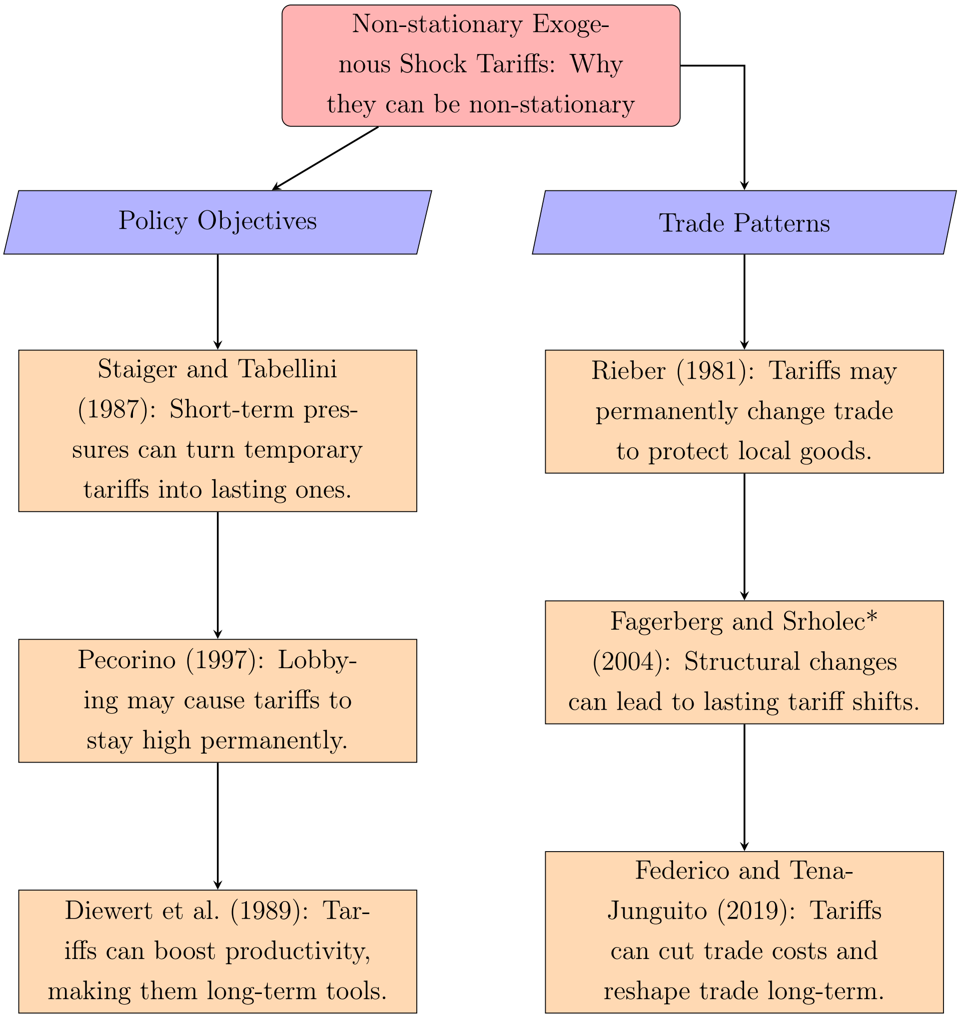

Figure 3.2.3: Non-stationary Exogenous Shock Tariffs: Why they can be non-stationary

The above content is summarised in Figure 3.2.3.

3.2.2 Remaining Endogenous Tariff Shocks

Unemployment

When a country faces rising unemployment, the government may adopt protectionist policies to support domestic employment. In such cases, tariffs may be raised to reduce imports and promote domestic industry. As Johansson and Löfgren (1981) noted, higher tariffs can make local goods more competitive, helping to boost production and create jobs. The idea is that by increasing the price of foreign products, domestic goods gain a price advantage, which can support employment. This suggests that rising unemployment may lead to changes in tariff policy aimed at protecting jobs.

However, Furceri et al. (2018) offered a different view. They argued that during periods of rising unemployment, tariffs should be reduced rather than increased. Higher tariffs raise the price of imported goods, which can increase production costs for domestic firms and lead to lower employment. In such cases, reducing tariffs may help contain production costs and limit job losses. This again suggests that changes in unemployment may lead to tariff adjustments aimed at easing pressure on the labour market.

Finally, Hashimoto (2015) examined the relationship between import tariffs and offshore outsourcing.[8] When domestic employment declines, governments may raise tariffs on goods linked to offshore outsourcing to reduce its appeal and encourage firms to relocate production back home. This, in turn, may help increase domestic job opportunities. It suggests that rising unemployment can lead to tariff changes aimed at supporting employment.

Foreign Tariffs

Changes in foreign tariff policies can influence a country's own tariff decisions, both directly and indirectly. When setting tariffs, governments often respond to foreign tariff changes to safeguard domestic interests and maintain trade balance. Shifts in foreign tariff rates may lead to domestic adjustments—not only to reflect global trade conditions and protect the local economy, but also to enhance bargaining power in trade negotiations.[9]

According to the collusive trade policy theory of Mayer (1985),[10] when foreign countries impose high tariffs, the affected country may respond by raising its own tariffs in return. Such retaliatory measures are intended to bring both sides back to the negotiating table. This suggests that increases in foreign tariffs can trigger domestic tariff changes aimed at protecting local industries and promoting fair trade.

When a foreign country imposes tariffs on domestic exports, the affected goods lose competitiveness abroad, leading to reduced export revenues and greater pressure on local producers. This can result in excess domestic supply, declining prices, and reduced profitability for domestic firms. If the home country does not impose reciprocal tariffs, foreign products may continue to enter the domestic market at stable prices. Compared to weakened domestic competitors, these foreign goods may gain a relative price advantage[11]. This situation intensifies pressure on domestic industries, prompting governments to raise tariffs in response, as noted by Traca (1997).

Furthermore, foreign tariff changes can influence domestic policy through international price movements. As Metzler (1949) noted, if a foreign country raises tariffs on a good,

[8]Offshore outsourcing refers to firms shifting certain business activities to overseas providers to reduce costs and improve efficiency. For example, a U.S. software company might outsource development work to India to benefit from lower labour costs and specialised skills.

[9]Bargaining power refers to the influence one party holds in negotiations, often based on economic strength, resources, political position, or other strategic advantages.

[10]This theory suggests that countries adjust trade policies through negotiation to maximise joint welfare, based on a shared social utility framework.

[11]A relative price advantage occurs when a product becomes more attractive not because its absolute price has decreased, but because competing products have become less competitive due to higher costs, lower quality, or reduced supply reliability.

reducing its demand abroad, the world price of that good may fall. In response, the domestic country may lower its own tariffs on the product to stabilise import prices. This reflects the indirect effects of foreign tariff policy on domestic decisions and shows how governments adjust to global market shifts to protect local stability. It highlights the role of international interaction in shaping domestic trade policy.

Foreign Subsidies

Subsidies are financial supports provided by governments to assist specific industries, firms, or individuals in achieving policy objectives. When foreign governments subsidise their domestic producers, these firms may enter other markets at lower cost, creating competitive pressure on local businesses. In response, governments may impose tariffs to protect domestic industries and maintain market balance. This indicates a direct link between foreign subsidies and domestic tariff policy. The following evidence supports this view.

Collie (1991) examined how domestic governments may respond to foreign export subsidies. The study found that they can either impose tariffs alone or combine tariffs with production subsidies. Both approaches can protect domestic industries from the effects of foreign subsidies. However, using tariffs alone avoids the fiscal cost of domestic subsidies and may lead to greater net benefits. This suggests that foreign export subsidies can influence domestic tariff policy, as governments weigh the relative costs and benefits of available responses.

Wang (2004) examined how domestic governments may respond to foreign export subsidies by imposing countervailing duties. These duties are added to existing tariffs and depend on the current tariff level. If tariffs are already high, the countervailing duty may be small or unnecessary, as existing protection is already sufficient. This suggests that foreign subsidies can affect domestic tariff policy, with countervailing measures adjusted in line with the extent of foreign support.

Furthermore, Wang (2004) find that when a foreign government withdraws subsidies on certain products, it can unexpectedly lead to an increase in domestic countervailing measures. This counterintuitive response highlights the complex ways in which global price changes affect domestic industries. For example, in the automotive sector, the removal of foreign subsidies may raise the price of imported vehicles. As a result, demand for these foreign cars may fall, which can reduce the need for foreign-made components—including those exported by the domestic country. Facing declining exports in upstream industries[12], the domestic government may respond by increasing countervailing duties—not to punish subsidies, but to raise the final cost of foreign goods and improve the competitiveness of local producers. This shows that changes in foreign sub-

[12]Upstream industries refer to sectors that supply inputs, materials, or components used in the production of final goods, such as auto parts manufacturers that supply carmakers.

sidy policies can influence not only tariff responses, but also broader export and industrial strategies, as governments act to protect domestic economic interests.

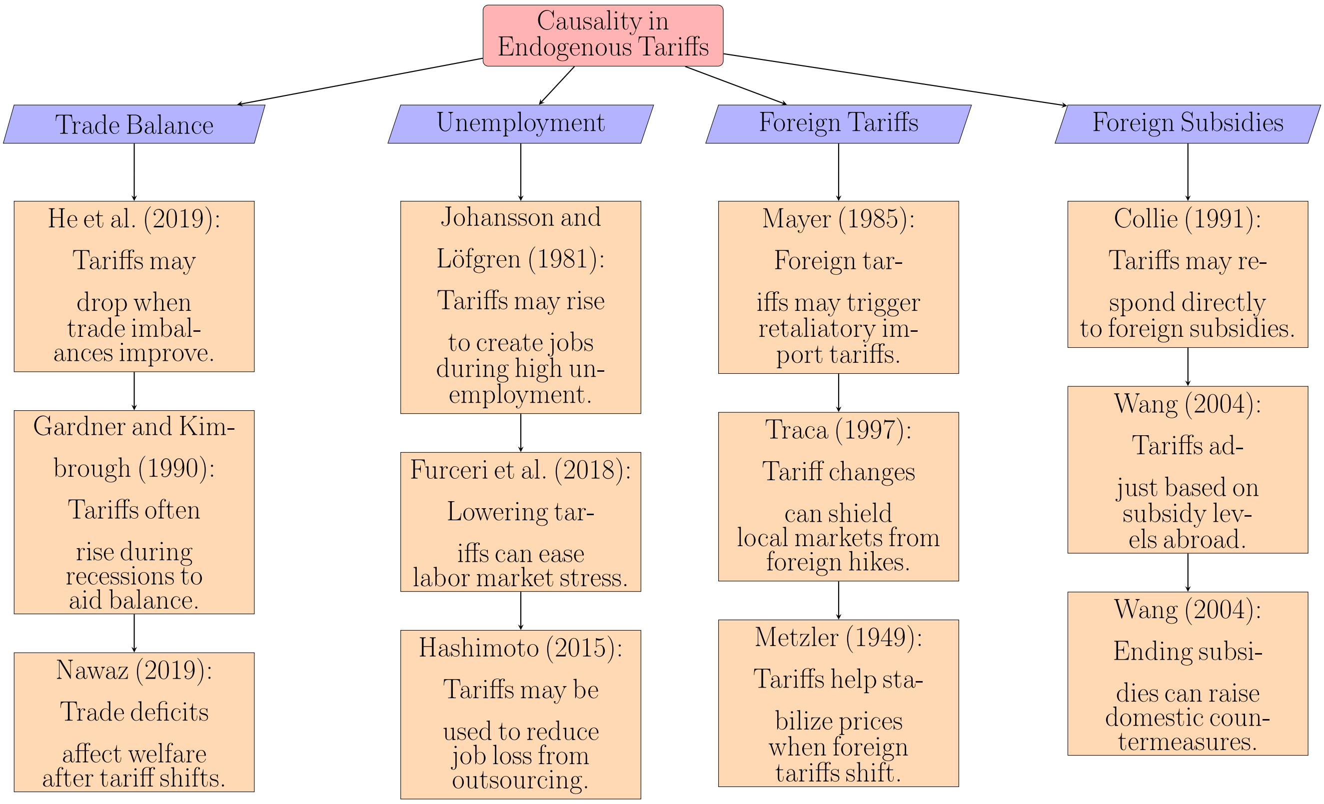

Figure 3.2.4: Causality in Endogenous Tariffs

Figure 3.2.4 provides a brief summary of the causal mechanisms discussed above.

3.2.3 Summary:Comparing Different Tariff Shocks

Tariffs can be classified into three types: stationary exogenous shocks, non-stationary exogenous shocks, and endogenous shocks. This classification clarifies the different sources of tariff variation and their respective economic effects.

Stationary exogenous shocks refer to tariff changes that occur over time but eventually return to their original level. These changes are typically predictable and cyclical, and do not cause lasting shifts in tariff levels. They often arise from pre-announced trade policies or short-term economic interventions.

Non-stationary exogenous shocks, by contrast, involve changes that do not revert to their initial level, or whose magnitude and persistence are difficult to predict. Such shocks may result from repeated policy changes or external disturbances, including trade disputes and global crises. They often lead to sustained market uncertainty and long-term disruption in trade patterns.

Endogenous shocks arise from within the economic system. Unlike exogenous shocks, they are shaped by interactions among domestic variables and reflect the government's response to internal economic conditions. Tariff changes of this kind are typically linked to broader policy goals, such as employment, industrial support, or trade balance, and evolve with the state of the economy.

Figure 3.2.5 summarises the classification and driving factors behind each type of shock.

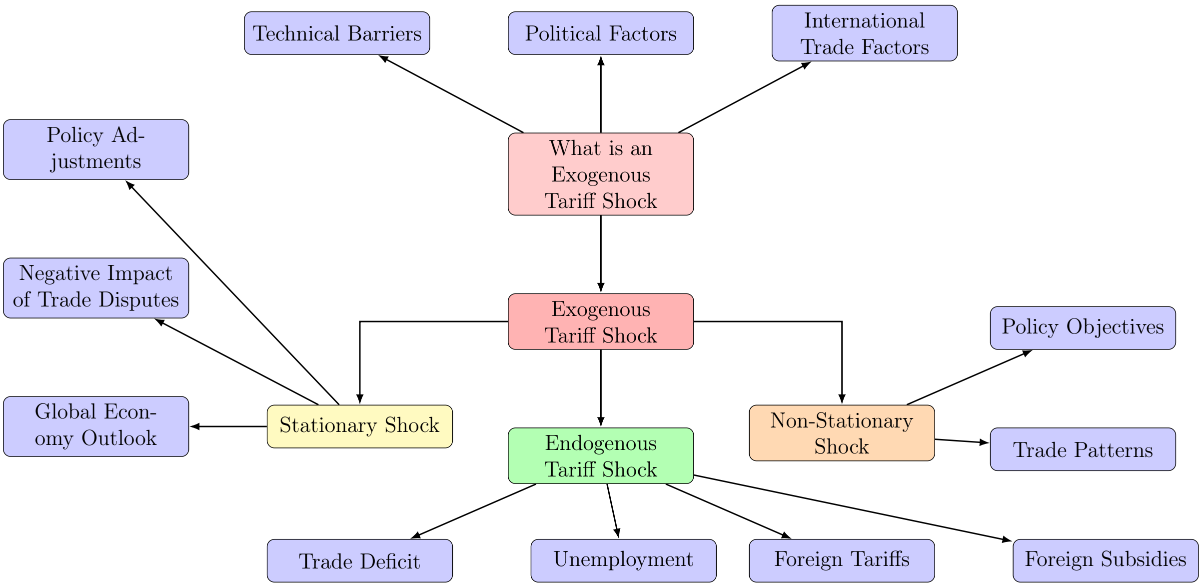

Figure 3.2.5: Literature Review Outline Flowchart

3.3 Model

The structure of the model in this section follows that of Chapter Two, with the main difference lying in the specification of the tariff equation. Accordingly, the analysis focuses on different scenarios by varying the functional form of the tariff equation, while keeping the remainder of the model unchanged.

As shown in the conceptual structure diagram (Figure 3.3.1), the mathematical formulation for each case is presented in detail.

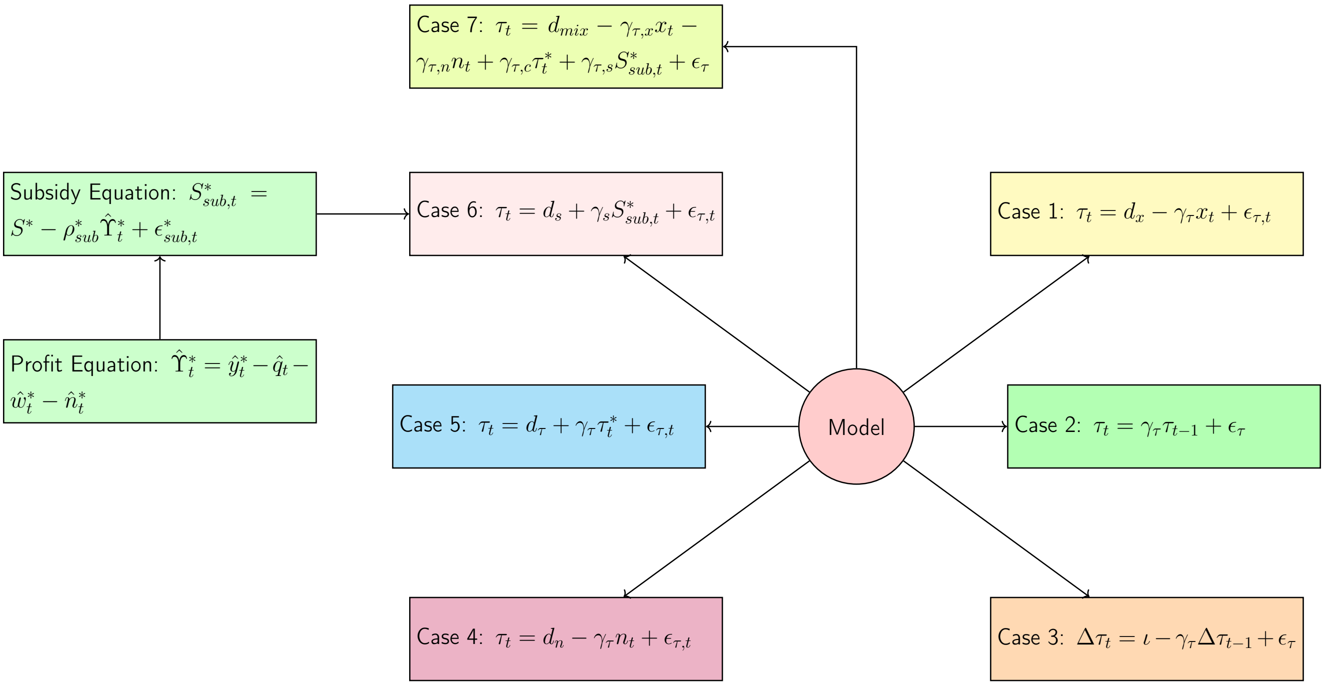

Figure 3.3.1: Conceptual diagram of different tariff shock models with their corresponding cases and interconnected equations.

3.3.1 Endogenous Tariff Equation with Trading Deficit

In this section, tariffs are treated as an endogenous dependent variable, determined solely by one endogenous explanatory variable—the trade deficit. The trade deficit is defined as total exports minus total imports. To express a trade surplus, a negative sign is applied. Accordingly, the tariff equation takes the following form:

$$\tau_t = d_x - \gamma_\tau x_t + \epsilon_{\tau,t} \tag{3.1}$$

Here, d_x is a constant, and γ_τ is a positive parameter.

3.3.2 Exogenous Stationary Tariff Shock

In this section, the tariff equation is no longer influenced by other endogenous variables but follows a simple autoregressive process of order one. The specific form is given by:

$$\tau_t = \gamma_\tau \tau_{t-1} + \epsilon_\tau \tag{3.2}$$

Here, γ_τ is the autoregressive coefficient, with $0 < \gamma_\tau < 1$. This implies that tariff shocks are transitory and gradually return to zero over time.

3.3.3 Exogenous Non-Stationary Tariff Shock

In this section, we consider a tariff equation that is similar to the stationary exogenous case in Case 2, but with one important difference: the effect of tariff shocks is assumed to be long-lasting and does not disappear over time. A common way to model this is to use the first-difference form of the tariff variable.

There are two main reasons for using this approach. First, it turns a non-stationary process into a stationary one, which makes it easier to study long-term effects. Second, it helps us focus on how fast and by how much tariffs change, rather than just looking at their level. This makes it possible to study the effects of sudden tariff changes more clearly.

$$\Delta\tau_t = \iota - \gamma_\tau \Delta\tau_{t-1} + \epsilon_\tau \tag{3.3}$$

Here, $\Delta\tau_t = \tau_t - \tau_{t-1}$ is the change in tariffs from one period to the next, and ι is a constant. This means that even if $\Delta\tau_{t-1} = 0$, the change in the current period $\Delta\tau_t$ is expected to equal ι. So, tariff changes do not disappear over time but become a regular part of the system. They are likely to continue and can lead to further changes in the economy.

3.3.4 Endogenous Tariff Equation with Unemployment

In this section, we examine tariffs as endogenous dependent variables, determined solely by the endogenous variable representing the unemployment rate. To capture this, we use the labour variable n_t, as introduced in Chapter 2. Specifically, tariffs are set as an inverse function of the labour variable, as shown below:

$$\tau_t = d_n - \gamma_\tau n_t + \epsilon_{\tau,t} \tag{3.4}$$

Here, d_n is a constant, and γ_τ is a positive parameter.

3.3.5 Endogenous Tariff Equation with Counterparty Tariff

In this section, we consider the case where tariffs are treated as endogenous dependent variables, determined solely by one endogenous explanatory variable—foreign tariffs. The relationship is given by:

$$\tau_t = d_\tau + \gamma_\tau \tau_t^* + \epsilon_{\tau,t} \tag{3.5}$$

Here, d_τ is a constant, and γ_τ is a positive parameter.

3.3.6 Endogenous Tariff Equation with Subsidies

In this section, we treat the domestic tariff as an endogenous policy instrument that responds to a single endogenous driver: the subsidy provided by the foreign country. This maps to the standard "unfair trade practices" narrative in which tariffs offset foreign export subsidies that can induce dumping in the home market (i.e., an anti-dumping style response).

Tariff rule.

$$\tau_t \;=\; d_s \;+\; \gamma_s\, S^*_{\mathrm{sub},t} \;+\; \epsilon_{\tau,t} \tag{3.6}$$

with $\gamma_s > 0$ capturing that tariffs rise when the foreign subsidy is stronger.

Foreign-subsidy proxy built from profits. We proxy the intensity of foreign subsidies by an inverse function of foreign firms' profits: subsidies increase when profits are weak (countercyclical with respect to profits). Formally,

$$S^*_{\mathrm{sub},t} \;=\; \bar{S}^* \;-\; \rho^*_{\mathrm{sub}}\, \widehat{\Upsilon}^*_t \;+\; \epsilon^*_{\mathrm{sub},t}, \qquad \rho^*_{\mathrm{sub}} > 0, \tag{3.7}$$

where $\bar{S}^*$ is the steady-state level. Lower profits ($\widehat{\Upsilon}^*_t < 0$) mechanically imply higher $S^*_{\mathrm{sub},t}$.

