D. A. TSENOV ACADEMY OF ECONOMICS

FACULTY OF MANAGEMENT AND MARKETING

DEPARTMENT OF INTERNATIONAL ECONOMIC RELATIONS

Jingxin Hu

ECONOMIC AND TRADE COOPERATION BETWEEN CHINA AND BULGARIA WITHIN THE FRAMEWORK OF "16+1 COOPERATION" AND "ONE BELT, ONE ROAD"

ABSTRACT

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Scientific adviser: Prof. Galina Zaharieva, PhD

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I. GENERAL CHARACTERISTIC OF THE DISSERTATION

Research context and background

In the second decade of the 21st century, China has successively proposed the "Belt and Road" initiative and established the "16+1 cooperation" mechanism for Central and Eastern European countries. Against this background, the economic cooperation between China and Bulgaria has become increasingly close, which has important practical significance and academic value. As an EU member state and an important node in the Balkans, Bulgaria has outstanding geostrategic significance and is one of the key fulcrums for China to promote European connectivity and market expansion. The "Belt and Road" initiative covers about 64% of the world's population and 30% of the total economy (Huang, 2016). Bulgaria's active participation is expected to promote its own development with the help of Chinese investment and market opportunities, and also reflects the new regional interaction trend in the global industrial and trade pattern.

From the perspective of international economics, China-Bulgaria economic cooperation can be examined with the help of theoretical frameworks such as global value chain, regional cooperation and bilateral trade structure. The theory of global value chain (GVC) emphasizes the transnational division of labor and value-added of production. The depth of a country's embedding in the global production network will affect its gains from trade (Koopman, Wang, & Wei, 2014). The theory of regional economic cooperation focuses on the role of geographical proximity and institutional coordination in promoting trade and investment. For example, the classic gravity model points out that shortening distance and reducing institutional barriers can significantly increase bilateral trade flows (Anderson & Van Wincoop, 2003). Incorporating the "Belt and Road" initiative and the "16+1" cooperation into the above theoretical framework will help analyze how factors such as infrastructure connectivity and policy coordination reshape the trade pattern and value chain connection between China and Bulgaria.

Research gap

Although the research on the Belt and Road Initiative and China-Central and Eastern Europe cooperation has increased in recent years, the existing literature still pays insufficient attention to the individual cases of small Central and Eastern European countries such as Bulgaria. Previous studies often focused on China's cooperation with major economies, or

analyzed Central and Eastern European countries as a whole, ignoring the differences in economic structure and cooperation effects of individual countries. This has created an academic gap: we lack an in-depth understanding of the specific model and impact of small EU countries such as Bulgaria participating in cooperation under the Belt and Road Initiative and the 16+1 framework.

This dissertation focuses on this gap by analyzing the current situation, characteristics and changes in the positioning of China–Bulgaria economic and trade cooperation in the global value chain, thereby providing new case-based evidence for evaluating the regional economic impact of the Belt and Road Initiative.

Building on recent contributions to China's economic diplomacy, infrastructure connectivity and trade restructuring in Central and Eastern Europe (Garlick, 2019; Gruebler, 2021; Jakóbowski, 2018; Shang, Ponikvar, & Kejžar, 2016; Song & Pavlićević, 2019; Shi & Ye, 2021), this dissertation narrows the focus to the specific case of Bulgaria within the wider CEE region, providing a micro-level complement to predominantly macro-regional studies.

Research aim and objectives

This dissertation aims to construct a comprehensive analytical framework for China–Bulgaria economic and trade cooperation under the Belt and Road Initiative and the 16+1 Initiative. The specific objectives are as follows:

1) To review and systematize the theoretical foundations of how small open economies integrate into global value chains, regional economic integration, and foreign direct investment (FDI);

2) To build a multidimensional evaluation system for China–Bulgaria economic and trade cooperation—combining trade structure indicators, an extended gravity-model framework, and machine-learning methods—in order to diagnose the current status, structural constraints, and new drivers of bilateral trade and investment;

3) To propose pragmatic policy recommendations that take into account "hard connectivity", "soft connectivity", and relevant EU regulations so as to enhance the efficiency, resilience, and long-term sustainability of bilateral cooperation.

This paper intends to focus on the following six core tasks:

1) Sorting out the theoretical basis and academic progress of China-Bulgaria economic cooperation under the framework of the "Belt and Road" and "16+1",

clarifying the application and debate of mainstream paradigms such as regional integration, global value chain and institutional economics in this topic;

2) Systematically quantifying the evolution of bilateral trade structure, comparative advantage and intra-industry trade (IIT) between China and Bulgaria from 2015 to 2023, and capturing the dynamic characteristics of industrial complementarity and mirror division of labor;

3) Constructing and estimating structured gravity models and machine learning models such as random forest/XGBoost, and using explanation tools such as SHAP to identify key economic, geographical and institutional variables that affect bilateral trade and investment flows;

4) To explore the potential for further cooperation by using the empirical results to infer the room for deeper embedding of China–Bulgaria trade into regional and global value chains, and to identify promising higher value-added sectors and critical connectivity nodes along relevant transport corridors;

5) To assess major constraints and risks by analysing how logistics bottlenecks, recent EU regulatory initiatives (such as the FSR and CBAM) and broader geopolitical uncertainties may affect cooperation costs, the resilience of supply chains and the long-term sustainability of China–Bulgaria economic ties, mainly through a combination of model-based evidence and qualitative discussion;

6) Put forward policy recommendations, and develop an operational implementation path and evaluation indicator system around improving the efficiency of infrastructure connectivity, improving financial and institutional connections, and building a green and sustainable cooperation mechanism.