Profits and log-linearization. We apply the exchange rate to profits as a whole. Let starred variables denote foreign objects. Define foreign-currency profits as

$$\Pi^*_t \;\equiv\; y^*_t \;-\; w^*_t n^*_t, \tag{3.8}$$

and convert them into home-currency units using q_t (foreign currency per one unit of home currency):

$$\Upsilon^*_t \;\equiv\; \frac{\Pi^*_t}{q_t}. \tag{3.9}$$

Log-linearizing around the steady state yields

$$\widehat{\Upsilon}^*_t = \widehat{y}^*_t - \widehat{w}^*_t - \widehat{n}^*_t - \widehat{q}_t, \tag{3.10}$$

which feeds into (3.7) and the tariff rule (3.6).

why this proxy is appropriate. We use profits as our proxy for three plain reasons: policy triggers, simple economics, and easy measurement. Governments step in when firms lose money; under EU state-aid rules, help starts after fixed loss thresholds (e.g., losses above half of subscribed capital), so deeper losses mean more support; our inverse linear map in (3.7) fits this design (Commission et al., 2014). Subsidies that lower firms' costs let them cut prices and sell more; countervailing (anti-dumping) duties aim to cancel that benefit, so a tariff rule with ($\gamma_s > 0$) in (3.6) is natural (Clarke and Horlick, 2005). When profits are low, even small export tax refunds (VAT rebates)[13] cut unit costs and can lift exports (Melitz, 2003; Chandra and Long, 2013). The proxy is also easy to build from observables ($\widehat{y}_t, \widehat{w}_t, \widehat{n}_t, \widehat{q}_t$) or from simple ratios like the profit margin. Because prices are sticky, shocks to costs, demand, or the exchange rate do not fully pass through, so profits move even if wages are flexible (Blanco and Cravino, 2020). Adding Calvo-style wage stickiness further amplifies this mechanism[14].

However, this approach has a major limitation: tariffs and foreign subsidies may be jointly driven by a third, unobserved factor. For example, when a common shock such as a global demand downturn occurs, foreign profits fall, which—via equation (3.6)—induces stronger foreign subsidies. Through equation (3.5), higher foreign subsidies then raise the home tariff. At the same time, the same demand downturn can directly push up the home tariff. Even though the third driving factor is absorbed into the residual of the tariff equation, we still perform additional checks to guard against over-interpreting the estimated relationship—particularly the risk that a common factor makes subsidies and tariffs move together in a way that could be mistaken for a causal effect of subsidies on tariffs.

Avoiding over-interpretation: third-factor co-movements and checks. To rule out the possibility that tariffs and foreign subsidies are jointly driven by a third factor, we conduct three tests: (i) a lead-term (pre-trend) test; (ii) an innovation orthogonality test; and (iii) a sign test. The pre-trend test shows that "future" subsidy signals do not predict current tariffs, whereas contemporaneous and lagged subsidy signals raise tariffs.

[13] An export VAT rebate means the government refunds to the exporter the value-added tax paid on inputs or the VAT owed on domestic purchases used for exports, which lowers per-unit production cost.

[14] With free entry, steady-state pure profits are zero (Lambson, 1992). In a two-country DSGE with monopolistic competition and fixed costs, operating profits (revenue in home currency minus wages) vary; any steady-state pure profits are rebated. The proxy captures short-run cash-flow stress while preserving budget constraints and the zero-profit logic.

The innovation orthogonality test indicates no common noise: the residual shocks in the subsidy and tariff equations are essentially uncorrelated. The sign test shows a positive short-run tariff response to subsidy signals in a parsimonious regression, consistent with the intuition that stronger subsidies lead to higher tariffs. Taken together, these results reduce concerns about mistaking correlation for causation.

Specifically, in the lead-term (pre-trend) test, using an auxiliary regression with leads and lags, the lead term has no significant predictive power for tariffs; by contrast, contemporaneous and one-period lagged subsidy signals are positive and significant: the contemporaneous coefficient is 0.274 ($p < 0.001$) and the one-period lag coefficient is 0.001 ($p = 0.028$), while the one-period lead is insignificant (coefficient ≈ -0.000, $p = 0.242$). Standard errors are HAC (Newey–West). In the innovation orthogonality test, the correlation between the foreign-subsidy innovation and the tariff innovation is near zero: corr $= 0.001$, $p \approx 0.967$, supporting independence of the two shocks. For the sign check (parsimonious regression), in a regression including only the subsidy proxy and its one-period lag, the short-run tariff response is positive: $\beta_0 = 0.273$ ($p < 0.001$) and $\beta_1 = 0.001$ ($p = 0.028$), consistent with a positive "anti-dumping–style" tariff rule. Taken together, these results indicate no anticipatory response, approximately orthogonal innovations, and a positive policy reaction—reducing the risk of mistaking comovement for causality and supporting a profit-based, countercyclical subsidy proxy.

3.3.7 Endogenous Tariff Equation: Deficit, Unemployment, Counterparty Tariff, Subsidies

This section considers the case in which all endogenous explanatory variables jointly determine the endogenous dependent variable—tariffs. We assume that tariff changes are influenced, either directly or indirectly, by all the variables discussed above. Thus, tariffs are not driven by a single factor, but by the combined effects of multiple endogenous variables.

$$\tau_t = d_{mix} - \gamma_{\tau,x} x_t - \gamma_{\tau,n} n_t + \gamma_{\tau,c} \tau_t^* + \gamma_{\tau,s} S_{sub,t}^* + \epsilon_\tau \tag{3.11}$$

Here, d_{mix} is a constant, and the coefficients on the explanatory variables are all positive constants, as defined in the cases above.

3.4 Estimation

The estimation process begins with an explanation of indirect inference, a description of the data, and the steps taken before estimation. Indirect inference is used to estimate the parameters of the DSGE model. It works by simulating the model and adjusting its parameters so that the simulated data match real economic data from Q1 2000 to Q1 2023. The data are seasonally adjusted and expressed in natural logarithms. We compare statistical features like autocorrelation and GDP volatility between the simulated and observed data to check accuracy. Finally, the model fit is assessed by comparing p-values.

3.4.1 Comparison of P-values under Different Scenarios

II Method: Detailed Pros and Cons vs. Bayesian Estimation We use indirect inference because it does not require a tractable likelihood and it is easy to simulate data from the model. Thus we avoid maximum likelihood and Bayesian estimation. Bayesian methods require a prior and can be sensitive to that choice. They often rely on MCMC (Markov chain Monte Carlo) or SMC (sequential Monte Carlo), which need many draws, convergence checks, and heavy computation. When the likelihood is intractable, Bayesian work commonly uses ABC (approximate Bayesian computation): draw parameters from the prior, simulate data, compute summary statistics (e.g., means or variances), and accept parameters when the distance to the empirical statistics is below a tolerance. ABC is very sensitive to the chosen statistics and the tolerance.

There are several limitations to indirect inference. First, if the selected features (summary statistics) do not match the data well, the conclusions are mainly driven by these chosen indicators. This requires extensive Monte Carlo calibration; otherwise, the acceptance rule may be too loose or too strict, either wrongly rejecting a good model or overlooking a poor one. Second, the results are sensitive to technical settings—such as the choice of weighting or distance matrix, the number of simulation runs, the random seeds, and the sample period (which should normally exclude extreme episodes)—so systematic sensitivity and robustness checks are needed. Finally, small samples and computational cost matter: auxiliary statistics can be biased in small samples, and standard errors typically rely on bootstrapping and repeated simulations, which creates a substantial computational burden (Minford et al., 2015). Compared with standard Bayesian estimation based on a tractable likelihood, which does not require choosing summary statistics or a distance measure, indirect inference therefore involves several extra decisions about how to match the model to the data, while both approaches remain sensitive to implementation details and can be computationally intensive.

II Method Results: Which Simulated Regime Best Matches Reality? We insert the above tariff variants into the two-country DSGE—changing only the tariff equation and leaving all others unchanged—to generate different regimes and determine which is closest to real-world data. Table 3.1 is generated using the II Method, which measures the distance between simulated and actual data. If the p-value exceeds 5%, we fail to reject the null that the two-country DSGE's simulated GDP series are consistent with the observed U.S. and China GDP data. While our regime is consistent with the data and not rejected, we still need to identify which regime is best among the non-rejected ones.

Interpreting p-values in Table 3.1 The p-values reported with Table 3.1 come from indirect inference and measure overall model fit in auxiliary space. Let $\widehat{\psi}^{\text{data}}$ be the vector of auxiliary estimates from the data (e.g., impulse-response targets or reduced-form coefficients) and $\widehat{\psi}^{\text{sim}}(\theta)$ the corresponding averages from simulations of the DSGE at parameters θ. Define

$$g(\theta) \equiv \widehat{\psi}^{\text{data}} - \widehat{\psi}^{\text{sim}}(\theta), \qquad \mathcal{W}(\theta) \equiv g(\theta)' \, \widehat{W} \, g(\theta),$$

with $\widehat{W}$ positive definite. The reported p-value is the right-tail probability of the realized Wald statistic under the model,

$$p \; = \; 1 - \widehat{F}_{\mathcal{W}}\big(\mathcal{W}(\widehat{\theta})\big),$$

where $\widehat{F}_{\mathcal{W}}(\cdot)$ is the (asymptotic χ^2 or bootstrap) reference distribution under the null that the model matches the auxiliary statistics. Interpretation: a larger p indicates the model-implied auxiliary statistics are closer to those in the data (we fail to reject the model); a smaller p indicates poorer fit.

In Table 3.1, the p-value is shown as p×100 (percentage form). A higher value means the model's auxiliary statistics are closer to those in the data; a lower value means worse fit.

p-values lie in a narrow band We initially observe that, in Table 3.1, the p-values are tightly clustered (about 5.6%–6.5%); Basically, we consider this narrow band insufficient to fully distinguish between regimes. Following Minford and Xu (2024), when p-values cluster within a narrow band, the tests have little discriminating power, so the models cannot be cleanly separated—implying limited separation. As usual, this does not mean all regimes are the same; instead, two factors may be at play—unsuitable auxiliary features and a sample that includes extreme shocks (Minford and Xu, 2024). We can address this with simple Monte Carlo checks: first assess the test's power; then swap the auxiliary indicators or drop the extreme-period data to see whether the results still hold (Minford and Xu, 2024). In conclusion, the narrow p-value spread indicates that, based only on China and U.S. GDP for this period, the chosen features cannot clearly distinguish regimes when only the tariff equation changes and all other equations remain the same.

Why might the p-value for Case 7 be lower than that for a single driver? Table 3.1 shows that Case 7 (multiple motivations) yields a lower p-value than single-factor cases such as Case 1 (trade deficit). This suggests that multimotive tariff adjustments fit the data worse, while a single-motive policy—like Case 1—fits better. Therefore, we may propose one question: Why do multifactor tariffs fit reality worse, while single-factor tariffs fit better?

Basically, the main reason is that the p-values are generated in a different way.In the usual approach, a regression model produces a test statistic that is compared with a fixed reference distribution to get a p-value, whereas in the IIM the simulated model generates its own data distribution and we locate the actual data within that distribution to compute the percentile (the p-value), so the direction of the comparison is essentially reversed.

Table 3.1: Case Studies and Indirect-Inference Fit (p-value, %)

Case Number	Tariff Determination Method	p-value (%)
Case 1	Trade deficit, tariff (endogenous shock)	6.5
Case 2	Stationary (exogenous shock)	5.7
Case 3	Non-stationary (exogenous shock)	5.9
Case 4	Labor, tariff (endogenous shock)	5.1
Case 5	Foreign tariffs (endogenous shock)	5.2
Case 6	Foreign subsidies, tariff (endogenous shock)	5.9
Case 7	Deficit, labor, foreign tariffs, subsidies (endogenous shock)	5.6

Based on the analysis above, we can identify which scenario best matches real-world data. Naturally, the next question is whether this scenario also represents the best economic environment—one where people feel the most well-being and happiness. Next, we compute the Lucas welfare loss over 1000 periods. The comparison across scenarios is used to examine how tariff changes affect welfare loss and to identify which types of adjustments are most effective in reducing that loss.

3.5 Comparison of welfare and Stability

Welfare loss is a common measure used to show how much individual well-being changes. It allows different scenarios to be compared using a single number. This study uses two measures: the Lucas welfare loss and the variance. The Lucas welfare loss follows Lucas (1987). It shows the share of consumption a person would need to give up to move from a stable to an unstable economy. This is used to measure how much instability reduces welfare. Variance is also used. It shows how uncertain the economy is (Ligon and Schechter, 2003; Brou and Ruta, 2009).

The Lucas welfare loss is calculated using the formula in Equation 3.12. The parameter λ shows the utility gap between the new case and the baseline (Case 1). If λ is positive, the new case gives higher welfare than Case 1. In this case, moving from Case 1 to the new scenario would require more consumption equal to the value of λ.

$$\lambda = \exp\left[(1-\beta)\left(U_{new} - U_{bench}\right)\right] - 1 \tag{3.12}$$

We now compare utility outcomes across eight scenarios, with Case 1 as the baseline. Cases 1 to 7 follow the model settings introduced earlier. Case 8 assumes no tariff shocks.[15] The welfare losses are shown by the λ values in Table 3.2.

To assess the outcomes under different scenarios, Tables 3.2 and 3.3 report consistent results across multiple measures. First, Case 8, which assumes zero tariffs, gives the lowest welfare losses for China, the United States, and the total. This is shown in Table 3.3, where the ad hoc welfare loss measure, which weights variances by the parameter ϖ, reaches its lowest value under all values of ϖ (0, 0.1, 0.3, and 0.5). Table 3.2 also shows that Case 8 has the highest λ value (0.001073), indicating the highest level of welfare among all cases. Second, Case 3, which includes a long-term exogenous tariff shock, leads to the largest welfare losses under all measures. In Table 3.2, the λ value is -1 in all categories, showing a complete welfare collapse. In Table 3.3, the losses in Case 3 are over 1,000 times higher than those in other cases. Third, the underlying motivation for imposing tariffs has only a limited impact on the overall size of welfare loss. For example, in Case 5 and Case 6, the total λ values reported in Table 3.2 are 0.001 and 0.000801, respectively. Despite different policy motivations, the welfare outcomes are similar. In sum, the results suggest that the zero-tariff case leads to the smallest welfare loss and is the most favourable among the scenarios considered.

[15] Tables 2 and 3 in the appendix show the parameters used in each case. The first 28 are from Case 1. The rest, selected by the highest p-value, are fixed across all cases. To keep simulations consistent, all parameters stay the same except for those in the tariff equations. So, the first 28 parameters from Case 1 are used in all other cases.

Table 3.2: Lucas (1987)'s λ calculation

Policy Shift	China	USA	Total
Case1 $\rightarrow$ Case2	4.18×10^{-4}	6.18×10^{-4}	1.037×10^{-3}
Case1 $\rightarrow$ Case3	-1.000×10^{0}	-1.000×10^{0}	-1.000×10^{0}
Case1 $\rightarrow$ Case4	4.34×10^{-4}	6.38×10^{-4}	1.072×10^{-3}
Case1 $\rightarrow$ Case5	4.03×10^{-4}	5.97×10^{-4}	1.000×10^{-3}
Case1 $\rightarrow$ Case6	3.56×10^{-4}	4.45×10^{-4}	8.01×10^{-4}
Case1 $\rightarrow$ Case7	4.26×10^{-4}	4.30×10^{-4}	8.56×10^{-4}
Case1 $\rightarrow$ Case8	4.20×10^{-4}	6.53×10^{-4}	1.073×10^{-3}

Table 3.3: Average social welfare loss

$\varpi = 0$	China	USA	Total	$\varpi = 0.1$	China	USA	Total
Case 1	1.80×10^{-4}	1.28×10^{-3}	7.40×10^{-4}	Case 1	1.498×10^{-2}	1.902×10^{-2}	1.704×10^{-2}
Case 2	2.70×10^{-4}	2.50×10^{-4}	2.60×10^{-4}	Case 2	1.56×10^{-3}	2.24×10^{-3}	1.90×10^{-3}
Case 3	6.767×10^{-2}	2.3063×10^{-1}	1.5063×10^{-1}	Case 3	1.49551	3.14447	2.33499
Case 4	3.30×10^{-4}	2.10×10^{-4}	2.70×10^{-4}	Case 4	1.55×10^{-3}	2.45×10^{-3}	2.01×10^{-3}
Case 5	3.20×10^{-4}	2.40×10^{-4}	2.80×10^{-4}	Case 5	1.76×10^{-3}	2.61×10^{-3}	2.19×10^{-3}
Case 6	3.20×10^{-4}	3.70×10^{-4}	3.50×10^{-4}	Case 6	3.09×10^{-3}	4.74×10^{-3}	3.93×10^{-3}
Case 7	6.60×10^{-4}	1.57×10^{-3}	1.12×10^{-3}	Case 7	9.67×10^{-3}	7.79×10^{-3}	8.71×10^{-3}
Case 8	1.80×10^{-4}	1.70×10^{-4}	1.80×10^{-4}	Case 8	7.80×10^{-4}	6.70×10^{-4}	7.20×10^{-4}
$\varpi = 0.3$	China	USA	Total	$\varpi = 0.5$	China	USA	Total
Case 1	4.459×10^{-2}	5.450×10^{-2}	4.963×10^{-2}	Case 1	7.419×10^{-2}	8.997×10^{-2}	8.223×10^{-2}
Case 2	4.15×10^{-3}	6.21×10^{-3}	5.20×10^{-3}	Case 2	6.74×10^{-3}	1.019×10^{-2}	8.50×10^{-3}
Case 3	4.35119	8.97213	6.70371	Case 3	7.20687	14.79979	11.07243
Case 4	3.98×10^{-3}	6.92×10^{-3}	5.48×10^{-3}	Case 4	6.42×10^{-3}	1.139×10^{-2}	8.95×10^{-3}
Case 5	4.63×10^{-3}	7.36×10^{-3}	6.02×10^{-3}	Case 5	7.50×10^{-3}	1.211×10^{-2}	9.85×10^{-3}
Case 6	8.62×10^{-3}	1.349×10^{-2}	1.110×10^{-2}	Case 6	1.414×10^{-2}	2.223×10^{-2}	1.826×10^{-2}
Case 7	2.769×10^{-2}	2.023×10^{-2}	2.389×10^{-2}	Case 7	4.571×10^{-2}	3.268×10^{-2}	3.907×10^{-2}
Case 8	1.97×10^{-3}	1.66×10^{-3}	1.81×10^{-3}	Case 8	3.16×10^{-3}	2.64×10^{-3}	2.90×10^{-3}

$$SWL_{us/china} = \frac{1}{2}[\tilde{\pi}^2_{us/china,t} + \varpi \hat{y}^2_{us/china,t}]$$

$$SWL_{total} = \frac{\bar{y}_{china}}{\bar{y}_{china}+\bar{y}_{us}} SWL_{china} + \frac{\bar{y}_{us}}{\bar{y}_{china}+\bar{y}_{us}} SWL_{us}$$

3.5.1 Policy Implications

Based on the above welfare loss analysis, we find that a zero-tariff regime may represent a potentially optimal policy choice. Specifically, zero tariffs are widely regarded as the ideal trade condition. Bhagwati (1967) argues that removing tariffs allows countries to access more goods at lower prices, improving efficiency through comparative advantage. Ghosh (1979) adds that under perfect competition, free trade improves price signals and resource allocation, leading to higher welfare.

However, several studies point to important qualifications. Ozturk (2018) notes that while free trade reduces entry barriers and increases competition, political factors often lead governments to use tariffs to protect domestic industries and maintain social stability. Rama and Mundial (1993) shows that zero-tariff policies are effective only when wages are centrally bargained. In settings with wage inequality and imperfect competition, such policies may lower worker welfare by exposing domestic firms to import competition, causing closures and job losses.

In conclusion, zero tariffs increase welfare in theory. But in practice, their effects depend on the market structure, labour rules, and political factors. If tariffs are used, they should match the real state of the economy. Poorly designed tariffs may cause losses in welfare.

3.5.2 Qualitative Assurance: Considering Lag and Threshold Does Not Affect the Ranking of Welfare Loss and Stability

To maintain consistency with the assumptions in Chapter 2, we conduct a qualitative robustness check in Chapter 3 to verify that introducing lag terms or threshold rules does not affect the rankings of welfare loss and stability(see Section 2.3.3). The key assumption of the model is that these rankings are driven by long-term average impacts, rather than short-term fluctuations. Specifically, welfare loss is calculated based on utility, which depends on consumption and labor—two factors that are only marginally affected by tariff shocks, as tariffs contribute little to the overall economy. Welfare loss is measured over a long period (e.g., 1000 periods), emphasizing cumulative effects rather than fluctuations in a single period. Stability is assessed by GDP and inflation volatility, and it is evident from variance decomposition methods that tariffs have only a small impact on these macroeconomic variables. Thus, we conclude that changing the tariff rule by adding lag terms or threshold effects will not significantly alter the welfare loss or stability rankings. Introducing lag terms primarily affects the timing of policy responses rather than their overall direction. Lag terms smooth the policy response, but do not alter the model's long-term effects or steady-state conditions, meaning welfare loss and stability rankings remain unchanged. Similarly, threshold rules trigger stronger policy responses under specific conditions but do not change the overall long-term impact of the policy.

3.6 Simulation-based HVD under Different Regimes

The main results from the simulation-based variance decomposition, using Case 1 as the baseline scenario, are presented in Figures 3.6.1, 3.6.2, 3.6.3, and 3.6.4. Case 1 parameters are used to simulate GDP and inflation across different regimes, allowing comparison of volatility under alternative policy and structural scenarios. These figures show how different tariff settings affect macroeconomic stability in China and the United States.

Among all cases, Case 3 leads to the worst outcomes. In this case, tariffs follow a non-stationary exogenous shock. This causes large increases in the volatility of GDP and inflation in both China and the United States. Figures 3.6.1 to 3.6.4 exhibit greater fluctuations compared to other cases, highlighting the destabilizing effect of uncontrolled tariff shocks. Finally, Case 1, which is most similar to the real-world data, is the second worst scenario in terms of volatility, as clearly shown in Figure 3.6.1 and Figure 3.6.2. In summary, tariffs with non-stationary case, can raise macroeconomic volatility.

Figure 3.6.1: Simulation-based HVD of China's GDP (Baseline: Case 1)

Figure 3.6.2: Simulation-based HVD of U.S. GDP (Baseline: Case 1)

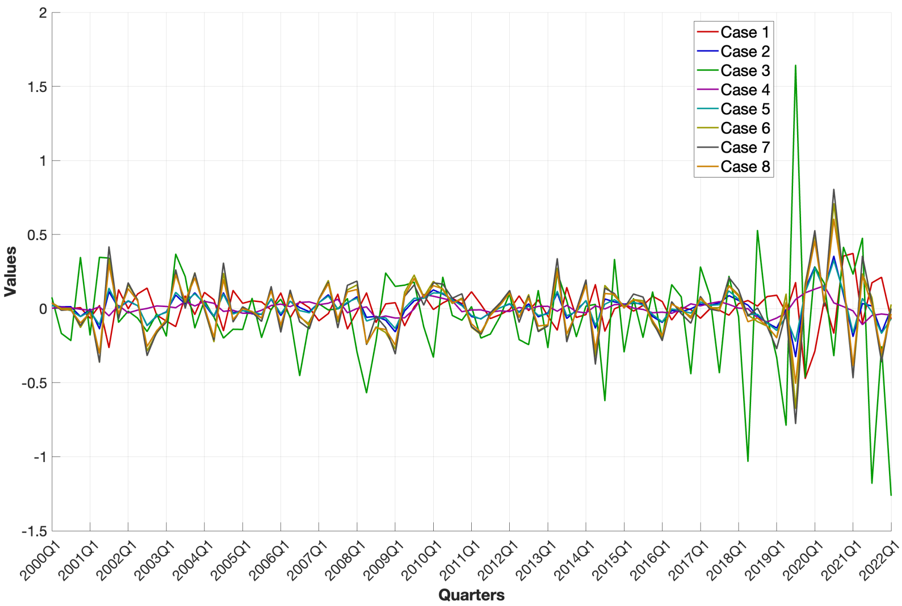

Figure 3.6.3: Simulation-based HVD of China's Inflation (Baseline: Case 1)

Figure 3.6.4: Simulation-based HVD of U.S. Inflation (Baseline: Case 1)

3.7 FEVD Analysis in Light of Recent Real-World Economic Trends

We extend this part to explain a real-world case similar to Case 5 above—also a partner-following case. Therefore, to complete the story, we start with an early question—also a core background question in Chapter 2: Since the WTO does not allow raising tariffs based on a trade deficit, why can the US still impose tariffs regardless of WTO rules?

Why Can the U.S. Administration Impose Tariffs Against WTO Rules? From a backward timeline starting in 2025—when Trump was elected US president again—the administration again imposed tariffs, citing the large trade deficit with China. The reason is that President Trump did not impose higher tariffs under WTO rules but under U.S. domestic law—the International Emergency Economic Powers Act of 1977 (IEEPA)[16](The White House, 2025b). Thus, IEEPA-imposed tariffs are not directly constrained by WTO rules.

This action is similar to an earlier episode during President Trump's first term, when he invoked Section 232 of the Trade Expansion Act to impose tariffs on steel and aluminum, citing national security. Although the WTO later ruled that this justification was not valid, the U.S. declined to remove the tariffs, arguing that national security is a matter for the U.S. government, not the WTO. Compared to Section 232, the current use of IEEPA appears even more aggressive: it defines the trade deficit as a national emergency and treats it as a national-security threat.

The Corresponding Relationship: How Does Our Case 5 (Partner-Following) Model Explain the 2025 Mapping? Now that we know the U.S. rationale for imposing tariffs, we turn to the real-world details, focusing on the 2025 mapping. The 2025 U.S.–China episode closely mirrors the partner-following case: acting under IEEPA, the United States layered a general tariff, a "reciprocal" add-on, and issue-linked surcharges, prompting China to respond with targeted retaliations and export controls(Oberlies et al., 2025; Jin et al., 2025). The escalation followed the familiar partner-following logic—sequential, reciprocal moves that ratcheted up effective protection across strategic sectors.[17]

Building on the real-world context discussed above, we now turn to Case 5. Since Case 5 represents a scenario where retaliatory tariffs are used in response to foreign tariffs[18] ,

[16]IEEPA authorizes the President to restrict or prohibit international economic activities in response to threats such as war, terrorism, or hostile states. As a domestic law, it operates independently of international trade obligations.

[17]For the dated chronology, sectoral detail, and the full timeline table, see Appendix G.

[18]A comprehensive literature review is provided in Section 2 of this chapter, which examines how domestic tariffs may respond to foreign tariffs—precisely the retaliatory mechanism considered here.

it helps us understand the underlying reasons behind welfare outcomes. We analyze this using the variance results reported in Table 3.4. The aim is to examine why this strategy may result in lower overall welfare compared to a zero-tariff regime.

Why We Choose Macro (GDP and Inflation) and Financial (Interest Rate and Exchange Rate) Dimensions to Analyze Welfare-Loss As shown in Table 3.3, retaliatory tariffs reduce welfare relative to zero tariffs. To probe the mechanism, we analyze macro and financial channels: on the macro side, we track China's and U.S. GDP (y_t, y_t^*) and inflation (π_t, π_t^*), since GDP gauges economic scale/growth and inflation captures price dynamics and stability (Jayathilaka et al., 2022; Rajewski, 1994); on the financial side, we track real interest rates—China's (r_t) and the U.S.'s (r_t^*)—and the bilateral real exchange rate (q_t), because real rates set borrowing costs and steer bank flows, investment, and consumption, while the exchange rate signals currency value and shapes cross-border capital flows (Wagenhofer, 2024; Roberts and Schwert, 2020; Bilawal et al., 2014). Using the variance results in Table 3.4, we assess how fluctuations in these variables contribute to the welfare losses in Table 3.3.

Table 3.4: Variances of Selected Key Variables

	$Var(\hat{y})$	$Var(\hat{y}^*)$	$Var(\hat{\pi})$	$Var(\hat{\pi}^*)$	$Var(\hat{r}_t)$	$Var(\hat{r}_t^*)$	$Var(\hat{q}_t)$
Case1	0.1480	0.1774	0.0004	0.0026	0.0021	0.0135	1.0117
Case2	0.0129	0.0199	0.0005	0.0005	0.0013	0.0005	0.0294
Case3	14.2784	29.1383	0.1353	0.4613	0.4389	0.0041	12.4612
Case4	0.0122	0.0224	0.0007	0.0004	0.0013	0.0004	0.0382
Case5	0.0144	0.0237	0.0006	0.0005	0.0015	0.0006	0.0297
Case6	0.0276	0.0437	0.0006	0.0007	0.0016	0.0002	0.0416
Case7	0.0901	0.0622	0.0013	0.0031	0.0049	0.0118	0.6803
Case8	0.0060	0.0049	0.0004	0.0003	0.0008	0.0004	0.0211

The macroeconomic and financial dimensions provide two key perspectives for analyzing the negative effects of the U.S.–China trade war. The macroeconomic dimension captures systemic impacts that go beyond specific firms, sectors, or products. Instead, it reflects broader disruptions to bilateral trade and overall economic performance(International Monetary Fund, 2024). In contrast, the financial dimension focuses on market responses and capital flow dynamics(Xu et al., 2025). Market effects refer to changes in asset prices—including equities, exchange rates, and interest rates—following tariff shocks. Capital flow effects involve cross-border reallocations of funds, such as asset sales and shifts in investment positions between the U.S. and China(Xu et al., 2025). Based on these definitions, we now introduce the variances of key variables as reported in Table 3.4.

How Do the Macro and Financial Dimensions Explain Welfare Loss? The analysis of Table 3.4 is structured as follows. We first compare the variance across cases by reading along the rows. We then compare the variance across variables by reading down the columns.

We first examine each row, which corresponds to a specific policy setting. This helps to identify which case is the most stable, and which is the most unstable. In Case 1, both macroeconomic and financial dimensions are affected, as shown by the output variances of 0.148 for China and 0.1774 for the United States, and a real exchange rate variance of 1.0117. In Case 2, all variables show very low variance across both macroeconomic and financial dimensions, lower than those in Case 1, with the real exchange rate variance being only 0.0294. Case 3, which models a long-term exogenous tariff shock, exhibits the highest variance across all variables, with output variances of 14.2784 for China and 29.1383 for the United States, inflation variances of 0.1353 and 0.4613, and severe financial instability reflected in a real interest rate variance of 0.4389 and a real exchange rate variance of 12.4612. Case 4 is similar to Case 2, with low volatility across variables and a low exchange rate variance of 0.0382. Case 5 is similar to Case 4, with low volatility under a symmetric and targeted policy response. Case 6, where tariffs respond to foreign subsidies, shows slightly higher volatility than Cases 4 and 5—especially in financial indicators like the exchange rate variance of 0.0416—but remains relatively stable overall. Case 7, which involves multi-dimensional tariff adjustments, shows moderate overall volatility, but higher instability in financial variables—especially the exchange rate, with a variance of 0.6803—highlighting the risks of complex policy design. Case 8, representing a zero-tariff or free trade scenario, is the most stable case overall, with minimal macroeconomic and financial volatility—such as a real exchange rate variance of 0.0211, and very low inflation and output variances in both China and the United States.

Taken together, the comparison shows a clear pattern. Cases 2, 4, 5, and 8 are highly stable in both macroeconomic and financial dimensions. Case 3 shows a complete breakdown of stability. Cases 1 and 7 show clear signs of financial fragility. These results show that good policy design is important for reducing economic volatility.

We now turn to the column-wise comparison to assess which variables are most affected and which dimensions are more vulnerable to volatility. First, consider real output. In Case 3, China's output variance reaches 14.2784, and the U.S. value is 29.1383 — the highest across all scenarios. By contrast, Case 8 shows the lowest output variances: 0.0060 for China and 0.0049 for the U.S. This suggests that long-term protectionism causes severe disruption to real economic activity, while open trade supports stability. Next, consider inflation. In Case 3, China's inflation variance is 0.1353 and the U.S. value is 0.4613 — both extraordinarily high. In other cases, inflation remains within a narrow range of 0.0003–0.0007. This implies that price stability holds under most policies, but collapses under prolonged tariff shocks, with the U.S. especially vulnerable. Turning to real interest rates, China's highest value is 0.4389 in Case 3, and its lowest is 0.0008 in Case 8. This shows that China's financial market is highly sensitive to long-term disturbances. For the U.S., real interest rate variance peaks at 0.0135 (Case 1) and drops to 0.0002 (Case 6), indicating a more stable financial system. Finally, consider the real exchange rate, a key financial variable shared by both countries. Its variance is highest in Case 3 at 12.4612 and lowest in Case 8 at 0.0211. Even in moderately complex cases such as Case 7, the variance rises to 0.6803. This confirms that the exchange rate is the most unstable variable, especially under structural shocks or multi-target tariff adjustments.

Therefore, this result is consistent with real-world experience. Case 5 is the main scenario we aim to study. While the model results suggest that this case is relatively stable, this does not contradict actual observations. In reality, many factors interact—such as political considerations, retaliatory tariffs, anti-dumping measures, and other external shocks. Financial markets often respond to the combined effect of these elements. Thus, real-world instability may not be driven by retaliatory tariffs alone, but by a broader set of influences.

Does this contradict real-world outcomes: Why isn't Case 5 the largest welfare-loss case? Supporting this point, Case 1 shows that even non-retaliatory factors—such as trade imbalances—can lead to tariff increases and contribute to instability. However, such adjustments may trigger high volatility in both macroeconomic and financial dimensions. This suggests that if the U.S. imposes large tariffs in response to a trade deficit, the result may be significant instability in the economic system, especially in the context of the U.S.–China trade war. This type of systemic instability is further illustrated in Case 7, which reflects a scenario involving multiple linkage mechanisms. This means that the interaction of various policy factors—such as Trump's tariff measures, China's retaliatory response, political considerations, anti-dumping tariffs, trade deficits, and job protection—can significantly increase economic volatility. These interacting elements contribute to severe disruptions in both macroeconomic and financial sectors.

3.8 Conclusion

In conclusion, the analysis shows that a zero-tariff regime (Case 8) delivers the lowest welfare losses and the highest stability. This is supported by both the Lucas welfare measure and the ad hoc social welfare loss measure. It suggests that eliminating tariffs can improve economic outcomes by reducing uncertainty and market distortions. In contrast, long-term exogenous tariff shocks (Case 3) lead to the highest welfare losses. This highlights the destabilizing effects of persistent and unpredictable tariff changes. In addition, the reasons for imposing tariffs—whether for retaliation or protection—have little effect on welfare. As shown in Cases 5 and 6, the welfare losses are very close, despite their different policy motivations.

These findings highlight the welfare gains from a zero-tariff policy, but also show the complexity of real-world trade decisions. Recent developments, such as U.S. tariff increases justified by national security and trade imbalances, reflect this complexity. While zero tariffs are ideal in theory, political and geopolitical factors may lead to higher tariffs. These increases can harm long-term stability and welfare. Therefore, policymakers should weigh both economic principles and political realities when setting trade policy.

Chapter 4

Mechanism Analysis: From Tariffs to Sovereign ESG and Macroeconomic Impacts

4.1 Introduction

In the previous chapters, we explained how tariffs affect key economic variables like GDP and inflation. However, we have not looked at some deeper reasons behind these effects. In particular, we have not studied how tariffs may influence the U.S. and Chinese economies through other factors that are not included in our model. Yet these missing channels are becoming more important in real-world situations.

The U.S.–China trade war, ongoing since 2018, has altered global trade patterns, highlighted the economic impact of tariffs, and increased attention to the role of ESG (ESG) goals in policy-making. Initially centered on tariffs and industrial competition, the U.S.–China trade conflict has evolved into a more complex dispute involving deeper political tensions and increasing focus on environmental and governance issues (Harahap, 2019). Both the U.S. and China have added ESG concerns to trade policy—for example, the U.S. limited some pension investments over human rights, China said it will achieve carbon neutrality by 2060, and both joined climate talks during the trade conflict (Krappel et al., 2021). The European Union's carbon border tax has added pressure, affecting how the U.S. and China trade with the EU (Devarajan et al., 2022). These changes show that governments are using ESG ideas to guide trade policy—not just at the company level, but as part of national goals.

Recent research shows that ESG performance matters for both the economy and financial markets. Strong ESG institutional structures can support growth, enhance governance, and attract investment—particularly in countries facing environmental risks or with well-developed institutions (Wang et al., 2023a, 2020; Olteanu et al., 2023). Studies also find that ESG affects capital markets by changing investor expectations and risk premiums (Berg et al., 2024; Loang, 2024). However, some key issues remain unclear. First, despite their growing role in global sustainability, we know little about how trade policies—such as tariffs and trade shocks—affect ESG. Second, it remains unclear how ESG conditions influence the transmission of economic shocks—such as those to productivity, inflation, or trade—through the economy. Third, many studies rely on simple linear models that may overlook the complex, nonlinear relationships between ESG and macroeconomic factors. This paper addresses these gaps by developing a structural model in which ESG both responds to trade policy and alters the transmission of economic shocks.

To address this gap, this paper includes ESG as an endogenous part of the model. It reacts to tariffs and changes how other shocks—such as productivity, inflation, and demand shocks—affect the economy. The results show that large tariff shocks lower ESG performance in a nonlinear (quadratic) way. This changes how the economy reacts and reduces the accuracy of standard regression methods. This paper offers a new macro-financial perspective and shows that ESG is an important channel in global economic shock transmission.

The rest of this paper is organised as follows. Section 2 reviews the literature on ESG, with a focus on its macroeconomic role, measurement problems, and links to trade policy. Section 3 sets out the benchmark and extended DSGE models, including the nonlinear effects of tariffs on ESG and the interaction between trade and technology shocks. Section 4 explains the estimation strategy. It describes the data, parameter choices, and how model fit is evaluated using indirect inference. Section 5 studies how ESG acts as a mechanism for transmitting tariff shocks. It presents forecast error variance decompositions and impulse responses under different shock types. Section 6 tests common ESG regression methods using simulated data, and shows where they may lead to false results or poor identification. Section 7 concludes by summarising the main results and their meaning for future macro-financial modelling and ESG-related policy.

4.2 Literature Review

4.2.1 Sovereign ESG as a Proxy for Institutional Structure

An economy's institutional structure is important in many respects. Institutional structures influence the economy by improving resource allocation, such as directing capital, technology, and labor to high-potential industries (Siddiqui and Singh, 2021). Secondly, institutional structures shape incentives by guiding subsidies and tax cuts, while preventing policy misuse and resource misallocation (Siddiqui and Singh, 2021). Third, a strong institutional structure supports risk management through capital controls and monetary policy to contain financial volatility (Shnyrkov et al., 2019). Next, strong institutional structure reduces unrest by addressing unemployment and inequality (Ferrini, 2012). Finally, strong institutional structure facilitates global coordination and negotiation, helping a country take initiative (Morse and Keohane, 2014). Thus, institutional structures can mitigate the U.S.–China trade war's negative impacts through resource allocation, incentives, risk control, social coordination, and global engagement, helping countries manage the resulting uncertainty.

Specifically, in the U.S.–China trade war, institutional structures help address uncertainty through property rights, incentives, information, transaction costs, and risk-sharing. Stronger institutions secure property rights, helping firms innovate, invest, and use resources efficiently, boosting growth (Zhou et al., 2023). Additionally, weak institutions distort incentives, lead to misallocation and rent-seeking, and lower firm efficiency and growth (Cavallo and Daude, 2011). Weak institutions also create information asymmetry and adverse selection, reducing market efficiency and trust, and hindering investment and consumption (Shnyrkov et al., 2019). Coase's theory suggests strong institutions lower transaction costs, while weak ones raise costs and harm efficiency (Bah and Abila, 2022). Stronger institutional structures improve risk-sharing, buffer external shocks, and support consumption, investment, and resilience (Cavallo and Daude, 2011). Thus, better institutional structures strengthen property rights, improve incentives, reduce information asymmetry, lower transaction costs, and enhance risk-sharing against external shocks.

Innovatively, we use the sovereign ESG score as a proxy for institutional quality, as it captures governance, legal protection, social stability, transparency, and environmental planning. Governance (the 'G' in sovereign ESG) captures core institutional features such as transparency and anti-corruption capacity, making sovereign ESG a valid proxy for a country's institutional quality, especially in terms of incentives and transaction costs(Katterbauer et al., 2022). Secondly, because the 'G' in sovereign ESG includes legal indicators such as property rights and contract enforcement—key to institutional function—it can serve as a proxy for institutional quality (Shnyrkov et al., 2019). The 'S' in sovereign ESG covers social stability and welfare-related factors, supporting its use as a proxy for institutional resilience and sustainability(Katterbauer et al., 2022). The 'G' in sovereign ESG also reflects transparency and accountability, which help stabilize market expectations—reinforcing its role as a proxy for institutional quality(Capelle-Blancard et al., 2019). Finally, the 'E' in sovereign ESG reflects environmental policy and long-term planning capacity, making it an extended dimension of institutional quality and supporting sovereign ESG as a valid proxy(Wang et al., 2023b). Therefore, sovereign ESG reflects core institutional mechanisms, including governance, legal protection, social stability, transparency, and environmental planning—making it a suitable proxy for institutional quality.

4.2.2 ESG vs. Sovereign ESG: Conceptual Consistency

We emphasize that ESG and sovereign ESG share the same conceptual basis, yet differ in measurement. Their consistency rests on four points: a shared core idea, the same E-S-G structure, a focus on long-term value, and a commitment to global responsibility and sustainability. Firstly, both sovereign ESG and ESG share the core idea of assessing sustainability and risks by evaluating an entity's E, S, and G performance(Gratcheva et al., 2021). Secondly, both sovereign ESG and ESG rely on the same E-S-G structure, comprising three pillars—E (climate and ecosystem), S (social equity, welfare, and human capital), and G (law, transparency, and anti-corruption)—to assess firms and countries alike (Capelle-Blancard et al., 2016; Bostjancic, 2023). Third, the ESG framework measures long-term value creation by focusing on sustainability over short-term gains, capturing firms' operational resilience and countries' macro stability and development capacity(Singhania et al., 2024). Finally, both sovereign ESG and ESG show global responsibility by integrating environmental, social, and governance goals into development to support the United Nations Sustainable Development Goals (UN SDGs), with countries and firms both part of the global sustainable finance system(Gratcheva et al., 2021). Therefore, we consider ESG and sovereign ESG consistent, as they share the core idea of assessing sustainability and risks, the same E-S-G structure, a focus on long-term value creation, and a commitment to global responsibility and sustainability.

4.2.3 Sovereign ESG in Macroeconomic Mechanisms

As ESG and sovereign ESG are conceptually consistent, we treat them the same in theory but distinguish them in data. Following this, ESG can influence the economy through multiple channels, including incentive mechanisms, risk-sharing, transaction costs, information flows, and capital mobility. Higher ESG scores enhance incentives, attracting FDI and sovereign investment, and improving capital allocation efficiency(Gratcheva et al., 2021). Secondly, low ESG scores reflect weak risk-sharing, making economies more vulnerable to global shocks like climate change and financial crises(Zhao et al., 2023). Higher ESG scores reduce transaction costs by improving legal and regulatory transparency, thus facilitating trade and investment cooperation(Capelle-Blancard et al., 2019). A higher ESG score can reduce information asymmetry, as it reflects government transparency, environmental reporting, and social engagement(Wong et al., 2022). Finally, ESG can promote capital mobility, as it has been incorporated into national risk assessment frameworks by Institutional strcuture such as the IMF and World Bank(Hübel, 2022). Therefore, ESG can influence the economy through multiple channels, including incentive mechanisms, risk-sharing, transaction costs, information flows, and capital mobility.

More specifically, analyzing ESG allows us to assess its impact on macroeconomic and financial outcomes. A higher ESG score enhances economic stability, reduces sovereign risk, and strengthens investor confidence. For example, Salzmann (2023) finds that richer countries can spend more on environmental and social programs, leading to better ESG performance. Ho et al. (2019) shows that strong public finances also improve governance and sustainability, which raise ESG scores. From a financial view, Zhang et al. (2022) finds that high ESG performance lowers default risk by improving fiscal credibility and trust. Capelle-Blancard et al. (2019) shows that ESG ratings can predict sovereign bond spreads, especially during crises. Nemoto and Liu (2020a) argues that growing demand for green investments pushes governments to improve ESG policies, which helps lower borrowing costs. These findings highlight the relevance of ESG to macro-financial outcomes but also raise the question of its construction. We contribute by innovatively using ESG as a mechanism variable, built from key macroeconomic factors.

4.2.4 Sovereign ESG from GDP, Interest Rates, Wages, and Tariffs

Economic growth is widely viewed as a key factor behind ESG performance. As GDP rises, governments usually gain more fiscal resources to support environmental, social, and governance goals. GDP may affect fiscal resources, as governments improve tax collection, budgeting, and oversight, thereby supporting ESG policies (Salzmann, 2023; Bostjancic; Morgenstern et al., 2022). Ho et al. (2019) also finds that growth boosts tax revenue and corporate profits, enabling governments to fund green projects and strengthen regulations. In addition, growth improves sovereign credit ratings, attracting ESG-focused investors and creating a feedback loop between economic stability and ESG performance (Zhang et al., 2022; Capelle-Blancard et al., 2019; Nemoto and Liu, 2020a). Overall, economic growth supports ESG performance by boosting fiscal resources, improving governance, and reinforcing stability through a positive feedback loop.

Monetary policy, especially interest rates, plays an important role in shaping ESG outcomes. ESG may be linked to interest rates, meaning that changes in interest rates can affect sovereign ESG. Firstly, higher interest rates raise debt costs, leaving fewer resources for education and health, which may weaken sovereign ESG through the S pillar(Apergis et al., 2022). Secondly, higher interest rates raise financing costs, delaying green projects and long-term investments in education and health, which lowers sovereign ESG through the environmental pillar(Aguila and Wullweber, 2024). Thirdly, debt pressures can weaken governance, leading to short-term, opaque measures—like loosening regulation—that lower sovereign ESG via the G pillar(Capelle-Blancard et al., 2016). Fourthly, higher U.S. rates can drive capital out of emerging markets, causing depreciation, inflation, and unrest, lowering sovereign ESG via S(Hoek et al., 2021). Finally, high interest rates can raise debt pressure, leading countries to back polluting industries to boost exports and taxes, lowering sovereign ESG via E(Edwards, 1986). Therefore, interest rate changes may affect sovereign ESG through debt costs, financing costs, governance, capital flows, and support for polluting industries.

Wage dynamics affect ESG through several channels. When considering sovereign ESG, higher wages may also affect its level. Higher wages can reduce income inequality and raise low-income earnings, strengthening the S pillar of sovereign ESG by enhancing social stability(Wilson, 2019). Additionally, higher wages strengthen labor rights by increasing workers' bargaining power, which raises the G pillar of sovereign ESG(Waas, 2021). Higher wages help workers retrain and switch jobs, making green transformation easier and improving the E in sovereign ESG(Krueger et al., 2020). However, higher wages may lower sovereign ESG by raising costs and job pressure, weakening social stability under the S pillar(Nemoto and Liu, 2020b). Besides, in economies with large public sectors, higher wages raise government debt, lowering the G pillar in sovereign ESG(Marzinotto and Turrini, 2014). Therefore, wage changes can influence sovereign ESG through income inequality, labor rights, green transformation, job pressure, and government debt.

Trade policy, especially tariffs, plays an important role in shaping ESG performance. Basically, we consider that tariffs impact sovereign ESG in both positive and negative ways. Firstly, higher tariffs protect domestic industries, promoting local industry and employment(Nasir, 2020), which raises the S pillar in sovereign ESG(Pascoal et al., 2023). Secondly, higher tariffs reduce demand by lowering imports, which cuts emissions and waste, thus supporting S (Chao et al., 2012; Islam et al., 2019; Haibara, 2019; Cottier, Thomas et al., 2024). However, higher tariffs may prompt retaliation, cutting exports and growth, and lowering G(Cassing, 1983). Furthermore, higher tariffs raise import prices and living costs, reducing welfare and lowering S in sovereign ESG(Adhikari Ph.D., 2019). Therefore, we consider that higher tariffs can affect sovereign ESG by raising employment, reducing waste, but also slowing growth and lowering welfare.