Thesis Statement

The decisive drivers of Sino–Bulgarian economic and trade cooperation arise from the joint effects of market demand, institutional facilitation, and infrastructure/compliance optimization, operating in asymmetric ways across exports and imports. On the export side, China's sales to Bulgaria are significantly driven by Bulgaria's population and income per capita; Schengen's border-free regime and unified procedures provide additional incremental gains. Scale economies and hub effects linked to Schengen gateways and sea–rail intermodal corridors help explain the observed positive distance elasticity. On the import side, China's purchases from CEE are more cost-sensitive and display an investment–trade amplification channel, with two-period lagged FDI exerting a positive effect. Overall, the IIT base remains

low and TCI has substantial room for improvement; advancing hard–soft connectivity—through port/corridor efficiency, compliance upgrades, and standards alignment—can meaningfully enhance the elasticity and quality of bilateral trade.

Methodology

Methodologically, the dissertation develops a multi-level analytical framework that combines macro-series analysis, structured econometric modelling and machine-learning techniques. It uses a combination of macro trade data analysis and micro case studies, employs the latest global input–output tables and bilateral trade and investment data, and constructs an indicator system reflecting the value-chain linkages and trade complementarity between China and Bulgaria. Advanced econometric models (including the Tweedie GLM gravity model) and network/ML methods (such as random forest and XGBoost, interpreted through SHAP) are used to quantify the impact of infrastructure projects and policy measures related to the Belt and Road Initiative on bilateral trade costs and investment flows.

In this way, the study combines historical-logic analysis, comparative statistics and hybrid econometric–ML tools to grasp the evolution of China–Bulgaria economic cooperation from a macro-series perspective, while capturing micro-structures and nonlinear relationships. This multi-level analytical framework provides solid support for testing the theoretical propositions on global value-chain integration, regional economic cooperation and institutional effects, and allows the dissertation to identify bottlenecks, evaluate effects and outline plausible future trends from a dynamic perspective.

Structure of the Dissertation

The paper consists of an introduction, three chapters, a conclusion and references: The introduction explains the research background and academic significance, clarifies the six core tasks and methodological framework, and defines the data source and technical route; The first chapter focuses on the "Belt and Road" and "16+1" mechanisms, sorts out the historical stages of the diplomatic and economic relations between the two countries, systematically reviews theoretical schools such as regional economic integration, global value chains, and new institutional economics, and compares the fit between China's foreign economic strategy and Bulgaria's "2030 National Development Plan", laying a theoretical and policy foundation for the empirical work in the following text;

Chapter 2 uses the data from UN Comtrade, EU Eurostat and China Customs from 2015 to 2023 to construct an indicator system including SITC RCA, TCI, TII and IIT,

quantifying the evolution of China-Bulgaria trade structure and comparative advantage. It then estimates trade elasticity through Tweedie GLM, examines the marginal impact of Schengen virtual items, green regulations and logistics costs on two-way trade, and uses SHAP to explain the machine learning model, revealing key driving factors such as population size, FDI, infrastructure and EU regulations.

Chapter 3, based on econometric models, machine learning analysis and cross-evidence of typical cases, first carefully depicts the structural challenges faced by China–Bulgaria economic and trade cooperation along the three main lines of trade, logistics and compliance. Second, it sets out realistic expectations and development prospects in light of long-term low IIT, logistics bottlenecks and stricter EU green compliance, while considering the upside from China's domestic demand upgrade, high-end capacity spillovers, the FDI trade multiplier and land-sea digital corridors. Third, it proposes actionable policy recommendations in the form of a four-dimensional solution—Black Sea–Danube Port–Rail Corridor, photovoltaic & energy-storage low-carbon parks, train–dry port collection–distribution networks and cultural–digital soft connectivity—using hard connectivity to reduce costs and soft connectivity to build trust, and leveraging Eurozone momentum and CBAM to co-create a green, mutually beneficial value chain that reshapes the resilience and depth of China–Bulgaria cooperation.

Scope and Limitations

This study uses Sino-Bulgarian and CEE-17 data for 2008–2023 and employs trade-structure indicators alongside a hybrid econometric–ML framework to map correlation patterns and mechanisms. The analysis is constrained by the absence of micro-level product and firm data; the use of proxy measures for infrastructure and compliance; potential endogeneity and informational overlap among FDI and institutional variables; and limited treatment of services trade, price dynamics, and exchange-rate shocks. Given these constraints—and the possibility of structural breaks associated with major macroeconomic events—the conclusions are primarily valid within the CEE-17/Sino-Bulgarian context. Accordingly, the policy implications should be viewed as correlational; causal extrapolation requires more granular data and quasi-causal designs for validation.