4.2.5 ESG and Firm Productivity

Building on the above studies, we incorporate ESG into the DSGE model through the production function to affect productivity, justified as follows. First, higher ESG scores let a country produce more with the same natural resources, raising productivity(Wang et al., 2023a). Second, higher ESG scores mean better working conditions, helping retain skilled workers and boosting productivity(Zhang et al., 2025). Third, higher ESG scores indicate less corruption, while lower scores may divert funds to connected parties and inefficient projects, reducing resource allocation efficiency and thus lowering productivity(Tian and Ma, 2022). Fourth, countries with higher ESG scores attract more foreign direct investment, leading to spillover effects—such as increased capital, advanced technology, and managerial expertise—that ultimately raise domestic productivity(Wang et al., 2023a). Finally, higher ESG scores reduce disruptions from social unrest, while low scores risk protests and conflicts that cut productivity(Cohen, 2023). Therefore, we consider that ESG affects productivity through five channels: more efficient use of limited resources, talent retention, lower corruption, greater foreign direct investment, and improved social stability.

Finally, we examine how most DSGE models incorporate ESG Firstly, some DSGE papers incorporate pollution into production, linking growth with environmental degradation to endogenize E in ESG(Smulders and Withagen, 2012). Secondly, some DSGE papers add ESG-related disutility to household utility, balancing consumption, leisure, and long-term ESG welfare(Wang et al., 2024). Thirdly, ESG enters DSGE models by adding carbon taxes and green subsidies to the government budget constraint(Li and Peng, 2020). Moreover, ESG enters through G by linking corruption to government spending efficiency(Kotlán et al., 2021). Next, ESG enters DSGE via S by adding income groups into the utility function to capture inequality effects(Stavytskyy and Kozub, 2019; **?**). Additionally, ESG enters DSGE via E by adding green capital to growth, making E drive ESG(Wang et al., 2024). Also, ESG enters DSGE by modeling climate shocks as productivity shocks, linking E to macro risks(Lubello, 2024). In addition, ESG enters DSGE by weighting E, S, and G directly in the welfare function, so optimal policies balance ESG trade-offs(Chan et al., 2024). Finally, ESG enters DSGE by adding extra borrowing costs from ESG risks(Giovanardi et al., 2023). Therefore, most DSGE models study ESG by incorporating it into production, disutility, the government budget, spending, utility, productivity shocks, welfare, and borrowing costs.

These models often miss complex structural relationships. They usually treat ESG as a fixed or external factor and do not consider how it responds to economic shocks or policy changes. Some recent studies suggest more advanced methods. Wang et al. (2024) and Busato et al. (2023) include ESG in DSGE models. Busato et al. (2024) and Heutel (2012) examine how environmental policy interacts with the business cycle. However, these models rarely treat ESG as a channel through which policy shocks spread. They also do not model ESG as a fully endogenous part of the system. To fill this gap, this paper builds a two-country DSGE model. In this model, ESG is an endogenous mechanism that responds to trade policy and shapes macroeconomic outcomes. This helps explain how tariffs affect both ESG and economic stability.

Therefore, our this paper provides several contributions: the first one is to use ESG as a mechanism linking tariffs to macro variables, as it reflects institutional dimensions often overlooked. Second, we endogenously construct the ESG variable based on GDP, nominal interest rates, wages, and tariff rates within a two-country DSGE framework, allowing us to model institutional quality as an outcome of macroeconomic dynamics. Third, we test alternative specifications, including ESG, ESG^2, and $ESG \times z_t$, to capture nonlinear and interaction effects. Forth, our two-country DSGE simulations show that statistically significant correlations—such as those at the 5% level—may arise without a true causal relationship.

4.3 Model

4.3.1 The Benchmark Model

Our benchmark model is a two-country DSGE framework that examines the dynamic interactions between $E\hat{S}G_t$[1] and macroeconomic variables. The model includes three sectors: households, firms, and the government. Households consume and supply labour. Firms hire labour and produce goods, which are sold under price stickiness. The government sets fiscal policy, and monetary policy is conducted by the central bank. The model structure is the same as in Chapter 1 and corresponds to Case 1 in Chapter 2.

A key feature of the model is the inclusion of sovereign $E\hat{S}G_t$ as a factor affecting firm productivity. We assume that a country's $E\hat{S}G_t$ performance influences the productivity of firms within its economy. This relationship is represented by the following equation:

$$\epsilon_{zt} = \rho_z \epsilon_{zt-1} + \mu_{z,t} + \gamma_{epz,esg} \cdot E\hat{S}G_t \tag{4.1}$$

Here, ϵ_{zt} denotes firm productivity. The parameter ρ_z captures the persistence of productivity over time. The term $\mu_{z,t}$ represents exogenous productivity shocks. The coefficient $\gamma_{epz,esg}$ measures the effect of sovereign $E\hat{S}G_t$ performance on firm productivity.

After introducing sovereign $E\hat{S}G_t$ through technology shocks, we now define the $E\hat{S}G_t$ variable formally. In this model, a country's sovereign $E\hat{S}G_t$ performance is a function of key macroeconomic indicators. These include GDP, wages, nominal interest rates, and import tariffs, as shown below:

$$E\hat{S}G_t = \gamma_y \hat{y}_t + \gamma_w \hat{w}_t + \gamma_R \hat{R}_t - \gamma_\tau \hat{\tau}_t + \epsilon_{esg,t} \tag{4.2}$$

Here, $\hat{y}_t$ denotes the log-linearized deviation of real GDP from its steady-state level. The term $\hat{w}_t$ represents the deviation of real wages. $\hat{R}_t$ is the deviation of the nominal interest rate. $\hat{\tau}_t$ captures the deviation of import tariffs. Sovereign $E\hat{S}G_t$ is assumed to be influenced by these macroeconomic variables. The shock term $\epsilon_{esg,t}$ represents an exogenous disturbance to sovereign $E\hat{S}G_t$. It follows an AR(1) process:

$$\epsilon_{esg,t} = \rho_{esg} \epsilon_{esg,t} + \mu_{esg,t} \tag{4.3}$$

Here, ρ_{esg} captures the persistence of the $E\hat{S}G_t$ shock over time. The term $\mu_{esg,t}$ denotes a white noise innovation.

[1] This variable represents the log-linearized form of the original ESG variable.

4.3.2 Nonlinear Effects in ESG: A Quadratic Approach

In the benchmark model, sovereign $E\hat{S}G_t$ is determined by macroeconomic variables—GDP, wages, nominal interest rates, and import tariffs. The relationship is assumed to be linear. This means the marginal effect of each variable on $E\hat{S}G_t$ is constant over time.

However, the relationship between trade policy and $E\hat{S}G_t$ may be nonlinear. To allow for more flexibility, we extend the model by adding a quadratic term for tariffs. This leads to the following extended equation for $E\hat{S}G_t$:

$$E\hat{S}G_t = \gamma_y \hat{y}_t + \gamma_w \hat{w}_t + \gamma_R \hat{R}_t - \gamma_\tau \hat{\tau}_t - \gamma_{\tau 2} \hat{\tau}_t^2 + \epsilon_{esg,t} \tag{4.4}$$

Consistent with the previous discussion, $\hat{y}_t$, $\hat{w}_t$, $\hat{R}_t$, and $\hat{\tau}_t$ denote the log-linearized deviations of real GDP, real wages, the nominal interest rate, and import tariffs from their steady-state levels, respectively. The quadratic term $\gamma_{\tau 2}\hat{\tau}_t^2$ introduces a second-order effect of tariffs on $E\hat{S}G_t$, allowing for nonlinearities in the influence of trade policy. For example, when tariffs are low, their effect on $E\hat{S}G_t$ may be limited. As tariffs rise, the marginal impact may increase. The sign and magnitude of $\gamma_{\tau 2}$ determine whether this relationship is convex (with diminishing effects) or concave (with amplified effects).

The overall structure of the model remains unchanged. The second-order term modifies the response of $E\hat{S}G_t$ to trade policy but does not affect its relationships with GDP, wages, or interest rates. This extension adds flexibility to the model and allows for richer dynamics between trade policy and ESG performance.

4.3.3 Extended ESG Model: Interaction Effects between Tariffs and Technological Shocks

The benchmark model and its nonlinear extension capture both the direct and quadratic effects of trade policy on sovereign $E\hat{S}G_t$ performance. However, these specifications abstract from the possibility that technological shocks may influence this relationship. In practice, changes in technology—such as innovation, digitalisation, or disruption—can alter how tariffs affect a country's ESG outcomes.

To address this, we extend the model to include an interaction term between import tariffs and technological shocks. This allows the effect of tariffs on sovereign $E\hat{S}G_t$ to vary with the state of technology. The extended $E\hat{S}G_t$ equation is written as:

$$E\hat{S}G_t = \gamma_y \hat{y}_t + \gamma_w \hat{w}_t + \gamma_R \hat{R}_t - \gamma_\tau \hat{\tau}_t + \gamma_{\tau 2} \hat{\tau}_t \epsilon_{z,t} + \epsilon_{esg,t} \tag{4.5}$$

The interaction term $\gamma_{\tau 2}\hat{\tau}_t\epsilon_{z,t}$ captures how the effects of trade policy on sovereign $E\hat{S}G_t$ performance depend on the state of technology. When technological shocks are positive—indicating stronger innovation and productivity—higher efficiency offsets the negative effects of tariffs on $E\hat{S}G_t$(Li et al., 2024). By contrast, when technological shocks are negative, efficiency falls, and the impact of tariffs becomes more damaging. Then, the economy struggles to adjust, and ESG drops more under trade barriers. This highlights that the effect of tariffs on ESG is not fixed, but depends on the technological environment in which they operate.

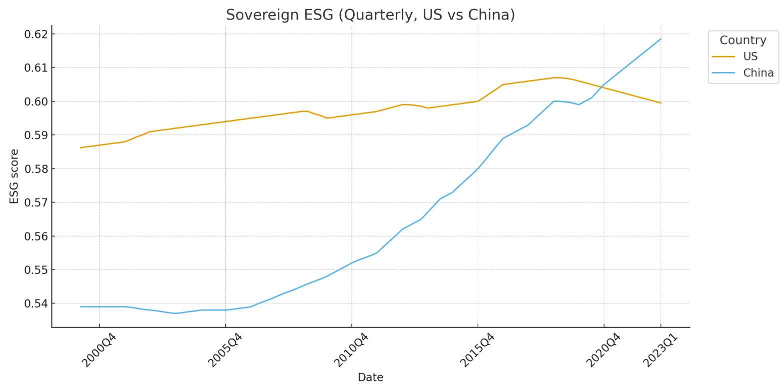

Figure 4.4.1: Sovereign ESG

4.4 Data Source

As shown in Figure 4.4.1, the sovereign ESG trajectories for China and the United States differ markedly over 2000–2023: the U.S. series rises steadily throughout, whereas China's remains relatively flat until the mid-2000s and then increases sharply after 2005.

We build sovereign ESG series only for China and the United States by strictly following Jiang et al. (2022) using the World Bank's Sovereign ESG Database. Starting from the full 171-country, 1990–2020 panel and the same 63 indicators, we (i) impute missing observations by within-indicator means; (ii) classify indicators as beneficial or detrimental; (iii) apply min–max normalization to $[0, 1]$ with a small positive offset to avoid zeros, computing $x_{\min}$ and $x_{\max}$ over the full panel for comparability; and (iv) estimate entropy weights at the indicator level. Specifically, we form proportions s_{ijk}, compute Shannon entropy $-\frac{1}{\ln q}\sum_i \sum_j s_{ijk} \ln s_{ijk}$, obtain information utilities $1 - \text{entropy}$, and normalize to weights $\text{weight}_k = \frac{\text{utility}_k}{\sum_k \text{utility}*k}$. Each country's annual composite score is $\text{ESG}*ij = \sum_k \text{weight}*k, p*ijk$. We retain annual series for 2000–2020 for China and the U.S. only (we do not digitize values from figures) and obtain quarterly 2000–2023 values by linear interpolation between adjacent year-end anchors, with a straight-line extrapolation from 2021 through 2023[2].

Our Sovereign ESG can identify the following aspects: environmental sustainability, social development sustainability, and governance quality(Jiang et al., 2022). For example, it assesses factors such as greenhouse gas emissions, energy consumption, education and health levels, poverty and inequality, as well as government effectiveness and legal stability(Jiang et al., 2022). However, this index cannot identify the specific policy context or the reasons behind the improvements(Jiang et al., 2022). It also fails to capture differences at the industry or regional level. Additionally, it focuses on long-term trends and may not reflect short-term fluctuations or local social and cultural disparities(Jiang et al., 2022).

[2]For full details on constructing the sovereign ESG series, see (Jiang et al., 2022).

We incorporate Sovereign ESG into our model via the production function to assess its impact on productivity, based on the following justifications. First, higher ESG scores enable a country to increase its output using the same amount of natural resources, thus improving productivity (Wang et al., 2023a). Second, higher ESG scores are indicative of better working conditions, which help retain skilled labor and, as a result, enhance productivity (Zhang et al., 2025). Third, stronger ESG scores reflect lower corruption levels, whereas lower scores may lead to the misallocation of resources to inefficient projects, thereby reducing productivity (Tian and Ma, 2022). Fourth, countries with higher ESG scores tend to attract more foreign direct investment, which brings in capital, advanced technology, and management expertise, contributing to productivity growth (Wang et al., 2023a). Finally, higher ESG scores are linked to greater social stability, reducing the likelihood of disruptions such as protests or social unrest, which can harm productivity (Cohen, 2023). Therefore, we argue that ESG affects productivity through five main channels: more efficient resource usage, talent retention, reduced corruption, increased foreign direct investment, and improved social stability.

4.5 Evaluating Model Fit: Do the Theoretical Frameworks Align with the Data?

Adding a nonlinear term in the ESG equation alters how trade policy affects the model. In particular, it changes how tariffs impact ESG, making it essential to test if the extended model fits the data. This section tests how well the model matches the data.

To do this, we use indirect inference, the same estimation method as in the previous two chapters. The idea is to compare simulated model behavior with data using a simpler statistical model. Therefore, we use a VARX model as a statistical benchmark to approximate the data process; indirect inference, originally for complex likelihoods (Gourieroux et al., 1993b), is now widely used to test DSGE models (Minford et al., 2009).

We use indirect inference to formally test how well the model fits the data. This is different from Bayesian estimation (Smets and Wouters, 2007), which only estimates parameters, and from DSGE-VAR (Del Negro et al., 2006), which measures fit but cannot reject bad models. Maximum likelihood can test hypotheses but often struggles with small samples (Le et al., 2016). In contrast, indirect inference clearly shows if the extended ESG model captures real economic behavior.

4.5.1 Estimating the DSGE Model via Indirect Inference

We use indirect inference, comparing DSGE results with an auxiliary model to test if key data features match. Then, we estimate by matching DSGE simulations to the auxiliary model and test if the gap is small; otherwise, we reject the DSGE model. As in the previous chapters, we use a VARX model as the auxiliary model:

$$Y_t = AY_{t-1} + X_{t-1} + e_t \tag{4.6}$$

Here, Y_t denotes GDP for China and the U.S., written as $Y_t = (y_t, y_t^*)'$, where y_t is China's GDP and y_t^* is U.S. GDP. The model includes a time trend, $X_t = (t, t)'$, to capture long-run changes. The error term e_t reflects random shocks.

This VARX model summarizes the data and serves as a reference to compare DSGE simulations. Estimation proceeds in three steps: (1) estimate the auxiliary model using actual data to obtain summary statistics; (2) simulate data from the DSGE model; (3) measure how close the simulated data match the actual data using a statistical distance metric.

4.5.2 Data and Parameter Calibration

The observed variables include ESG for China and the U.S., added to study how ESG interacts with macroeconomic dynamics. The dataset from 2000Q1 to 2023Q1 spans multiple economic cycles and policy shifts. ESG scores are used in levels without logs; since data prep was covered in Chapter 1, this section focuses on ESG (see Figure **??**).

Some model parameters are fixed based on standard values in the literature. The time discount factor is set at 0.99 for both China and the U.S. (Smets and Wouters, 2007). ν (import share) is 0.35 for China, 0.30 for the U.S. (Du and Gong, 2005). φ_s(adjustment cost) is 0.1 (Dongzhou and Mi, 2023), capturing investment frictions. Other parameters follow common values. Wage elasticity φ is set at 3.0 for both countries (Smets and Wouters, 2007). η (home-foreign elasticity) is 1.5 (Smets and Wouters, 2007), indicating moderate substitutability. θ (Calvo price stickiness) is 0.7 (Calvo, 1983). For the Taylor rule, ρ_R (policy inertia) is 0.8 (Clarida et al., 2000), ϕ_Y (response to output) is 0.25, and ϕ_π (response to inflation) is 1.5 (Taylor, 1993), consistent with standard policy rules. There is no established prior for parameters linking ESG to macro factors like GDP, wages, interest rates, and tariffs. We thus set each coefficient to an initial value of 0.5 for estimation.

4.5.3 Model Estimation and Fit

The estimated parameters and corresponding p-values are presented in Tables 4.1 and 4.2. Of Of the four tariff models, the quadratic one fits best, with a p-value of 9.2%, showing that nonlinear tariffs better capture real trade outcomes. In contrast, the linear and tariff–technology models have lower p-values (7.5% and 8.0%), while excluding ESG

Table 4.1: P-values for DSGE Models with Different Tariff Specifications

Model Specification	**Tariff Variable**	**P-value**
Linear Tariff Mechanism	$\hat{\tau}_t$	0.075
Quadratic Tariff Mechanism	$\hat{\tau}_t^2$	0.092
Tariff and Tech Shock Interaction	$\hat{\tau}_t \epsilon_{zt}$	0.080
No ESG Effect	None(No Tariff Impact)	0.065

Table 4.2: Adjusted II-Wald Estimates and p-values of the DSGE Model with Non-linear Tariff Mechanism for the US and China

Parameter	Definition	Calibrated Starting Values		Adjusted II Estimates	
		China	US	China	US
β	Subjective discount factor	0.99	0.99	Fixed	Fixed
q	Steady-state real exchange rate	1.00	-	Fixed	-
C/Y	Consumption-to-GDP ratio at steady state	0.70	0.85	Fixed	Fixed
G/Y	Government spending-to-GDP ratio at steady state	0.24	0.34	Fixed	Fixed
x/Y	Net exports-to-GDP ratio at steady state	0.03	-0.03	Fixed	Fixed
S_f/Y	Foreign bond-to-GDP ratio at steady state	0.15	0.08	Fixed	Fixed
C_f/Y	Imports-to-GDP ratio at steady state	0.12	0.18	Fixed	Fixed
C_f^*/Y	Exports-to-GDP ratio at steady state	0.16	0.13	Fixed	Fixed
ν	Share of imported goods in consumption	0.30	0.15	Fixed	Fixed
φ_s	Capital control intensity	0.10	-	Fixed	-
φ	Inverse wage elasticity of labor supply	3.00	3.00	3.91	3.41
η	Inverse elasticity of substitution between domestic and foreign goods	1.50	1.50	1.02	2.54
θ	Price stickiness parameter	0.70	0.70	0.65	0.58
ρ_R	Interest rate smoothing coefficient	0.80	0.80	0.18	0.98
ϕ_π	Inflation targeting coefficient	1.50	1.50	1.07	1.35
ϕ_Y	Output growth targeting coefficient	0.25	0.25	0.13	0.13
γ_z	Productivity shock persistence	0.50	0.50	0.06	0.98
γ_G	Fiscal shock persistence	0.50	0.50	0.18	0.05
γ_R	Interest rate shock persistence	0.50	0.50	0.03	0.39
γ_τ	Tariff shock persistence	0.50	0.50	0.18	0.05
$\phi_{x\tau}$	Tariff adjustment coefficient	0.50	0.50	0.23	0.02
γ_π	Inflation shock persistence	0.50	0.50	0.07	0.51
γ_j	Demand shock persistence	0.50	0.50	0.95	0.13
γ_{ESG}	ESG shock persistence	0.50	0.50	0.20	0.87
esg_y	GDP coefficient in ESG dynamics	0.50	0.50	0.20	0.03
esg_w	Wage coefficient in ESG dynamics	0.50	0.50	0.48	0.02
esg_R	Interest rate coefficient in ESG dynamics	0.50	0.50	0.70	0.15
esg_τ	Tariff rate coefficient in ESG dynamics	0.50	0.50	0.98	0.45
$\gamma_{epz,esg}$	ESG effect on productivity shocks	0.50	0.50	0.70	0.50
$\gamma_{\tau 2}$	Quadratic tariff rate coefficient in ESG dynamics	0.50	0.50	0.70	0.80
Model p-value					9.2%

yields the lowest at 6.5%, indicating weaker fit without ESG dynamics[3].

Two key conclusions follow. First, incorporating ESG as a mechanism enhances the model's fit to observed macroeconomic patterns. This confirms that ESG factors are crucial in shaping trade policy effects. Second, among ESG models, the quadratic tariff best fits the data, highlighting the need to capture nonlinear trade policy responses.

Given these results, we focus on parameter estimates under the quadratic tariff model, shown in Table4.2. The II-Wald estimates reveal structural differences between the U.S. and China. China's inverse wage elasticity (φ) higher at 3.91 vs. 3.41 for the U.S., indicating a more rigid labor supply. The substitution elasticity (η) is lower in China (1.02) than in the U.S. (2.54), indicating that Chinese imports respond less to relative price changes. ρ_R is 0.98 (U.S.) vs. 0.18 (China), showing slower Fed moves. ϕ_π is

[3]The p-value for the model without ESG comes from Chapter 2 results.

close—1.35 vs. 1.07—so both target price stability. γ_G is higher in the U.S. (0.98); γ_R too (0.39 vs. 0.03). γ_τ is similar (0.18), so trade shocks last equally long.

For ESG links, the U.S. shows stronger ties to macro variables. The GDP coefficient (esg_y) is 0.03 and the wage coefficient (esg_w) is 0.02. In China, these effects are weaker, indicating ESG has less influence on macro dynamics.

In summary, the quadratic tariff model yields a p-value of 9.2%, indicating a good statistical fit. This confirms that adding nonlinear tariffs and ESG effects improves the model's explanation of U.S.–China trade.

4.6 Impact of ESG as a Mechanism Variable on Tariff Shock Transmission

The enhanced model introduces ESG as a mechanism variable to study the effects of tariff shocks during the U.S.–China trade war. It includes eight main shocks: productivity shocks (ϵ_{zt}, ϵ^*_{zt}), government spending shocks (ϵ_{Gt}, ϵ^*_{Gt}), monetary policy shocks (ϵ_{Rt}, ϵ^*_{Rt}), tariff shocks ($\epsilon_{\tau t}$, $\epsilon^*_{\tau t}$), inflation shocks ($\epsilon_{\pi t}$, $\epsilon^*_{\pi t}$), and demand shocks (ϵ_{jt}, ϵ^*_{jt}). Shocks with asterisks come from the U.S., and those without come from China. We also add ESG shocks (ϵ_{esgt}, ϵ^*_{esgt}) to capture how environmental, social, and governance factors affect the transmission of tariff shocks.

We begin by using forecast error variance decomposition (FEVD) to measure how each shock, especially the tariff shock, contributes to output and inflation volatility. We compare results from models with and without ESG to see how much ESG changes the model's ability to explain macroeconomic fluctuations. Next, we study the model's impulse response functions (IRFs) to examine how tariff shocks affect the economy over time. This helps us understand how adding ESG changes the way tariff shocks move through the system and how strong their effects are.

4.6.1 FEVD Analysis

Table 4.3 presents the variance decomposition of output and inflation at various forecast horizons under the ESG specification. For comparison, Table 2.2 reports the same decomposition without ESG, allowing a direct assessment of how ESG considerations influence the results.

In China's case, the overall pattern remains largely unchanged across both models. The contribution of each shock to the variance of output and inflation is stable over time and across specifications. This suggests that the main shocks converge quickly and that the underlying macroeconomic structure remains robust regardless of ESG inclusion. Output variance is consistently dominated by the productivity shock (ϵ_{zt}), which accounts for about 28% across all horizons, both with and without ESG. Inflation variance is mainly explained by the inflation shock ($\epsilon_{\pi t}$), contributing between 28% and 34%, again with little difference across models. The impact of the tariff shock ($\epsilon_{\tau t}$) is negligible, contributing less than 0.1% to inflation or output variance, whether ESG is included or not.

In contrast, the results for the United States show a markedly different pattern when comparing the ESG and non-ESG models, especially with respect to productivity shocks. Without ESG (Table 2.2), U.S. productivity shocks (ϵ^*_{zt}) dominate the variance of output across all forecast horizons. Their contribution remains stable at around 45% up to the 40th quarter. This strong and persistent influence highlights the importance of technological progress as a key driver of U.S. output. The result suggests that, in the absence of ESG mechanisms, supply-side factors play a central and consistent role in shaping macroeconomic outcomes.

However, once ESG is included, this pattern changes notably. In the short run (quarters 4 to 12), productivity shocks remain important, rising from 23% to 26%. But over the medium and long term, their influence fades. By the 20th quarter, the contribution falls to about 16%, and by the 40th quarter, it drops to just 5%. This decline is not simply a loss in explanatory power—it reflects a shift. The variance is increasingly explained by China's productivity shocks and by inflation shocks in both countries. This pattern suggests that, under ESG mechanisms, U.S. technology shocks have a reduced role in driving output volatility. The interaction between trade policy and ESG conditions may dampen the direct transmission of supply-side effects in the U.S. economy.

The main reason for this difference is the non-linear effect of tariff shocks on ESG. As shown in Equation 4.4, ESG is very sensitive to the square of the tariff variable ($\gamma_\tau \hat{\tau}_t^2$). This means that when tariffs rise, the negative impact on ESG becomes stronger. As tariffs keep increasing, ESG performance drops more quickly. When ESG performance weakens, it cannot support the effect of productivity shocks as before. As a result, U.S. productivity shocks become less important, and the effects of China's productivity shocks and inflation shocks from both countries become stronger. This shows that although ESG is meant to improve stability, large tariff shocks can reduce its effectiveness and make the economy more sensitive to other shocks.

Now we look at inflation. In both China and the U.S., inflation shocks ($\epsilon_{\pi t}$, $\epsilon^*_{\pi t}$) are the most important, explaining 30% to 34% of the changes in inflation. This does not change much whether or not ESG is included in the model. Productivity shocks (ϵ_{zt}, ϵ^*_{zt}) are also important, explaining 20% to 29%. Monetary policy shocks (ϵ_{Rt}, ϵ^*_{Rt}) explain only 3% to 4%. Tariff and demand shocks explain less than 0.1%. This means that inflation is mainly affected by its own shocks, with productivity playing a secondary role. Other shocks have very little effect.

Our study leads to three main conclusions. First, supply-side shocks are still the most important factor in explaining changes in U.S. GDP, whether or not ESG is included. This result is in line with previous studies such as Ball and Mankiw (1995) and Madeira et al. (2023). When ESG is not included, productivity shocks explain about 45% of the changes in U.S. GDP. But when ESG is added, the influence of productivity shocks becomes smaller over time. Instead, other supply-side factors—like inflation shocks and China's productivity shocks—become more important. Second, this shift happens because of the non-linear effect of tariff shocks.

The square of the tariff variable strongly reduces the ESG index, which makes productivity shocks less effective in stabilizing the economy. Third, this result shows that adding ESG to trade policy creates new challenges. When tariff shocks interact with ESG in unexpected ways, they can reduce stability instead of improving it.

Table 4.3: FVD - Equal Weights on E, S, and G

Quarters	Variable	μ_{zt}	μ^*_{zt}	μ_{Gt}	μ^*_{Gt}	μ_{Rt}	μ^*_{Rt}	$\mu_{\tau t}$	$\mu^*_{\tau t}$	$\mu_{\pi t}$	$\mu^*_{\pi t}$	μ_{jt}	μ^*_{jt}	μ_{esgt}	μ^*_{esgt}
4	y_t	28.21	4.22	0.00	0.00	3.42	4.89	0.07	0.00	28.11	29.15	0.33	0.04	0.00	1.56
	y^*_t	24.38	23.06	0.00	0.00	2.95	3.15	0.06	0.00	24.30	20.12	0.23	0.04	0.00	1.71
	π_t	34.73	0.80	0.00	0.00	1.90	3.13	0.08	0.00	34.17	23.40	0.26	0.03	0.00	1.50
	π^*_t	29.53	1.32	0.00	0.00	3.57	3.88	0.07	0.00	29.45	30.10	0.29	0.04	0.00	1.73
12	y_t	28.63	4.28	0.00	0.00	3.47	4.77	0.07	0.00	28.54	28.38	0.31	0.04	0.00	1.50
	y^*_t	22.87	25.85	0.00	0.00	2.77	3.31	0.05	0.00	22.80	20.30	0.23	0.03	0.00	1.79
	π_t	34.13	0.82	0.00	0.00	2.11	3.34	0.08	0.00	33.63	24.07	0.25	0.03	0.00	1.54
	π^*_t	29.53	1.32	0.00	0.00	3.58	3.89	0.07	0.00	29.45	30.09	0.29	0.04	0.00	1.73
20	y_t	28.61	4.58	0.00	0.00	3.46	4.74	0.07	0.00	28.52	28.18	0.31	0.04	0.00	1.47
	y^*_t	25.58	15.91	0.00	0.00	3.10	3.92	0.06	0.00	25.51	23.68	0.26	0.04	0.00	1.95
	π_t	33.78	0.84	0.00	0.00	2.24	3.46	0.08	0.00	33.31	24.46	0.24	0.03	0.00	1.56
	π^*_t	29.53	1.32	0.00	0.00	3.58	3.89	0.07	0.00	29.45	30.09	0.29	0.04	0.00	1.73
40	y_t	28.38	5.51	0.00	0.00	3.44	4.69	0.07	0.00	28.29	27.86	0.30	0.04	0.00	1.42
	y^*_t	28.65	5.21	0.00	0.00	3.47	4.54	0.07	0.00	28.57	27.18	0.29	0.04	0.00	1.98
	π_t	33.30	0.85	0.00	0.00	2.41	3.63	0.08	0.00	32.88	25.01	0.24	0.03	0.00	1.57
	π^*_t	29.53	1.32	0.00	0.00	3.58	3.89	0.07	0.00	29.45	30.09	0.29	0.04	0.00	1.73

4.6.2 The Key Impulse Responses

Tariff Shock and ESG Impact

Figure 4.6.1 shows how ESG levels and technology progress in China and the United States respond to tariff shocks from both sides. In general, when tariffs go up, they increase production costs and reduce competitiveness. This usually causes ESG performance to fall. However, some positive changes—such as higher output, better wages, and higher interest rates—can partly offset this drop. In some cases, ESG may even improve in the long run.

Tariff shocks raise costs for producers. This puts pressure on ESG by making it harder for firms to invest in social and environmental goals. But over time, as the economy adjusts, output and wages tend to rise. These improvements help reduce the negative effect on ESG. For example, Chinese tariffs can slow down innovation in the U.S. On the other hand, U.S. tariffs—though harmful at first—can later help the economy recover. This shows that while tariffs create short-term problems, they may lead to longer-term gains in some cases.

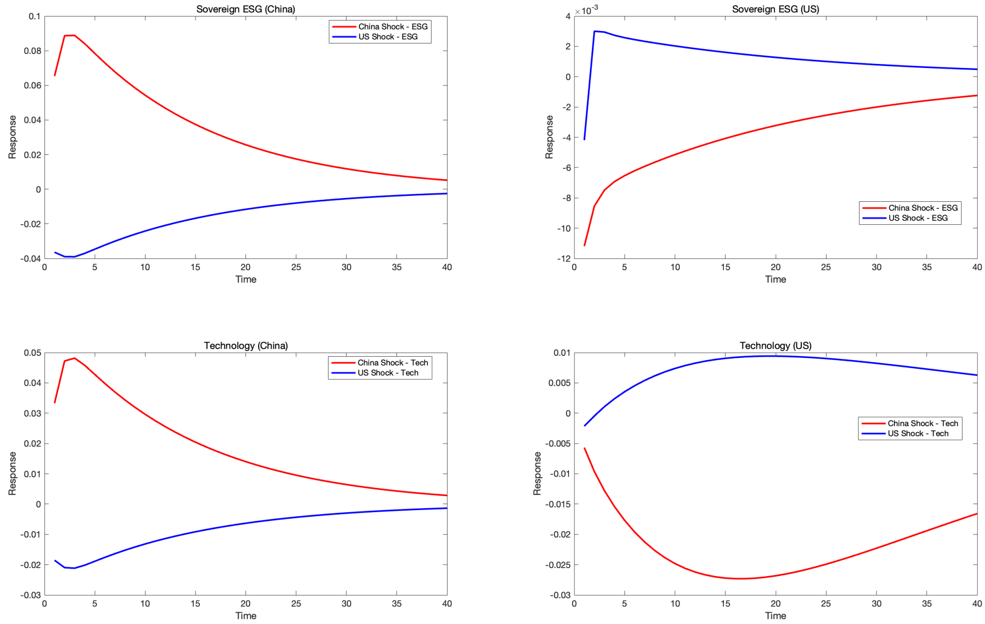

Figure 4.6.1: Tariff Shock to Tech Shocks and ESG

Compare the IRFs under tariff shocks with and without ESG

Our main focus is on variables that change direction after introducing ESG as a mechanism, as shown in Figure 4.6.2. These include the China–U.S. exchange rate, China's trade surplus, and the U.S. trade surplus. For the exchange rate, we compare the effects of Chinese and U.S. tariff shocks, with and without ESG. Under a Chinese shock, the exchange rate shifts from falling to rising after ESG is added. Under a U.S. shock, it shifts from rising to falling. For trade surpluses, we look at both direct and spillover effects. When China or the U.S. raises tariffs, ESG causes both countries' trade surpluses to shift from decreasing to increasing. However, the spillover effect reverses. After ESG is added, the trade surpluses of both countries shift from rising to falling in response to each other's tariff shocks. In short, ESG mainly affects the exchange rate and trade surplus behavior.

The mechanism works as follows. As shown in Figure 4.6.1, tariff shocks affect ESG both directly and indirectly. Without ESG, higher interest rates strengthen the local currency through the UIP channel. With ESG, interest rates become part of the ESG index and influence foreign demand for local bonds (S_f). This can lead to capital outflows and currency depreciation. So ESG changes the link between interest rates and exchange rates. In some cases, higher interest rates may lead to a weaker currency. For trade surplus, China's tariffs reduce imports. Without ESG, this is due to a weaker exchange rate. With ESG, the drop in imports is mainly due to the tariffs themselves. The same applies to the U.S. Spillover effects are symmetric. A tariff shock in one country has the opposite effect on both countries' trade balances.

After discussing the variables that change direction, we note that other macro variables—such as GDP, inflation, and interest rates—mainly change in magnitude. This completes the core mechanism analysis, showing how tariff shocks affect ESG and how this, in turn, changes macroeconomic responses.

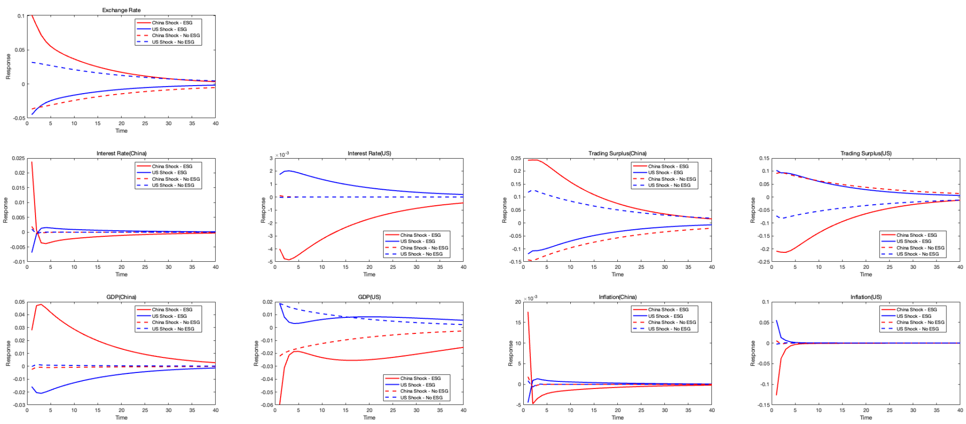

Figure 4.6.2: IRFs of Tariff Shocks

Technology Shock Impact on China and the US: Key Variables

After analyzing tariff shocks, we now turn to the technology shock z_t, which explains the largest share of variation in FEVD (see Table 4.3). This shock is the most important across all periods.

As before, we first look at variables that change direction, then at those with changes in magnitude. After adding ESG, the exchange rate under China's technology shock shifts from rising to falling. Trade surpluses also reverse: China's surplus shifts from increasing to decreasing, and the U.S. surplus from decreasing to increasing. In contrast, the impact of U.S. technology shocks is small and not significant. Other macro variables do not reverse direction, but their responses become stronger or weaker.

The exchange rate mechanism works as follows: With ESG, a positive technology shock in China increases GDP. This improves ESG scores, attracts more foreign bond investment (S_f), and causes the exchange rate q to fall. Without ESG, the same rise in GDP is seen as overheating, which lowers interest rates and pushes q up. For the trade surplus, with ESG, better technology boosts consumer confidence and raises domestic demand. This leads to more imports and a smaller surplus. Without ESG, higher output causes interest rates to rise, which reduces consumption and imports, leading to a larger surplus. A similar effect appears in the U.S. Technology shocks there also raise ESG scores and foreign bond demand (S_{ft}). In short, the main result is that ESG improves access to foreign capital, especially during technology-driven growth. Next, we turn to the effects of inflation shocks.

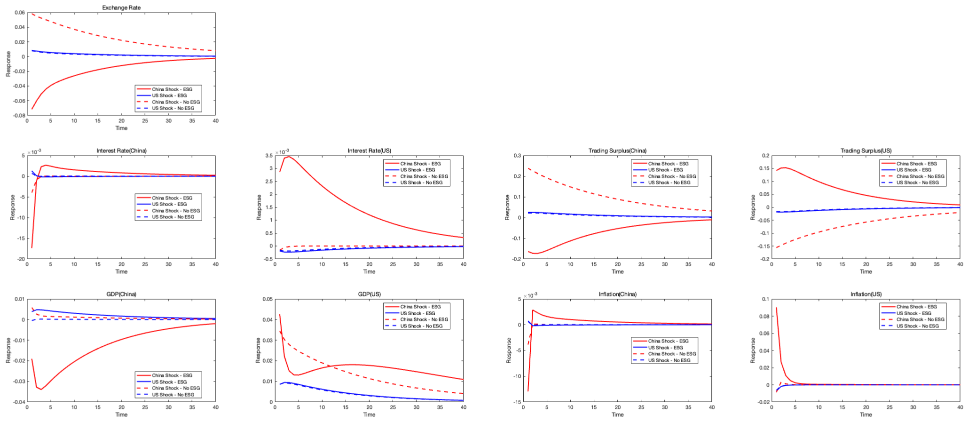

Figure 4.6.3: IRFs of Tech Shocks

Inflation Shock Impact on China and the US: Key Variables

Inflation shocks have different effects on the exchange rate depending on whether ESG is included. In China, the exchange rate changes from falling (without ESG) to rising (with ESG). In the U.S., the pattern is reversed—it changes from rising to falling. For trade surpluses, both China and the U.S. show a similar shift. Under their own inflation shocks, the trade surplus moves from falling to rising. But when facing foreign inflation shocks, the trade surplus shifts from rising to falling.

The exchange rate mechanism works as follows. In China, an inflation shock raises prices and interest rates. This improves ESG scores and makes markets expect tighter green policies. Confidence in the currency drops, and people expect it to lose value. As a result, the expected future exchange rate $E_t(q_{t+1})$ rises, pushing the current exchange rate q_t higher. The U.S. shows a similar dynamic. For the trade surplus, with ESG, higher interest rates reduce consumption and imports. This leads to a larger trade surplus in China and a smaller one in the U.S. Without ESG, consumption remains strong, imports increase, and the pattern reverses: China's surplus becomes smaller, and the U.S. surplus grows. Under U.S. inflation shocks, the same logic applies, but the direction of impact is reversed. In summary, ESG changes the way inflation shocks affect trade and currency outcomes.

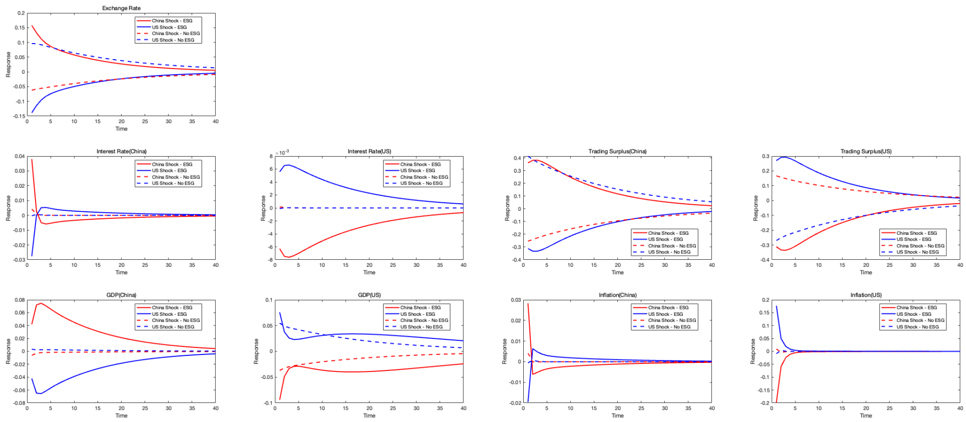

Figure 4.6.4: IRFs of Inflation Shocks

4.7 Simulation:Emergent ESG Regressions: Group-wise Identification Tests

This section uses our two-country DSGE model to explain how common data patterns can result from deeper structural forces. The model is built to match real-world evidence, but it does so without relying on standard regression equations. This shows that regression results may reflect surface-level patterns rather than the true causes. In contrast, the structural model helps identify how these patterns emerge from the underlying economy.

4.7.1 Overview and Identification Strategy

This section tests whether common ESG regression patterns can be reproduced using data from our structural two-country DSGE model. These patterns are not built into the model. Instead, we check if they appear naturally in the simulated data. To do this, we adjust the standard auxiliary VARX model by replacing its variables with those used in typical ESG regressions. For example, when testing equation 4.9, we replace U.S. and China GDP with $E\hat{S}G_t$ and $\hat{\tau}_t \varepsilon_z$, while keeping the same lag structure and estimation method.

Next, we simulate data from the model and estimate several OLS regressions that match the ESG regressions found in the literature. We then conduct Wald tests and report the p-values for the main coefficients. If a p-value is greater than 0.05, we cannot reject the idea that the coefficient is zero. This suggests that the result may not reflect a true cause-and-effect relationship, but instead a pattern that appears by chance. All p-values are listed in Table 4.4.

4.7.2 ESG as a Function of Core Macroeconomic Fundamentals

Since Equations 4.7 and 4.8 are based on the third model setup—where the ESG equation includes the interaction between tariffs and technology shocks as in Equation 4.5—we begin by testing these two cases.

Equations 4.7 and 4.8 examine how ESG is related to output, wages, interest rates, and tariffs. These relationships are not assumed by the model. We simulate data from the model and run the same regressions. The results show that the p-values are close to zero. This means that the model does not support these patterns. So, we cannot use the model to confirm whether these empirical links are real or just spurious.

4.7.3 ESG Driven by Interaction Between Tariff and Technology Shock

Empirical studies suggest that green innovation can reduce the environmental impact of trade policies like tariffs or trade openness. For example, a 2024 study on Malaysia found that green technology helped lower the effect of trade openness on CO emissions by including an interaction term in the model (Ehigiamusoe et al., 2024). Specifically, the study showed that the interaction between technology and trade (Tech $\times$ Trade) helped reduce emissions, meaning that stronger innovation can limit the negative environmental effects of open trade.

To follow this idea, we test a simplified version using Equations 4.9 and 4.10, where ESG is regressed on the interaction term $\hat{\tau}_t \varepsilon_z$. These regressions test whether ESG is linked to the interaction between tariff rates and technology shocks. However, both regressions give p-values of 0. This means the model cannot reproduce the pattern seen in the data. So, it cannot judge whether the link between ESG and the interaction term truly exists.

4.7.4 ESG Driven Purely by Tariff

Consistent with the parameter setup in the case that includes both tariffs and technology shocks, we now test a simpler case. Here, we focus only on the role of tariffs. To do this, we use a basic regression that excludes other macro variables and keeps $\hat{\tau}_t$ as the only explanatory factor.

Equations 4.11 and 4.12 test whether ESG is explained purely by tariffs. Both equations show strong results in the real data. But when we run the same test using simulated data from the model, the p-values are zero. This means the model cannot reproduce the relationship. So, we cannot say if the link between ESG and tariffs really holds in theory.

4.7.5 Foreign Economic Output and International ESG Spillovers

Rising output in one country can affect sustainability in other countries. A study using global trade networks found that international economic links improve countries' sustainability scores (Li, 2021). On average, trade and investment increased national SDG index scores by about 20%, with 91% of countries seeing gains. This means that higher GDP in one country—through trade or investment—can help improve ESG in other countries. The main channels include technology transfer and higher income, though richer countries benefit more (Li, 2021). Another study showed that growth in major economies like the US and China helps each other's ESG performance instead of hurting it (Taghvaee et al., 2022). These findings show the importance of cross-border effects when studying ESG.

To test this idea in our model, we estimate Equations 4.13 and 4.14, using foreign GDP ($\hat{y}_t^*$) to explain ESG. The p-values are above 5%, meaning the model cannot reject the null. Since this regression is not built into the model, the result shows that the observed link between ESG and foreign GDP may not be real.

4.7.6 Foreign Consumption and Environmental Spillovers

A country's consumption can affect ESG outcomes in other countries. Recent research shows that many countries' environmental impacts are caused by the consumption of foreign goods (Ishii et al., 2024). For example, the 2024 Global Commons Stewardship Index finds that more than 30% of greenhouse gas emissions in South Korea, Japan, and the EU come from goods consumed in other countries (Ishii et al., 2024). Likewise, more than half of the deforestation linked to Germany, India, and China happens abroad, as these countries import goods from other regions. This means that countries with high consumption may "export" their environmental burden, harming ESG performance in producer countries. Studies in environmental accounting support this, showing carbon leakage and outsourced pollution. This suggests that when one country's ESG score improves, it may partly be because it shifts carbon-intensive production to its trade partners.

To study this idea, we test Equations 4.15 and 4.16, using foreign consumption ($\hat{c}_{h,t}^*$) to explain ESG. Both regressions have p-values greater than 5%, so the model cannot reject the null hypothesis. Since this relationship is not built into the model, the result shows that the proposed regression is likely not a real effect.

4.7.7 Foreign Wage Levels and Offshoring Effects on ESG

Differences in wages between countries can shape where economic activity—and ESG impacts—take place. A study by Mair et al. (2020) looked at the apparel supply chain in Western Europe and asked what would happen if wages rose in supplier countries like Brazil, Russia, India, and China. They found that higher wages led to only small changes in global carbon emissions. Western consumers bought slightly less, which lowered emissions. But rising incomes in supplier countries increased local demand, which raised emissions again. The net environmental effect was small. However, the wage increases led to clear social benefits. They raised income and improved employment in supplier countries. The study concluded that higher wages help with social equity, but do not solve environmental problems on their own. This highlights the pollution haven effect, where rich countries outsource polluting industries to low-wage countries. Raising foreign wages can reduce this imbalance, but without cleaner technology or changes in consumption, the overall environmental gain is limited.

To test this idea, we look at Equations 4.17 and 4.18, using foreign wages ($\hat{w}_t^*$) to explain ESG. In Equation 4.17, the p-value is above 5%, so the model cannot reject the null hypothesis. Since this relationship is not in the model, the result shows that the regression theory is likely false. In Equation 4.18, the p-value is zero, meaning the model cannot replicate the observed pattern. So, we cannot tell if the relationship really exists.

No.	Equation		P-value
1	$E\hat{S}G_t = \beta_1\hat{y}_t + \beta_2\hat{w}_t + \beta_3\hat{R}_t - \beta_4\hat{\tau}_t + \beta_5\hat{\tau}_t\varepsilon_z + \epsilon_{esg,t}$	(4.7)	0
2	$E\hat{S}G_t^* = \beta_1^*\hat{y}_t^* + \beta_2^*\hat{w}_t^* + \beta_3^*\hat{R}_t^* - \beta_4^*\hat{\tau}_t^* + \beta_5^*\hat{\tau}_t^*\varepsilon_z^* + \epsilon_{esg,t}^*$	(4.8)	0
3	$E\hat{S}G_t = \beta_1\hat{\tau}_t\varepsilon_z + \epsilon_{esg,t}$	(4.9)	0
4	$E\hat{S}G_t^* = \beta_1^*\hat{\tau}_t^*\varepsilon_z^* + \epsilon_{esg,t}^*$	(4.10)	0
5	$E\hat{S}G_t = \beta_1\hat{\tau}_t + \epsilon_{esg,t}$	(4.11)	0
6	$E\hat{S}G_t^* = \beta_1^*\hat{\tau}_t^* + \epsilon_{esg,t}^*$	(4.12)	0
7	$E\hat{S}G_t = \beta_1\hat{y}_t^* + \epsilon_{esg,t}$	(4.13)	6.8%
8	$E\hat{S}G_t^* = \beta_1^*\hat{y}_t + \epsilon_{esg,t}^*$	(4.14)	6%
9	$E\hat{S}G_t = \beta_2\hat{c}_{h,t}^* + \varepsilon_{esg,t}$	(4.15)	6.3%
10	$E\hat{S}G_t^* = \beta_2^*\hat{c}_{h,t} + \varepsilon_{esg,t}^*$	(4.16)	7%
11	$E\hat{S}G_t = \beta_3\hat{w}_t^* + \epsilon_{esg,t}$	(4.17)	6.7%
12	$E\hat{S}G_t^* = \beta_3^*\hat{w}_t + \epsilon_{esg,t}^*$	(4.18)	0

Table 4.4: Model equations with corresponding P-values

4.7.8 Summary and Interpretation

Therefore, based on our analysis, we find that the link between most ESG indicators and foreign shocks—often called "spillover effects"—is mainly a statistical correlation, not a true cause-and-effect relationship. In other words, these patterns are likely spurious and do not reflect real economic mechanisms.

4.8 Conclusion

This study explores how sovereign ESG factors influence the transmission of macroeconomic shocks, focusing on tariff policies in the U.S.–China trade war. The results show that ESG plays an important role. In the United States, adding ESG reduces the effect of productivity shocks on output. Instead, other factors—like inflation and China's productivity—become more important. This means that ESG not only reacts to trade policy but also changes how key variables respond to shocks. In China, the effects are smaller. Its economic system stays stable even after ESG is added. This shows that China is more resilient to tariff changes. This suggests that institutional structure could be crucial, as a strong system may help buffer against tariff shocks from abroad.

This study adds to the existing research by placing ESG inside a dynamic DSGE model. It shows that ESG and trade policy interact in complex and nonlinear ways. The findings also suggest that standard linear models may not fully capture these effects. For policymakers, this means that tariffs can hurt ESG outcomes and make sustainability targets harder to reach. Future research can build on this by adding green finance or global supply chain effects, helping us better understand how trade and ESG are linked across countries.

Chapter 5

Conclusion

5.1 Research Background and Core Question

The US-China trade war is a key recent global economic event. First, the scale and scope of the shock are substantial, given that the US and China are the two largest economies and dominate global trade volumes. Second, it triggered a major shift in global trade norms, with the US turning from a free trade leader to a protectionist actor. Third, as shown in Chapter 2, this event is not temporary; the sharp increase in tariffs represents a structural policy response to a persistent trade deficit. Fourth, as shown in Chapter 4, the trade war has also triggered institutional changes. Beyond its surface effects on GDP and inflation, it has deeper impacts on institutional stability, social structure, and environmental quality. Finally, the trade war has reshaped global supply chains, with technological spillovers reaching third-party countries like Southeast Asia, Mexico, and Europe. In summary, the US-China trade war has had major effects: it is large in scale, changes global trade, reflects structural policy, affects institutions, and reshapes supply chains.

Building on this, we explore the question: how are tariffs employed as a policy response to trade deficits? Second, we ask how different types of tariff shocks, particularly exogenous versus endogenous ones, influence key macroeconomic outcomes. Finally, how do tariffs influence macroeconomic outcomes via sovereign ESG scores as a transmission mechanism?

5.2 Summary of Main Contributions

Our contribution lies in constructing a DSGE model that explicitly incorporates trade deficits into the macroeconomic framework. On the one hand, we develop a two-country DSGE model in which tariffs are endogenously determined by trade deficits, rather than imposed as exogenous shocks. On the other hand, we use the indirect inference method to evaluate the model's fit, demonstrating its strong explanatory power.

Secondly, our contribution lies in multi-scenario analysis and welfare loss comparison. Not only do we compare different motivations for tariffs—such as political factors, unemployment, anti-dumping, and subsidies—and assess their explanatory power, but we also use empirical results to support the view that trade deficits are the primary driver of tariff policy, consistent with actual policy trends.

Finally, we investigate the transmission chain linking tariff shocks to sovereign ESG scores and, subsequently, to macroeconomic performance. On the one hand, we incorporate sovereign ESG scores as the key transmission mechanism through which tariff shocks affect macroeconomic outcomes. On the other hand, we find that tariff changes affect sovereign ESG scores, which in turn influence investor confidence, governance structures, and macroeconomic volatility.

5.3 Theoretical and Practical Contributions

Therefore, we provide both theoretical and practical contributions. On the theoretical side, we incorporate an endogenous tariff rule into a DSGE model, providing an operational, rule-based framework for policy simulation. Secondly, we introduce sovereign ESG scores into the trade economics model, establishing a causal link between institutions, economic policy, and macroeconomic outcomes. On the practical side, our findings suggest to policymakers that rule-based tariff adjustments may offer greater foresight and predictability than ad hoc tariff shocks. In addition, this highlights the need for tariff policy to consider its impact on social structure and institutional stability.

In this way, we adopt the following structure to examine different aspects of the research. Chapter 2 shows that although the Trump administration imposed high tariffs and escalated the trade war, tariff shocks had only limited effects in addressing the trade imbalance. Chapter 3 finds that long-term exogenous tariffs cause the highest welfare loss, zero tariffs the lowest, and that deficit-based tariff adjustments best match real-world data. Therefore, Chapter 4 investigates why trade-deficit-based tariffs align more closely with real-world data, suggesting that the limited impact of tariffs may be explained by sovereign ESG factors, which reflect institutional strength and government effectiveness.

5.4 Limitations and Reflections

However, our research has some limitations. First, certain factors such as geopolitics and technological conflicts cannot be easily quantified. Second, there may be measurement errors in sovereign ESG data, as some dimensions involve a degree of subjectivity in their evaluation. Finally, as our model is based only on parameter calibration, incorporating micro-level data in future structural analysis would enhance the credibility of simulation results.

5.5 Future Research

Future research may extend to model expansion, micro-data-based structural estimation, deeper exploration of ESG dimensions, and broader policy simulations. Model expansion enables analysis of dynamic trade strategies in a fragmented global system and allows for incorporating non-tariff barriers such as technical standards and foreign investment screening. Micro-data-based structural estimation can improve the precision of the model by incorporating firm-level or industry-level data. We can also study sovereign ESG by separating it into E, S, and G parts. This helps us see if governance (G) plays the biggest role in transmission. We can also check if weak ESG performance makes trade negotiations more difficult. Finally, we can design broader policy simulations, like carbon tariffs or regional tariff unions, to predict their dynamic effects using our current model.

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Appendix

A Household Part

A.1 FOC

The following equation represents the Lagrangian formulation used to determine the optimal demand for both domestic and foreign consumption, optimal savings in domestic and foreign country and optimal labour supply.

$$
\begin{aligned}
\mathcal{L} =& E_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ \log c_t - \frac{n_t^{1+\psi}}{1+\psi} - \lambda_t \left[c_{h,t} + (1+\tau_t)\, q_t c_{f,t} \right. \\
& \left. + s_{h,t} + q_t s_{f,t} + \frac{\varphi_s}{2}\left(s_{f,t} - s_f\right)^2 - (1+r_{t-1})\, s_{h,t-1} - \left(1 + r^*_{t-1}\right) q_t s_{f,t-1} - w_t n_t - \pi_t + t_t \right] \Bigg\}
\end{aligned} \tag{A.1}
$$

Then, taking FOC with $c_{h,t}$, $c_{f,t}$, n_t, s_t $\Rightarrow$

$$
c_{h,t} : \left((1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}} + \nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}} \right)^{-1} \cdot (1-\nu)^{\frac{1}{\eta}} \cdot c_{h,t}^{\frac{-1}{\eta}} = \lambda_t \tag{A.2}
$$

$$
c_{f,t} : \left[(1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}} + \nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}} \right]^{-1} \cdot \nu^{\frac{1}{\eta}} \cdot c_{f,t}^{\frac{-1}{\eta}} = (1+\tau_t)\, q_t \lambda_t \tag{A.3}
$$

$$
s_{h,t} : \lambda_t = \beta E_0 \left[\lambda_{t+1} (1+r_t) \right] \tag{A.4}
$$

$$
s_{f,t} : \lambda_t \left(q_t + \varphi_s s_{f,t} - \varphi_s s_f \right) = \beta E_0 \left[\lambda_{t+1} q_{t+1} \left(1 + r_t^*\right) \right] \tag{A.5}
$$

$$
n_t : n_t^{\psi} = \lambda_t w_t \tag{A.6}
$$

By combining equation (A2) and (A3), the intra-temporal condition between home demand and foreign demand can be derived:

$$
\left(\frac{1-\nu}{\nu} \right)^{\frac{1}{\eta}} \cdot \left(\frac{c_{h,t}}{c_{f,t}} \right)^{\frac{-1}{\eta}} = \frac{1}{(1+\tau_t) q_t} \tag{A.7}
$$

By combining equation (A2) with (A4), we can arrive at the Euler equation for consumption within the home country.

$$\begin{aligned}&\left[(1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}}+\nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}}\right]^{-1} \cdot c_{h,t}^{\frac{-1}{\eta}} \\ &=\beta E_0\left\{\left[(1-\nu)^{\frac{1}{\eta}} c_{h,t+1}^{\frac{\eta-1}{\eta}}+\nu^{\frac{1}{\eta}} c_{f,t+1}^{\frac{n-1}{\eta}}\right]^{-1} \cdot c_{h,t+1}^{\frac{-1}{\eta}} \cdot\left(1+r_t\right)\right\}\end{aligned} \tag{A.8}$$

By combining equation (A2) with (A6), we can derive the intratemporal optimality condition between home consumption and labor at time t.

$$n_t^{\psi}=\left[(1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}}+\nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}}\right]^{-1} \cdot(1-\nu)^{\frac{1}{\eta}} \cdot c_{h,t}^{\frac{-1}{\eta}} w_t \tag{A.9}$$

By employing a similar method as used with equations (A3) and (A4), we can derive the Euler equation for importing goods.

$$\begin{aligned}&\left[(1-\nu)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}}+\nu^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}}\right]^{-1} \cdot c_{f,t}^{\frac{-1}{\eta}} \cdot\left[\left(1+\tau_t\right) q_t\right]^{-1} \\ &=\beta E_0\left\{\left[(1-\nu)^{\frac{1}{\eta}} c_{h,t+1}^{\frac{\eta-1}{\eta}}+\nu^{\frac{1}{\eta}} c_{f,t+1}^{\frac{n-1}{\eta}}\right]^{-1} \cdot c_{f,t+1}^{\frac{-1}{\eta}}\left[\left(1+\tau_{t+1}\right) q_{t+1}\right]^{-1} \cdot\left(1+r_t\right)\right\}\end{aligned} \tag{A.10}$$

By merging equations (A4) and (A5), we can derive the Uncovered Interest Parity (UIP) equation(Minford et al., 2023a).

$$\frac{1}{q_t+\varphi_s s_{f,t}-\varphi_s s_f}=\frac{\beta E_0\left[\lambda_{t+1}\left(1+r_t\right)\right]}{\beta E_0\left[\lambda_{t+1} q_{t+1}\left(1+r_t^*\right)\right]} \tag{A.11}$$

A.2 Log-linearization

Log-linearization, also referred to as the First Order Taylor Expansion, is a method used to simplify complex equations, such as those from (A7) to (A11). Due to the complexity of equations (A7) through (A11), we opt to perform log-linearization on equations (A2) to (A6), which represent the FOC containing all the relevant variables. Let's start from the equation (A4). The steady-state of equation (A4):

$$r=\frac{1}{\beta}-1>0$$

Therefore, we have the deviation form of net interest rate:

$$\hat{r}_t \equiv r_t-r$$

Using the equation $x_t=x \exp \left(\tilde{x}_t\right) \simeq x\left(1+\tilde{x}_t\right)$, equation (A4) can be transformed:

$$\lambda\left(1+\hat{\lambda}_t\right)=\beta\lambda\left(1+r_t\right)\mathrm{E}_t\left(1+\hat{\lambda}_{t+1}\right)=\lambda\left(\frac{1+r_t}{1+r}\right)\mathrm{E}_t\left(1+\hat{\lambda}_{t+1}\right)$$

Then, with the first order Taylor expansion: $(1+x)^{\alpha}\simeq 1+\alpha x$, above equation can be transformed (omitting cross-terms):

$$\left(1+\hat{\lambda}_t\right)\approx\left(1+\hat{r}_t+\mathrm{E}_t\hat{\lambda}_{t+1}\right)$$

So, we have the version of log-linearization of Euler equation with variable $\hat{\lambda}_t$:

$$\hat{\lambda}_t=\hat{r}_t+\mathrm{E}_t\hat{\lambda}_{t+1} \tag{A.12}$$

Next, we do the log-linearization of equations (A2), (A3), and (A6).

For equation (A2), it can be transformed to:

$$\frac{(1-\nu)^{\frac{1}{\eta}}\cdot c_{h,t}^{\frac{-1}{\eta}}}{(1-\nu)^{\frac{1}{\eta}}c_{h,t}^{\frac{\eta-1}{\eta}}+\nu^{\frac{1}{\eta}}c_{f,t}^{\frac{\eta-1}{\eta}}}=\lambda_t$$

Dividing both sides and organizing:

$$\frac{1}{\lambda_t}=c_{h,t}+\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}c_{h,t}^{\frac{1}{\eta}}c_{f,t}^{\frac{\eta-1}{\eta}}$$

Steady-state:

$$\frac{1}{\lambda}=c_h+\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}c_h^{\frac{1}{\eta}}c_f^{\frac{\eta-1}{\eta}}$$

Define:

$$X_5=c_h+\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}c_h^{\frac{1}{\eta}}c_f^{\frac{\eta-1}{\eta}} \tag{A.13}$$

Log-form:

$$-\ln\lambda_t=\ln\left[c_{h,t}+\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}c_{h,t}^{\frac{1}{\eta}}c_{f,t}^{\frac{\eta-1}{\eta}}\right]$$

Taylor expansion:

$$-\hat{\lambda}_t=X_1\hat{c}_{h,t}+X_2\hat{c}_{f,t} \tag{A.14}$$

Where:

$$X_1=\left[c_h+\frac{1}{\eta}\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}c_h^{\frac{1}{\eta}}c_f^{\frac{\eta-1}{\eta}}\right]X_5^{-1}$$

$$X_2=\left[\frac{\eta-1}{\eta}\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}c_h^{\frac{1}{\eta}}c_f^{\frac{\eta-1}{\eta}}\right]X_5^{-1}$$

Then substitute into Euler equation:

$$\hat{c}_{ht} = E_t\left[\hat{c}_{h,t+1}\right] + \frac{X_2}{X_1}\left[E_t\left(\hat{c}_{f,t+1}\right) - \hat{c}_{f,t}\right] - \frac{1}{X_1}\hat{r}_t \tag{A.15}$$

Similarly for (A3):

$$-\hat{\lambda}_t = X_3\hat{c}_{h,t} + X_4\hat{c}_{f,t} + \left(\frac{\tau}{1+\tau}\right)\hat{\tau}_t + \hat{q}_t \tag{A.16}$$

Where:

$$X_3 = \left[\left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\eta}}\frac{\eta-1}{\eta}c_h^{\frac{\eta-1}{\eta}}c_f^{\frac{1}{\eta}}\right]X_5^{-1}(1+\tau)q$$
$$X_4 = \left[\left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\eta}}\frac{1}{\eta}c_h^{\frac{\eta-1}{\eta}}c_f^{\frac{1}{\eta}} + c_f\right]X_5^{-1}(1+\tau)q$$

Substitute:

$$\hat{c}_{f,t} = E_t\left[\hat{c}_{f,t+1}\right] + \frac{X_3}{X_4}\left[E_t\left(\hat{c}_{h,t+1}\right) - \hat{c}_{h,t}\right] + \frac{\tau}{X_4(1+\tau)}\left[E_t\left(\hat{\tau}_{t+1}\right) - \hat{\tau}_t\right] - \frac{1}{X_4}\hat{r}_t \tag{A.17}$$

For (A6):

$$\hat{\lambda}_t = \varphi\hat{n}_t - \hat{w}_t \tag{A.18}$$

Substitute into Euler:

$$\hat{n}_t = \frac{1}{\varphi}\hat{w}_t - \frac{X_1}{\varphi}\hat{c}_{h,t} - \frac{X_2}{\varphi}\hat{c}_{f,t} \tag{A.19}$$

For (A5):

$$\hat{\lambda}_t + \hat{q}_t = \hat{r}_t^* + E_0\hat{\lambda}_{t+1} + E_0\hat{q}_{t+1} - \frac{\varphi_s}{q}\hat{s}_{f,t} \tag{A.20}$$

Combine with Euler:

$$\hat{r}_t - \hat{r}_t^* = E_t\hat{q}_{t+1} - \hat{q}_t - \frac{\varphi_s}{q}s_f\hat{s}_{f,t} \tag{A.21}$$

Combine (A13) and (A15):

$$(X_1 - X_3)\hat{c}_{h,t} + (X_2 - X_4)\hat{c}_{f,t} = \left(\frac{\tau}{1+\tau}\right)\hat{\tau}_t + \hat{q}_t \tag{A.22}$$

Log-linearization summary:

$$
\begin{aligned}
&-\hat{\lambda}_t = X_1\hat{c}_{h,t} + X_2\hat{c}_{f,t} \\
&-\hat{\lambda}_t = X_3\hat{c}_{h,t} + X_4\hat{c}_{f,t} + \left(\frac{\tau}{1+\tau}\right)\hat{\tau}_t + \hat{q}_t \\
&\hat{\lambda}_t = \hat{r}_t + \mathrm{E}_t\hat{\lambda}_{t+1} \\
&\hat{\lambda}_t + \hat{q}_t = \hat{r}_t^* + E_0\hat{\lambda}_{t+1} + E_0\hat{q}_{t+1} - \frac{\varphi_s}{q}s_f\hat{s}_{f,t} \\
&\hat{\lambda}_t = \varphi\hat{n}_t - \hat{w}_t
\end{aligned}
$$

A.3 Summation

And the log-linearization conditions for domestic demand, importing demand, working hours and UIP condition are shown as following:

$$
\begin{aligned}
&\hat{c}_{ht} = E_t\left[\hat{c}_{h,t+1}\right] + \frac{X_2}{X_1}\left[E_t\left(\hat{c}_{f,t+1}\right) - \hat{c}_{f,t}\right] - \frac{1}{X_1}\hat{r}_t \\
&\hat{c}_{f,t} = \frac{X_3 - X_1}{X_2 - X_4}\hat{c}_{h,t} + \frac{\tau}{(X_2 - X_4)(1+\tau)}\hat{\tau}_t + \frac{1}{X_2 - X_4}\hat{q}_t \\
&\hat{n}_t = \frac{1}{\varphi}\hat{w}_t - \frac{X_1}{\varphi}\hat{c}_{h,t} - \frac{X_2}{\varphi}\hat{c}_{f,t} \\
&\hat{r}_t - \hat{r}_t^* = E_t\hat{q}_{t+1} - \hat{q}_t - \frac{\varphi_s}{q}\hat{s}_{f,t}
\end{aligned}
$$

Where:

$$
\begin{aligned}
X_1 &= \left[c_h + \left(\frac{1}{\eta}\right)\left(\frac{v}{1-v}\right)^{\frac{1}{\eta}} c_h^{\frac{1}{\eta}} c_f^{\frac{\eta-1}{\eta}}\right]\lambda \\
X_2 &= \left[\left(\frac{\eta-1}{\eta}\right)\left(\frac{v}{1-v}\right)^{\frac{1}{\eta}} c_h^{\frac{1}{\eta}} c_f^{\frac{\eta-1}{\eta}}\right]\lambda \\
X_3 &= \left[\left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\eta}}\left(\frac{\eta-1}{\eta}\right) c_h^{\frac{\eta-1}{\eta}} c_f^{\frac{1}{\eta}}\right]\lambda(1+\tau)q \\
X_4 &= \left[\left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\eta}}\left(\frac{1}{\eta}\right) c_h^{\frac{\eta-1}{\eta}} c_f^{\frac{1}{\eta}} + c_f\right]\lambda(1+\tau)q
\end{aligned}
$$

B Firm Part

B.1 Pricing Decision

The profit equation can be shown as following:

$$
\max_{\bar{P}_t}\sum_{k=0}^{\infty}\theta^k E_t\left\{Q_{t,t+k}\left[Y_{t+k}\left(\frac{\bar{P}_t}{P_{t+k}} - mc_{t+k}\right)\right]\right\}
$$

Where θ^k is the probability for the representative firm keep its price. E_t is the expectation operator. $Q_{t,t+k} = \beta^k\left(C_{t+k}/C_t\right)^{-\sigma}$ is the stochastic discount factor, where β^k is the time discount factor and $U_{c,t+k}/U_{c,t}$ can be expressed by the ratio of marginal utility between period t+k and t(Ou, 2011). Y_{t+k} is the output in period t+k. The ratio $\frac{\bar{P}_t}{P_{t+k}}$ represents the relative value of the adjusted price, $\bar{P}_t$, compared to the market price, P_{t+k}, for evaluating the firm's competitiveness and profitability with the real marginal cost, mc_{t+k} in time t+k.

The profit maximization equation follows the budget constraint shown as following:

$$Y_{t+k}(j) \leq \left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon} C_{t+k} \equiv Y^d_{t+k}\left(\bar{P}_t\right)$$

This is the explanation of this demand constraint. The equation represents an economic constraint for firm j at time t, where the income generated by the firm at time t+k (left-hand side, represented by $Y_{t+k}(j)$) must be less than or equal to the demand for its goods (right-hand side). If the income is greater than the demand, it means that the supply of goods produced by the firm at time t+k is higher than the demand, allowing the firm to raise its prices at time t and optimize its revenue at time t+k. This equation ensures that the income of the firm is aligned with the demand for its goods at time t+k, and the firm can adjust its prices at time t to reach an optimal level.

Following this, the variable $Y_{t+k}(j)$ represents the total income at time $t+k$. The Calvo method takes into account the adjusted price at time t, represented by $\bar{P}_t$, the market price at time $t+k$, represented by P_{t+k}, and the price elasticity, represented by ε, by using the formula $\left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon}$. $Y^d_{t+k}\left(\bar{P}_t\right)$ is the demand at time t+k, which is also a function of $\bar{P}_t$.

Next, In order to get the optimal value of $\bar{P}_t$, we substitute the equation $Y_{t+k}(j) = \left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon} C_{t+k}$ into the profit equation. (Walsh, 1998)After that, taking the FOC with respect to $\bar{P}_t$. Consequently, we obtain the equation:

$$\max_{\bar{P}_t} \sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} \left[\left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon} C_{t+k} \left(\frac{\bar{P}_t}{P_{t+k}} - mc_{t+k}\right)\right]\right\}$$

Rewritten as:

$$\max_{\bar{P}_t} \sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} \left[\left(\frac{\bar{P}_t}{P_{t+k}}\right)^{1-\varepsilon} - mc_{t+k} \left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon}\right] C_{t+k}\right\}$$

Then, FOC with respect to $\bar{P}_t$, we have:

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} \left[(1-\varepsilon)\left(\frac{\bar{P}_t}{P_{t+k}}\right) + \varepsilon mc_{t+k}\right] \left(\frac{1}{\bar{P}_t}\right) \left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon} C_{t+k}\right\} = 0$$

Then, as a fact that:

$$Q_{t,t+k} = \beta^k \left(C_{t+k}/C_t\right)^{-\sigma}$$

By inserting the equation into the FOC equation, we can analyze the optimal solution:

$$\left(\frac{\bar{P}_t}{P_t}\right) = \left(\frac{\varepsilon}{\varepsilon - 1}\right) \frac{\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k C_{t+k}^{1-\sigma} mc_{t+k} \left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon}}{\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k C_{t+k}^{1-\sigma} \left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon-1}}. \tag{B.23}$$

In this step, the critical calculation is to retain all variables with t+k to avoid missing important information. As the aggregate price can be stated in the average form given below:

$$P_t^{1-\varepsilon} = (1-\theta)\left(\bar{P}_t\right)^{1-\varepsilon} + \theta P_{t-1}^{1-\varepsilon}$$

Where P_t is the price at time t, $\bar{P}_t$ is the adjusted price at time t, P_{t-1} is the price in period t-1, parameter $(1-\theta)$ is the fraction of firms which will adjust its price at time t, ε is the elasticity of consumption demand.

I am trying to connect the aggregate price equation to the equation of the optimal solution by transforming it into the form $\frac{\bar{P}_t}{P_t}$. For simplicity, the ratio of $\bar{P}_t/P_t$ is represented by J_t. For this reason, the above aggregate price equation is divided by $P_t^{1-\varepsilon}$ on both sides:

$$1 = (1-\theta)J_t^{1-\varepsilon} + \theta \Pi_t^{\varepsilon-1}$$

Where $\Pi_t = \frac{P_t}{P_{t-1}}$ is the aggregate inflation. Then, taking log on both sides:

$$0 = \log\left[(1-\theta)J_t^{1-\varepsilon} + \theta\Pi_t^{\varepsilon-1}\right]$$

Then, using the first two terms of Taylor extension:

$$0 = \log\left[(1-\theta)J^{1-\varepsilon} + \theta\Pi^{\varepsilon-1}\right] + \frac{(1-\theta)(1-\varepsilon)J^{-\varepsilon}}{(1-\theta)J^{1-\varepsilon} + \theta\Pi^{\varepsilon-1}}(J_t - J) + \frac{\theta(\varepsilon-1)\Pi^{\varepsilon-2}}{(1-\theta)J^{1-\varepsilon} + \theta\Pi^{\varepsilon-1}}(\Pi_t - \Pi)$$

The variables without the subscript "t" are considered constants and have economic interpretations as the steady states of those variables. For instance, J represents the steady state of J_t, and Π represents the steady state of Π_t. Due to the fact that the steady state of these variables is around zero inflation, this implies that the gross inflation, $\Pi = P_t/P_{t-1} = 1$. Additionally, the ratio of J, $J = \bar{P}_t/P_t = 1$, means that all firms are able to adjust their prices randomly at any time. The expressions can be rewritten as follows:

$$0 = (1-\theta)(1-\varepsilon)(J_t - J) + \theta(\varepsilon - 1)(\Pi_t - \Pi)$$

Then, as the concept that dispersion of a variable is $\hat{x}_t = \frac{x_t - x}{x}$, so the expression of above can be transformed into following equation:

$$0 = (1-\theta)(1-\varepsilon)J\frac{J_t - J}{J} + \theta(\varepsilon - 1)\frac{\Pi_t - \Pi}{\Pi}$$

After some easy organization, we have the following equation:

$$\hat{j}_t = \left(\frac{\theta}{1-\theta}\right)\pi_t \tag{B.24}$$

The deviation of j_t can be expressed as such, and the deviation form of aggregate inflation, π_t, is equivalent to the gross inflation, Π_t, in the world of deviation variables.

Next, let's simplify equation (B22) into a more straightforward form:

$$\left[\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k C_{t+k}^{1-\sigma} \left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon-1}\right] J_t = \mu \left[\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k C_{t+k}^{1-\sigma} mc_{t+k} \left(\frac{P_{t+k}}{P_t}\right)^{\varepsilon}\right]$$

Where $J_t = \bar{P}_t / P_t$ and $\mu = \varepsilon/(\varepsilon - 1)$

In steady-state, we have the equation:

$$j = \mu \cdot mc = 1$$

For the given equation, we are now performing a log-linearization on both sides . The specific steps are shown as following:

$$LHS = \left[\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k (C(1+\hat{C}_{t+k}))^{1-\sigma} \left(\frac{P(1+\hat{P}_{t+k})}{P(1+\hat{P}_t)}\right)^{\varepsilon-1}\right] j(1+\hat{j}_t)$$

$$RHS = \mu \left[\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k (C(1+\hat{C}_{t+k}))^{1-\sigma} (mc(1+\widehat{mc}_{t+k})) \left(\frac{P(1+\hat{P}_{t+k})}{P(1+\hat{P}_t)}\right)^{\varepsilon}\right]$$

Then, using the first order Taylor expansion equation: $(1+x)^\alpha \simeq 1 + \alpha x$:

$$LHS = C^{1-\sigma} \left[\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k (1 + (1-\sigma)\hat{C}_{t+k}) \Big((1 + (\varepsilon - 1)\hat{P}_{t+k})(1 + (1-\varepsilon)\hat{P}_t)\Big)\right] j(1+\hat{j}_t)$$

$$RHS = \mu C^{1-\sigma} \left[\mathrm{E}_t \sum_{k=0}^{\infty} \theta^k \beta^k (1 + (1-\sigma)\hat{C}_{t+k})(mc(1+\widehat{mc}_{t+k})) \Big((1 + \varepsilon\hat{P}_{t+k})(1 - \varepsilon\hat{P}_t)\Big)\right]$$

Next, making some organizations, delete the items including the μmc, j and the cross items):

$$LHS = C^{1-\sigma}\left(\sum_{k=0}^{\infty}\theta^k\beta^k\right)\left(1+\hat{j}_t\right)+\left[\mathrm{E}_t\sum_{k=0}^{\infty}\theta^k\beta^k\left(1+(1-\sigma)\hat{C}_{t+k}+(\varepsilon-1)\hat{P}_{t+k}+(1-\varepsilon)\hat{P}_t\right)\right]$$
$$RHS = C^{1-\sigma}\left(\sum_{k=0}^{\infty}\theta^k\beta^k\right)+\left[\mathrm{E}_t\sum_{k=0}^{\infty}\theta^k\beta^k\left(1+(1-\sigma)\hat{C}_{t+k}+\widehat{mc}_{t+k}+\varepsilon\hat{P}_{t+k}-\varepsilon\hat{P}_t\right)\right] \tag{B.25}$$

Next, using the equiproportional series summation formula $S_n = \frac{a(1-r^n)}{1-r}$ to $\sum_{k=0}^{\infty}\theta^k\beta^k$ we have:

$$\begin{aligned}\sum_{k=0}^{\infty}\theta^k\beta^k &= 1+\theta\beta+\theta^2\beta^2+\dots\\ &= \frac{1\cdot(1-\theta^{\infty}\beta^{\infty})}{1-\theta\beta}\end{aligned}$$

As $0<\theta<1$ and $0<\beta<1$, then:

$$\sum_{k=0}^{\infty}\theta^k\beta^k = \frac{1}{1-\theta\beta}$$

So, equation (B24) can be written as:

$$LHS = C^{1-\sigma}\left(\frac{1}{1-\theta\beta}\right)\left(1+\hat{j}_t\right)+\left[\mathrm{E}_t\sum_{k=0}^{\infty}\theta^k\beta^k\left(1+(1-\sigma)\hat{C}_{t+k}+(\varepsilon-1)\hat{P}_{t+k}+(1-\varepsilon)\hat{P}_t\right)\right]$$
$$RHS = C^{1-\sigma}\left(\frac{1}{1-\theta\beta}\right)+\left[\mathrm{E}_t\sum_{k=0}^{\infty}\theta^k\beta^k\left(1+(1-\sigma)\hat{C}_{t+k}+\widehat{mc}_{t+k}+\varepsilon\hat{P}_{t+k}-\varepsilon\hat{P}_t\right)\right]$$

After some organizations, we will have:

$$\hat{j}_t+\hat{p}_t = (1-\theta\beta)\sum_{k=0}^{\infty}\theta^k\beta^k\left(\mathrm{E}_t\widehat{mc}_{t+k}+\mathrm{E}_t\hat{p}_{t+k}\right)$$

Since our goal is to examine the relationship between period t and t+1, we will concentrate on k=0 and k=1. As a result, the right-hand side (RHS) of the equation transforms into:

$$\hat{j}_t+\hat{p}_t = (1-\theta\beta)\left(\widehat{mc}_t+\hat{p}_t\right)+\theta\beta\left(\mathrm{E}_t\hat{j}_{t+1}+\mathrm{E}_t\hat{p}_{t+1}\right)$$

The coefficient $\theta\beta$ can be obtained using the following formula: $\theta\beta = \frac{1}{1-\theta\beta}-1$, where the value 1 corresponds to the case when k=0.

$$
\begin{aligned}
\hat{j}_t &= (1-\theta\beta)\hat{m}c_t + \theta\beta\left(\mathrm{E}_t\hat{j}_{t+1} + \mathrm{E}_t\hat{p}_{t+1} - \hat{p}_t\right) \\
&= (1-\theta\beta)\hat{m}c_t + \theta\beta\left(\mathrm{E}_t\hat{j}_{t+1} + \mathrm{E}_t\pi_{t+1}\right).
\end{aligned}
$$

Then, using equation (B23) to substitute out $\hat{j}_t$ and doing some organizations:

$$
\pi_t = \tilde{\kappa}\widehat{mc}_t + \beta\mathrm{E}_t\pi_{t+1} \tag{B.26}
$$

where

$$
\tilde{\kappa} = \frac{(1-\theta)(1-\theta\beta)}{\theta}
$$

Since the derivation process of equation (B25) is identical to that used in a closed economy, we assume that the New Keynesian Phillips curve in a closed economy is the same as the domestic Phillips curve in the 2-country DSGE model.

$$
\pi_{h,t} = \tilde{\kappa}\widehat{mc}_t + \beta\mathrm{E}_t\pi_{h,t+1} \tag{B.27}
$$

where

$$
\tilde{\kappa} = \frac{(1-\theta)(1-\theta\beta)}{\theta}
$$

B.2 CPI Equation

Next equation is CPI, which is used to measure the level of inflation and purchasing power, presented as follows:

$$
P_t = \left[(1-\nu)P_{h,t}^{1-\eta} + \nu(Q_t(1+\tau_t)P_{h,t}^*)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{B.28}
$$

Where $P_{h,t}$ is the price of home goods, $P_{h,t}^*$ is the price of foreign goods, which equivalently $Q_tP_{h,t}^*$is the importing price of foreign goods in home currency. In line with PPP(purchasing power parity), nominal exchange rate,Q_t typically expressed as one unit of foreign currency in terms of home currency.

Hence, the log-linearization form of equation B.28 is :

$$
\hat{P}_t = (1-\nu)\hat{P}_{h,t} + \nu\hat{P}_{h,t}^* + \nu\hat{Q}_t + \nu\hat{\tau}_t \tag{B.29}
$$

At time t-1 we have:

$$
\hat{P}_{t-1} = (1-\nu)\hat{P}_{h,t-1} + \nu\hat{P}_{h,t-1}^* + \nu\hat{Q}_{t-1} + \nu\hat{\tau}_{t-1} \tag{B.30}
$$

Equation B.29 minus B.30, we have:

$$\hat{\pi}_t = (1-\nu)\hat{\pi}_{h,t} + \nu\hat{\pi}^*_{h,t} + \nu\Delta\hat{Q}_t + \nu(\hat{\tau}_t - \hat{\tau}_{t-1}) \tag{B.31}$$

Where $\hat{\pi}_t = \hat{P}_t - \hat{P}_{t-1}$, $\hat{\pi}_{h,t} = \hat{P}_{h,t} - \hat{P}_{h,t-1}$, $\hat{\pi}^*_{h,t} = \hat{P}^*_{h,t} - \hat{P}^*_{h,t-1}$, $\Delta\hat{Q}_t = \hat{Q}_t - \hat{Q}_{t-1}$, $\hat{\tau}_t$ denotes the (log) tariff rate.

B.3 Summation

Moreover, to ensure compatibility with the linearized equations of the household section, important equations like the production function and marginal cost function are incorporated. The log-linearized form of the production function and marginal cost are presented as follows:

$$\begin{aligned} \hat{y}_t &= \hat{\varepsilon}_{z,t} + \hat{n}_t \\ \widehat{mc}_t &= \hat{w}_t - \hat{\varepsilon}_{z,t} \end{aligned} \tag{B.32}$$

So far, here's a simple summary of the log-linearized equations for the firm section. The following equations are: production function, marginal cost equation, domestic price inflation, as well as CPI inflation:

$$\begin{aligned} \hat{y}_t &= \hat{\varepsilon}_{z,t} + \hat{n}_t \\ \widehat{mc}_t &= \hat{w}_t - \hat{\varepsilon}_{z,t} \\ \hat{\pi}_{h,t} &= \tilde{\kappa}\widehat{mc}_t + \beta \mathrm{E}_t \hat{\pi}_{h,t+1} \\ \hat{\pi}_t &= (1-\nu)\hat{\pi}_{h,t} + \nu\hat{\pi}^*_{h,t} + \nu\Delta\hat{q}_t + \nu(\hat{\tau}_t - \hat{\tau}_{t-1}) \end{aligned} \tag{B.33}$$

Where:

$$\tilde{\kappa} = \frac{(1-\theta)(1-\theta\beta)}{\theta}$$

C Market Clearing

Rest of equations are derived in the same process as above equations.

C.1 Policy Equations

Government spending

$$g_t = \varepsilon_{g,t} \tag{C.34}$$

As above equation is already in linearized form, therefore we have:

$$\hat{g}_t = \hat{\varepsilon}_{g,t} \tag{C.35}$$

The specific form of Taylor Rule is presented in the following (Minford et al., 2023b):

$$1 + R_t = (1 + R_{t-1})^{\rho_R} (1 + \pi_t)^{(1-\rho_R)\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{(1-\rho_R)\phi_Y} (1 + r)^{(1-\rho_R)} \varepsilon_{r,t} \tag{C.36}$$

Where R_t is nominal interest rate, r is the steady-state of real interest rate, ρ_R, ϕ_Y, ϕ_π are simply the parameters and $\varepsilon_{r,t}$ is the nominal interest rate shock. We then only do the log-linearization of y_t, y_{t-1} and $\varepsilon_{r,t}$:

$$\begin{aligned} 1 + R_t = & \left(1 + \rho_R R_{t-1}\right) \left(1 + (1 - \rho_R)\, \phi_\pi \pi_t\right) \left(1 + (1 - \rho_R)\, \phi_Y \hat{y}_t\right) \left(1 - (1 - \rho_R)\, \phi_Y \hat{y}_{t-1}\right) \\ & \left(1 + (1 - \rho_R)\, r\right) \left(\varepsilon_r \left(1 + \hat{\varepsilon}_r\right)\right) \end{aligned} \tag{C.37}$$

As the steady-state of $\varepsilon_r = 1$, then we have (omit the cross-items):

$$R_t = \rho_R R_{t-1} + (1 - \rho_R) \left[r + \phi_\pi \pi_t + \phi_Y \left(\hat{y}_t - \hat{y}_{t-1}\right)\right] + \hat{\varepsilon}_{r,t} \tag{C.38}$$

I have used trading surplus, the exports minus the imports, to represent this factor.

$$x_t = c^*_{f,t} - c_{f,t} \tag{C.39}$$

Where $c^*_{f,t}$ is the export of home country, $c_{f,t}$ is the import of home country (Minford et al., 2023b). Its log-linearized form is:

$$\hat{x}_t = \frac{c^*_f}{c^*_f - c_f} \hat{c}^*_{f,t} - \frac{c_f}{c^*_f - c_f} \hat{c}_{f,t} \tag{C.40}$$

In order to be consistent with the empirical work, the following section presents an expression of the tariff equation similar to the Taylor Rule. The variables we have chosen in constructing this equation are trading surplus, CPI, and GDP growth rate respectively.

$$\tau_t = d_x - \gamma_\tau x_t + \epsilon_{\tau,t} \tag{C.41}$$

Log-linearization of the above equation:

$$\hat{\tau}_t = -\gamma_\tau \hat{x}_t + \hat{\epsilon}_{\tau,t} \tag{C.42}$$

C.2 Equilibrium

$$y_t = c_{h,t} + g_t + x_t$$

After the log-linearization, its expression becomes:

$$\hat{y}_t = \frac{c}{y}\hat{c}_{h,t} + \frac{g}{y}\hat{g}_t + \frac{x}{y}\hat{x}_t \tag{C.43}$$

Following equation is BOP, which is also the way to determine the value of real exchange rate.

$$q_t\left[s_{f,t} + (1+\tau_t)c_{f,t} - \left(1+r^*_{t-1}\right)s_{f,t-1}\right] = c^*_{f,t}$$

The log-linearization form is:

$$(qc_h - qs_f r^*)\hat{q}_t + qs_f\hat{s}_{f,t} + qc_f\hat{c}_{f,t} - (1+r^*)qs_f\hat{s}_{f,t-1} - qs_f\hat{r}^*_{t-1} = c^*_f\hat{c}^*_{f,t} \tag{C.44}$$

The Fisher Equation serves as a connecting equation between the nominal interest rate and the real interest rate:

$$(1+R_t) = (1+r_t)(1+E_t\pi_{t+1}) \tag{C.45}$$

Then, taking the log-linearization of equation (C.43):

$$\hat{R}_t = E_t\pi_{t+1} + \hat{r}_t \tag{C.46}$$

Where r_t is real interest rate, R_t is nominal interest rate.

Furthermore, the relationship between the nominal exchange rate and the real exchange rate is as follows:

$$q_t = \frac{Q_t p^*_{h,t}}{p_{h,t}}$$

Transforming to the equation incorporating inflation, π_t and π_{t-1}:

$$\Delta\hat{Q}_t = \Delta\hat{q}_t - \pi^*_{h,t} + \pi_{h,t} \tag{C.47}$$

In this part, the summation of equations is:

$$\begin{aligned}
&\hat{y}_t = \frac{c}{y}\hat{c}_{h,t} + \frac{g}{y}\hat{g}_t + \frac{x}{y}\hat{x}_t \\
&(qc_h - qs_f r^*)\hat{q}_t + qs_f\hat{s}_{f,t} + qc_f\hat{c}_{f,t} - (1+r^*)qs_f\hat{s}_{f,t-1} - qs_f\hat{r}^*_{t-1} = c^*_f\hat{c}^*_{f,t} \\
&\hat{R}_t = E_t\pi_{t+1} + \hat{r}_t \\
&\Delta\hat{Q}_t = \Delta\hat{q}_t - \pi^*_{h,t} + \pi_{h,t}
\end{aligned} \tag{C.48}$$

D The List Of All Equations

Combining equations in Appendix A, B and C, we can close the whole basic two-country DSGE model:

Domestic Consumption:

$$\hat{c}_{ht} = E_t\left[\hat{c}_{h,t+1}\right] + \frac{X_2}{X_1}\left[E_t\left(\hat{c}_{f,t+1}\right) - \hat{c}_{f,t}\right] - \frac{1}{X_1}\hat{r}_t - \frac{1}{X_1}\left[E_t\hat{\epsilon}_{j,t+1} - \hat{\epsilon}_{j,t}\right] \tag{D.49}$$

Importing Consumption:

$$\hat{c}_{f,t} = \frac{X_3 - X_1}{X_2 - X_4}\hat{c}_{h,t} + \frac{\tau}{\left(X_2 - X_4\right)\left(1+\tau\right)}\hat{\tau}_t - \frac{1}{X_2 - X_4}\hat{q}_t \tag{D.50}$$

Labour Supply:

$$\hat{n}_t = \frac{1}{\varphi}\hat{w}_t - \frac{X_1}{\varphi}\hat{c}_{h,t} - \frac{X_2}{\varphi}\hat{c}_{f,t} \tag{D.51}$$

UIP:

$$\hat{r}_t - \hat{r}_t^* = E_t\hat{q}_{t+1} - \hat{q}_t - \frac{\varphi_s}{q}\hat{s}_{f,t} \tag{D.52}$$

Production Function:

$$\hat{y}_t = \hat{\varepsilon}_{z,t} + \hat{n}_t \tag{D.53}$$

Marginal Cost:

$$\widehat{mc_t} = \hat{w}_t - \hat{\varepsilon}_{z,t} \tag{D.54}$$

New Keynesian Equation:

$$\pi_{h,t} = \tilde{\kappa}\widehat{mc}_t + \beta \mathrm{E}_t\pi_{h,t+1} + \hat{\epsilon}_{\pi,t} \tag{D.55}$$

CPI Equation:

$$\pi_t = (1-\nu)\pi_{h,t} + \nu\Delta\hat{Q}_t + \nu\pi_{h,t}^* + \nu\left(\hat{\tau}_t - \hat{\tau}_{t-1}\right) \tag{D.56}$$

Government Spending:

$$\hat{g}_t = \hat{\varepsilon}_{g,t} \tag{D.57}$$

Taylor Rule:

$$\hat{R}_t = \rho_R\hat{R}_{t-1} + \left(1-\rho_R\right)\left[\phi_\pi\pi_t + \phi_Y\left(\hat{y}_t - \hat{y}_{t-1}\right)\right] + \hat{\varepsilon}_{R,t} \tag{D.58}$$

Tariff Policy:

$$\hat{\tau}_t = -\gamma_\tau\hat{x}_t + \hat{\epsilon}_{\tau,t} \tag{D.59}$$

Trading Surplus:

$$\hat{x}_t = \frac{c_f^*}{c_f^* - c_f}\hat{c}_{f,t}^* - \frac{c_f}{c_f^* - c_f}\hat{c}_{f,t} \tag{D.60}$$

Market Clearing:

$$\hat{y}_t = \frac{c}{y}\hat{c}_{h,t} + \frac{g}{y}\hat{g}_t + \frac{x}{y}\hat{x}_t \tag{D.61}$$

BOP:

$$\frac{s_f}{y}\hat{s}_{f,t} = \frac{s_f}{y}\hat{r}_{t-1}^* + (1+r^*)\frac{s_f}{y}\hat{s}_{f,t-1} + \frac{1}{q(1+\tau)}\frac{c_f^*}{y}(\hat{c}_{f,t}^* - \hat{q}_t - \hat{\tau}_t) - \frac{c_f}{y}\hat{c}_{f,t} \tag{D.62}$$

Fisher Equation:

$$\hat{R}_t = E_t\pi_{t+1} + \hat{r}_t \tag{D.63}$$

Nominal Exchange Rate:

$$\Delta\hat{Q}_t = \Delta\hat{q}_t - \pi_{h,t}^* + \pi_{h,t} \tag{D.64}$$

Where:

$$X_1 = \left[\frac{c_h}{y} + \left(\frac{1}{\eta}\right)\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}\left(\frac{c_h}{y}\right)^{\frac{\nu}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{1-\nu}{\eta}}\right]\left[\frac{c_h}{y} + \left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}\left(\frac{c_h}{y}\right)^{\frac{\nu}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{1-\nu}{\eta}}\right]^{-1}$$

$$X_2 = \left[\left(\frac{\eta-1}{\eta}\right)\left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}\left(\frac{c_h}{y}\right)^{\frac{\nu}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{1-\nu}{\eta}}\right]\left[\frac{c_h}{y} + \left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}\left(\frac{c_h}{y}\right)^{\frac{\nu}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{1-\nu}{\eta}}\right]^{-1}$$

$$X_3 = \left[\left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\eta}}\left(\frac{\eta-1}{\eta}\right)\left(\frac{c_h}{y}\right)^{\frac{1-\nu}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{\nu}{\eta}}\right]\left[\frac{c_h}{y} + \left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}\left(\frac{c_h}{y}\right)^{\frac{\nu}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{1-\nu}{\eta}}\right]^{-1}(1+\tau)q$$

$$X_4 = \left[\left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\eta}}\frac{1}{\eta}\left(\frac{c_h}{y}\right)^{\frac{\nu-1}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{\nu}{\eta}} + \frac{c_f}{y}\right]\left[\frac{c_h}{y} + \left(\frac{\nu}{1-\nu}\right)^{\frac{1}{\eta}}\left(\frac{c_h}{y}\right)^{\frac{\nu}{\eta}}\left(\frac{c_f}{y}\right)^{\frac{1-\nu}{\eta}}\right]^{-1}(1+\tau)q$$

$$\tilde{\kappa} = \frac{(1-\theta)(1-\theta\beta)}{\theta}$$

For the equations in Foreign Country, the equations list is:
Domestic Consumption:

$$\hat{c}_{ht}^* = E_t\left[\hat{c}_{h,t+1}^*\right] + \frac{X_2^*}{X_1^*}\left[E_t\left(\hat{c}_{f,t+1}^*\right) - \hat{c}_{f,t}^*\right] - \frac{1}{X_1^*}\hat{r}_t^* - \frac{1}{X_1^*}[E_t\hat{\epsilon}_{j,t+1}^* - \hat{\epsilon}_{j,t}^*] \tag{D.65}$$

Importing Consumption:

$$\hat{c}_{f,t}^* = \frac{X_3^* - X_1^*}{X_2^* - X_4^*}\hat{c}_{h,t}^* + \frac{\tau^*}{(X_2^* - X_4^*)(1+\tau^*)}\hat{\tau}_t^* - \frac{1}{X_4^* - X_2^*}\hat{q}_t \tag{D.66}$$

Labour Supply:

$$\hat{n}_t^* = \frac{1}{\varphi^*}\hat{w}_t^* - \frac{X_1^*}{\varphi^*}\hat{c}_{h,t}^* - \frac{X_2^*}{\varphi^*}\hat{c}_{f,t}^* \tag{D.67}$$

Production Function:

$$\hat{y}_t^* = \hat{\varepsilon}_{z,t}^* + \hat{n}_t^* \tag{D.68}$$

Marginal Cost:

$$\widehat{mc}_t^* = \hat{w}_t^* - \hat{\varepsilon}_{z,t}^* \tag{D.69}$$

New Keynesian Equation:

$$\pi_{h,t}^* = \tilde{\kappa}^*\widehat{mc}_t^* + \beta^*\mathrm{E}_t\pi_{h,t+1}^* + +\hat{\epsilon}_{\pi,t}^* \tag{D.70}$$

CPI Equation:

$$\pi_t^* = (1-\nu^*)\pi_{h,t}^* - \nu^*\Delta\hat{Q}_t + \nu^*\pi_{h,t} + \tau_t^* - \tau_{t-1}^* \tag{D.71}$$

Government Spending:

$$\hat{g}_t^* = \hat{\varepsilon}_{g,t}^* \tag{D.72}$$

Taylor Rule:

$$\hat{R}_t^* = \rho_R^*\hat{R}_{t-1}^* + (1-\rho_R^*)\left[\phi_\pi^*\pi_t^* + \phi_Y^*\left(\hat{y}_t^* - \hat{y}_{t-1}^*\right)\right] + \hat{\varepsilon}_{R,t}^* \tag{D.73}$$

Tariff Policy:

$$\hat{\tau}_t^* = (1-\rho_\tau^*)\left(\phi_{2\pi}^*\pi_t^* + \phi_x^*\hat{x}_t^* + \phi_{2Y}^*\left(\hat{y}_t^* - \hat{y}_{t-1}^*\right)\right) + \hat{\varepsilon}_{\tau t}^* \tag{D.74}$$

Trading Surplus:

$$\hat{x}_t^* = \frac{c_f}{c_f - c_f^*}\hat{c}_{f,t} - \frac{c_f^*}{c_f - c_f^*}\hat{c}_{f,t}^* \tag{D.75}$$

Market Clearing:

$$\hat{y}_t^* = \frac{c^*}{y^*}\hat{c}_{h,t}^* + \frac{g^*}{y^*}\widehat{g}_t^* + \frac{x^*}{y^*}\hat{x}_t^* \tag{D.76}$$

BOP:

$$\frac{s_f^*}{y^*}\hat{s}_{f,t}^* = \frac{s_f^*}{y^*}(\hat{r}_{t-1} - r) + (1+r)\frac{s_f^*}{y^*}\hat{s}_{f,t-1}^* + \frac{q}{1+\tau^*}\frac{c_f}{y^*}(\hat{c}_{f,t} + \hat{q}_t - \hat{\tau}_t^*) - \frac{c_f^*}{y^*}\hat{c}_{f,t}^* \tag{D.77}$$

Fisher Equation:

$$\hat{R}_t^* = E_t\pi_{t+1}^* + \hat{r}_t^* \tag{D.78}$$

Where:

$$X_1^* = \left[\frac{c_h^*}{y^*} + \left(\frac{1}{\eta^*}\right)\left(\frac{\nu^*}{1-\nu^*}\right)^{\frac{1}{\eta^*}}\left(\frac{c_h^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{1-\nu^*}{\eta^*}}\right]\left[\frac{c_h^*}{y^*} + \left(\frac{\nu^*}{1-\nu^*}\right)^{\frac{1}{\eta^*}}\left(\frac{c_h^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{1-\nu^*}{\eta^*}}\right]^{-1}$$

$$X_2^* = \left[\left(\frac{\eta^*-1}{\eta^*}\right)\left(\frac{\nu^*}{1-\nu^*}\right)^{\frac{1}{\eta^*}}\left(\frac{c_h^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{1-\nu^*}{\eta^*}}\right]\left[\frac{c_h^*}{y^*} + \left(\frac{\nu^*}{1-\nu^*}\right)^{\frac{1}{\eta^*}}\left(\frac{c_h^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{1-\nu^*}{\eta^*}}\right]^{-1}$$

$$X_3^* = \left[\left(\frac{1-\nu^*}{\nu^*}\right)^{\frac{1}{\eta^*}}\left(\frac{\eta^*-1}{\eta^*}\right)\left(\frac{c_h^*}{y^*}\right)^{\frac{1-\nu^*}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}}\right]\left[\frac{c_h^*}{y^*} + \left(\frac{\nu^*}{1-\nu^*}\right)^{\frac{1}{\eta^*}}\left(\frac{c_h^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{1-\nu^*}{\eta^*}}\right]^{-1}(1+\tau^*)q^*$$

$$X_4^* = \left[\left(\frac{1-\nu^*}{\nu^*}\right)^{\frac{1}{\eta^*}}\frac{1}{\eta^*}\left(\frac{c_h^*}{y^*}\right)^{\frac{\nu^*-1}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}} + \frac{c_f^*}{y^*}\right]\left[\frac{c_h^*}{y^*} + \left(\frac{\nu^*}{1-\nu^*}\right)^{\frac{1}{\eta^*}}\left(\frac{c_h^*}{y^*}\right)^{\frac{\nu^*}{\eta^*}}\left(\frac{c_f^*}{y^*}\right)^{\frac{1-\nu^*}{\eta^*}}\right]^{-1}(1+\tau^*)q^*$$

$$\tilde{\kappa}^* = \frac{(1-\theta^*)(1-\theta^*\beta^*)}{\theta^*}$$

E Data Adjustment

Before applying the IIM model, it is essential to process the raw data. The following section provides a comprehensive description of all the variables involved. As outlined earlier, the endogenous variables are: $\hat{c}_{h,t}$ $\hat{c}^*_{h,t}$ $\hat{c}_{f,t}$ $\hat{c}^*_{f,t}$ $\hat{n}_t$ $\hat{n}^*_t$ $\hat{w}_t$ $\hat{w}^*_t$ $\hat{\tau}_t$ $\hat{\tau}^*_t$ $\hat{r}_t$ $\hat{r}^*_t$ $\hat{R}_t$ $\hat{R}^*_t$ $\hat{s}_{f,t}$ $\hat{s}^*_{f,t}$ $\hat{q}_t$ $\Delta\hat{q}_t$ $\Delta\hat{Q}_t$ $\hat{y}_t$ $\hat{y}^*_t$ $\hat{mc}_t$ $\hat{mc}^*_t$ π_t π^*_t $\pi_{h,t}$ $\pi^*_{h,t}$ $\hat{g}_t$ $\hat{g}^*_t$ $\hat{x}_t$ $\hat{x}^*_t$ In total, there are 31 endogenous variables.

The model comprises eight exogenous variables, outlined as follows: productivity shocks: $\epsilon_{z,t}$ $\epsilon^*_{z,t}$; fiscal shocks: $\epsilon_{g,t}$ $\epsilon^*_{g,t}$; interest shocks: $\epsilon_{R,t}$ $\epsilon^*_{R,t}$; and tariff shocks: $\epsilon_{\tau,t}$ $\epsilon^*_{\tau,t}$.

In this study, we denote economic indicators for the United States with an asterisk (*) and those for China without one.

Our analysis begins with U.S. domestic consumption, denoted as $c^*_{h,t}$. Since this data is not directly available from the Bureau of Economic Analysis (BEA), we derive it from total U.S. consumption (c^*_t), which primarily relies on the personal consumption expenditures (PCE) index. The PCE index effectively captures personal consumption across different regions.

In the two-country DSGE model, total domestic consumption includes both domestically produced and imported goods. To obtain U.S. domestic consumption ($c^*_{h,t}$), we subtract U.S. imports from China ($c^*_{f,t}$) from total U.S. consumption:

$$c^*_{h,t} = c^*_t - c^*_{f,t}$$

Data for $c^*_{f,t}$ is available from the BEA.

Similarly, China's total consumption (c_t) is obtained from the National Bureau of Statistics of China (NBS), primarily using the total retail sales index of consumer goods. To determine China's domestic consumption ($c_{h,t}$), we use the following formula:

$$c_{h,t} = c_t - c_{f,t}$$

Here, $c_{f,t}$ represents China's import consumption, which corresponds precisely to U.S. export data and is available from the BEA.

To study trade surpluses in China and the U.S., represented by x_t and x_t^*, we use the equation $c_{f,t} - c_{f,t}^*$. Since these surpluses are usually opposite in direction, we must convert the U.S. trade surplus into yuan to compare it accurately.

For U.S. working hours (n_t^*), data from the Bureau of Economic Analysis (BEA) includes full-time and part-time workers. However, the data is available only yearly from 2000 to 2021. We use cubic interpolation to turn it into a seasonal dataset extending to 2023. Similarly, China's working hours (n_t) come from an online news report (Zhou, 2023), covering 2000 to 2022. We apply the same interpolation method to create seasonal data from 2000 to 2023.

For U.S. wages (w_t^*), seasonal data from 2000 to 2023 is taken from the BEA's "Wages and Salaries by Industry" table. China's wage data (w_t) from the National Bureau of Statistics (NBS) is available only yearly from 2000 to 2023. To make it seasonal, we divide each annual value by four and use MATLAB's "spline" function for smooth interpolation.

Tariff rates in the U.S. (τ_t^*) and China (τ_t) come from the World Integrated Trade Solution (WITS). The Average Harmonized System (AHS) index provides a weighted average for comparison. Since the data is only available yearly from 1991 to 2020, we fill in missing values and extend it to 2023. We use cubic interpolation for smoother data transitions and apply a logarithmic transformation to avoid negative values. After interpolation, we revert the data to its original scale. However, this method may make values from 2021 to 2023 approach zero due to data limits.

The real interest rate in the U.S. (r_t^*) is found by subtracting inflation (π_t^*) from the nominal interest rate (R_t^*). The Federal Funds Effective Rate from FRED provides the nominal rate, while inflation is calculated as the percentage change in the Consumer Price Index (CPI). Core inflation ($\pi_{h,t}^*$) is from FRED, excluding food and energy prices. China's nominal interest rate (R_t) is sourced from The People's Bank of China (PBOC) as yearly data, which we convert into a seasonal format. China's real interest rate and inflation data from the World Bank follow the same process. Core inflation in China ($\pi_{h,t}$), available yearly from 2014 to 2023, is converted to seasonal data from 2000 to 2023 Chen and Zhang (2023).

Exchange rate data (q_t) for the China-U.S. corridor comes from FRED. Foreign savings data, including China's savings in the U.S. ($s_{f,t}$) and U.S. savings in China ($s_{f,t}^*$), is from the BEA. Yearly data from 2000 to 2023 is turned into seasonal data. U.S. GDP (y_t^*) is from FRED, while China's GDP (y_t) comes from the NBS. Since U.S. marginal cost (mc_t^*) is not directly available from FRED, we use labor productivity as a proxy. China's marginal cost (mc_t) is sourced from the OECD. Government spending for the U.S. (g_t^*) and China (g_t) is from the World Bank, using the "General Government Final Consumption Expenditure (Current LCU)" index for consistency.

All the details can be seen in table1.

Table 1: US-China variables

Observable variables	**Time series collected**	**Source**[1]	**Divided by CPI?**	**Divided by pop.?**	**Seasonally adjusted?**
Y_t^* (US Output or GDP)	GDP time series	FRED	✓	✓	✓
C_t^* (Total consumption in the US)	Personal consumption expenditures (PCE)	US Bureau of Economic Analysis	✓	✓	✓
$C_{f,t}^*$ (Consumption imported from China to the US)	Imported goods consumption time series	US Bureau of Economic Analysis	✓	✓	✓
N_t^* (Working hours in the US)	Hours worked by full and part time employees (Annual)	US Bureau of Economic Analysis	No	No	✓
W_t^* (Wages in the US)	Quarterly data (2000 to 2023)	US Bureau of Economic Analysis	No	No	✓
q_t (Exchange rate in the US)	Quarterly time series	FRED	No	No	✓
mc_t^* (Marginal cost in the US)	Labour productivity	FRED	No	No	✓
π_t^* (US Inflation rate)	Calculated as the percentage change from CPI for All Urban Consumers	FRED	No	No	✓

$\pi^*_{h,t}$ (Core inflation rate in the US)	Commodities Less Food and Energy Commodities CPI	FRED	No	No	✓
G^*_t (Government spending in the US)	General government final consumption expenditure (current LCU)	World Bank	✓	✓	✓
Y_t (Output or GDP in China)	GDP time series	NBS	✓	✓	✓
C_t (Total consumption in China)	Total retail sales of consumer goods	NBS	✓	✓	✓
$C_{f,t}$ (Consumption imported from the US to China)	Exporting consumption from the US	US Bureau of Economic Analysis	✓	✓	✓
N_t (Working hours in China)	Annual working hours	Web News	No	No	✓
W_t (Wages in China)	Annual data (2000 to 2023)	NBS	No	No	✓
mc_t (Marginal cost in China)	Labour productivity	OECD	No	No	✓

G_t (Government spending in China)	General government final consumption expenditure (current LCU)	World Bank	✓	✓	✓
π_t (China Inflation rate)	Calculated as the percentage change from CPI	World Bank	No	No	✓
$\pi_{h,t}$ (Core inflation rate in China)	Analysis by Chen and Zhang (2023); annual data converted to seasonal data	Chen and Zhang (2023)	No	No	✓

Note: We used data interpolation to improve dataset continuity and coverage, applying cubic and Matlab's spline interpolation to fill gaps and extend data. To enhance accuracy, we converted annual data into a quarterly format and transformed values into logarithmic form during interpolation, preventing negative numbers and ensuring reliable analysis.

[1]NBS (National Bureau of Statistics of China); FRED (Federal Reserve Economic Data); OECD (Organisation for Economic Co-operation and Development); World Bank; US Bureau of Economic Analysis.

F Parameters of Different Cases

Table 2: Parameters Used for Simulated Data Generation in China and US: Case 1 to Case 4 (1000 Periods)

Parameter	Description	China	US
	Case 1		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.010	0.140
ν	Percentage of imported goods in all goods	0.019	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.989	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.011
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.989	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.920	0.057
γ_π	Persistence of inflation shock	0.010	0.018
$\phi_{x\tau}$	Coefficient in tariff equation	0.700	0.001
	Case 2		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.022	0.140
ν	Percentage of imported goods in all goods	0.010	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.989	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.017
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.989	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.920	0.057
γ_π	Persistence of inflation shock	0.010	0.018
	Case 3		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.022	0.140
ν	Percentage of imported goods in all goods	0.010	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.989	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.011
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.983	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.920	0.057
γ_π	Persistence of inflation shock	0.010	0.018
	Case 4		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.022	0.140
ν	Percentage of imported goods in all goods	0.010	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.800	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.011
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.983	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.920	0.057
γ_π	Persistence of inflation shock	0.010	0.018
$\phi_{n\tau}$	Coefficient in tariff equation	0.700	0.001

Table 3: Parameters Used for Simulated Data Generation in China and US: Case 5 to Case 8 (1000 Periods)

Parameter	Description	China	US
	Case 5		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.022	0.140
ν	Percentage of imported goods in all goods	0.010	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.989	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.011
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.983	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.920	0.057
γ_π	Persistence of inflation shock	0.010	0.018
ϕ_τ	Coefficient in tariff equation	0.700	0.001
	Case 6		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.022	0.140
ν	Percentage of imported goods in all goods	0.010	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.989	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.011
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.983	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.920	0.057
γ_π	Persistence of inflation shock	0.010	0.018
ϕ_τ	Coefficient in the equation affecting subsidies	0.700	0.001
γ_{sub}	Persistence of subsidy shock	0.188	0.822
	Case 7		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.022	0.140
ν	Percentage of imported goods in all goods	0.010	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.989	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.011
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.983	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.920	0.057
γ_π	Persistence of inflation shock	0.010	0.018
$\phi_{x,\tau}$	Coefficient of trading deficit in tariff equation	0.700	0.001
$\phi_{n,\tau}$	Coefficient of unemployment in tariff equation	0.193	0.019
$\phi_{f\tau}$	Coefficient of foreign tariff in tariff equation	0.111	0.097
$\phi_{s\tau}$	Coefficient of foreign subsidies in tariff equation	0.188	0.822
$\text{Coef}_{s\tau}$	Coefficient in the equation affecting subsidies	0.628	0.628
γ_{sub}	Persistence of subsidy shock	0.581	0.392
	Case 8		
φ	Inverse of wage elasticity in labor supply	0.922	0.010
φ_s	Adjustment cost parameter for investment portfolio	0.022	0.140
ν	Percentage of imported goods in all goods	0.010	0.181
η	Elasticity of substitution between foreign and domestic products	0.054	0.100
θ	Fraction of firms that do not change prices	0.989	0.920
ρ_R	Parameter in Taylor Rule	0.011	0.011
ϕ_π	Monetary policy response to inflation	2.120	0.990
ϕ_Y	Monetary policy response to output growth	0.010	0.920
γ_z	Persistence of productivity shock	0.983	0.714
γ_G	Persistence of government spending shock	0.920	0.989
γ_R	Persistence of fiscal shock	0.999	0.920
γ_τ	Persistence of tariff shock	0.000	0.000
γ_π	Persistence of inflation shock	0.010	0.018
$\phi_{x,\tau}$	Coefficient in tariff equation	0.000	0.000

G Trade War Timeline

To clarify recent developments in U.S.–China tariff policy, Table 4 presents a timeline beginning in 2025. At its peak, the U.S. tariff rate on Chinese goods reached 245%, combining a general tariff (10%), a reciprocal tariff (25%), a counter-retaliation tariff (50%), and a special "fentanyl-related" tariff (20%)(Oberlies et al., 2025).[1] These tariffs primarily target sectors such as shipbuilding, shipping, semiconductors, and port equipment, as well as consumer electronics, pharmaceuticals, automotive products, metal goods, energy equipment, and e-commerce platforms including Temu and Shein(Akin Public Policy and Lobbying Team, 2025). On the Chinese side, the maximum tariff on U.S. goods reached 125%. This includes an initial 15% on energy products and farm machinery, followed by a 34% retaliatory tariff, and further increases up to the final level(Jin et al., 2025). China's tariffs have focused mainly on U.S. agricultural products, energy, farm machinery, medical devices, and fiber optic equipment(Oberlies et al., 2025). In summary, the tariff escalation has resulted in U.S. rates of up to 245% on Chinese goods, and Chinese rates of up to 125% on American goods.

Table 4 illustrates the escalation of tariffs between the United States and China throughout 2025. The U.S. initiated the first round of increases on February 1st, when President Trump, citing a "national emergency," announced a 10% tariff on all imports from China(Oberlies et al., 2025). At the same time, the administration cancelled the previous tariff exemption for small parcels under $800, directly impacting China's cross-border e-commerce sector. On March 4th, the tariff rate was raised to 20%(The White House, 2025a). This was followed on April 2nd by the introduction of a "reciprocal tariff,"[2] adding an additional 25% and bringing the total to 54%(Elms, 2025). In the same month, the U.S. imposed a countervailing duty. On April 9th, the total tariff rate was raised again to 125%. Two days later, on April 11th, an additional 20% fentanyl-related tariff was introduced, justified by the opioid crisis, bringing the total to 145%(Husch Blackwell Trade Team, 2025). Finally, on April 17th, the cumulative U.S. tariff rate reached 245%.

In response, China implemented a series of countermeasures, gradually escalating its own tariffs. On February 10th, China imposed a 15% tariff on U.S. liquefied natural gas (LNG), along with an additional 10% tariff on gas products and farm machinery(Catone, 2025). At the same time, it tightened export controls on selected metals. On March 4th, China expanded its tariffs to cover U.S. agricultural products, with rates ranging from

[1]Fentanyl is a highly potent synthetic opioid, widely abused in the United States as a painkiller and associated with significant mortality each year. The Trump administration has repeatedly accused China of being a major source of fentanyl, an allegation denied by the Chinese government. This dispute led the U.S. to link the fentanyl issue with trade policy and to impose an additional fentanyl-related tariff on Chinese imports.

[2]This refers to a key element of Trump's trade policy, whereby the United States applies the same tariff rate that another country imposes on American goods.

10% to 15%(Kanth, 2025). As the U.S. continued its tariff increases, China raised its own tariff rate to 34%. On April 9th, a further 50% was added, bringing the total to 84%. On April 11th, in direct response to the latest U.S. action, China increased its tariff rate again to 125%(Pham and Ruwitch, 2025). Finally, on April 17th, China filed a formal complaint and announced that it would refuse to enter trade negotiations under what it described as unfair conditions. Since then, China has maintained its tariff rate at 125%.

Table 4: 2025: Trump 2.0 Era U.S.–China Trade War Timeline

Date	**China's Tariff Increases**	**China's Measures**	**U.S. Tariff Increases**	**U.S. Measures**
Feb 1	None	None	10% (initial general tariff)	Declared "national emergency"; imposed 10% tariff on all Chinese imports; canceled de minimis exemption (<$800)
Feb 10	15% on LNG, 10% on gas and farm machinery	Tightened export controls on selected metals	None	None
Mar 4	10–15% on U.S. agricultural products	Expanded tariff coverage	Raised to 20% total	Second round of tariff increases
Apr 2	Maintained at 34%	None	Added 25% reciprocal tariff (total 54%)	Implemented reciprocal tariff policy
Apr 9	Added 50%, total 84%	None	Imposed countervailing duty; total 125%	Introduced countervailing duties
Apr 11	Increased to 125%	None	Added 20% fentanyl-related tariff (total 145%)	Justified by opioid crisis
Apr 17	Maintained at 125%	Filed WTO complaint; refused trade talks under "unfair" terms	Total raised to 245% (final peak)	Combined: 10% base + 25% reciprocal + 50% countervailing + 20% fentanyl