II. CONTENT OF THE DISSERTATION

INTRODUCTION

The introduction first outlines the historical context of China-Bulgaria economic and trade cooperation and its academic and practical significance within the frameworks of the Belt and Road Initiative and the 16+1 framework, pointing out the shortcomings of existing research in areas such as the perspective of small countries and bilateral empirical evidence. Building upon this foundation, the core research arguments are presented, defining the research object and content, clarifying the research objectives, six core tasks, and main research questions. The introduction also outlines the trade structure indicator system, the Tweedie-GLM gravity model, and random forest/XGBoost methods used, explaining the data sources and technical approaches, and briefly describing the paper's chapter structure and logical arrangement.

CHAPTER 1: THEORETICAL AND HISTORICAL FOUNDATIONS OF CHINA-BULGARIA ECONOMIC COOPERATION

1.1. Evolution of China-Bulgaria Relations Within the BRI and "16+1"

1.1.1. Brief historical overview of diplomatic and economic ties between China and Bulgaria

This section traces how China–Bulgaria relations evolved from sporadic contact to institutionalised cooperation. Before 1949, the two countries had almost no modern diplomatic exchanges, only limited indirect cultural links. In 1949, Bulgaria became one of the first states to recognise the People's Republic of China, and cooperation grew within the socialist bloc, before entering a period of stagnation in the 1960s–1970s due to China's non-membership in COMECON and the Sino–Soviet split. Since reform and opening-up, bilateral ties have been rebuilt on a gradually legal framework and, in the 21st century, further deepened through cultural platforms such as the Confucius Institute and, more recently, through the Belt and Road Initiative and the 16+1 framework, which have accelerated cooperation in infrastructure, energy, agriculture and emerging fields such as new energy and the digital economy.

1.1.2. Genesis and expansion of the Belt and Road Initiative (BRI)

This section sketches the BRI as both a continuation of China's earlier external economic practices and a formally upgraded national strategy. Proposed in 2013 and later anchored in the *Vision and Actions* document, the 13th Five-Year Plan and the CPC Constitution, the initiative links overseas infrastructure and corridor building with domestic goals such as

absorbing industrial overcapacity, promoting western development and advancing "Digital" and "Green" Silk Roads. Geographically, it has expanded from an initial Eurasian focus into a global network involving over 140 countries. In Central and Eastern Europe, however, Chinese trade and investment remain modest and are concentrated in non-EU Balkan states, while EU members such as Bulgaria have attracted fewer large BRI projects due to China's investment priorities and EU regulatory constraints.

1.1.3. Establishment and objectives of the "16+1" mechanism in relation to Bulgaria

This section outlines the establishment and evolution of the China–CEEC "16+1" mechanism and its specific implications for Bulgaria. Launched at the 2012 Warsaw Summit, the format provided credit lines, investment funds and corridor projects, and was later folded into the BRI, with Bulgaria among the first CEE states to sign a BRI MoU and to host a leaders' summit in Sofia in 2018, where the China–CEEC Global Partnership Center was proposed to help align projects with EU rules. Bulgaria views the mechanism as a way to leverage Chinese finance and markets for infrastructure and development, while China regards Bulgaria as a Black Sea and Balkan hub; yet EU procurement, competition, FDI-screening and cohesion-fund rules constrain large-scale, state-led infrastructure deals, pushing cooperation towards commercially oriented, low-sensitivity sectors such as agriculture, tourism and selected green-transition projects. Since 2023, the format has effectively shifted from "17+1" to "14+1" after Baltic withdrawals driven by limited economic gains and the EU's broader "de-risking" agenda, reducing the platform's marginal utility. For China–Bulgaria relations, this implies not a retreat of cooperation but a rebalancing towards EU27+1 and bilateral channels, with "selective re-engagement" in highly complementary but politically less sensitive domains.

1.2. Theoretical Basis: Regional Economic Integration and Development Theories

1.2.1. Regional integration theories and their relevance to Sino-Bulgarian cooperation

This section links regional integration theory and global value chain (GVC) theory to the analysis of China–Bulgaria cooperation. GVC theory, from Porter and Gereffi to Sturgeon, shows how production is fragmented and governed across borders, with core firms capturing high value and latecomer economies facing both opportunities and constraints in upgrading within global production networks. Regional integration theory has evolved from "old regionalism" to new and comparative regionalism, where regions are seen as socially constructed, multi-level and overlapping, with states and non-state actors jointly shaping

cooperation; Bulgaria's simultaneous participation in the EU and the China–CEEC format is a typical case of "overlapping regionalism". Empirical studies indicate that Bulgaria, as a small open economy, has increased but still limited GVC integration and remains concentrated in lower-tech, labour-intensive exports, leaving room for upgrading through better logistics, infrastructure and institutional quality. Under the BRI and 16+1 frameworks, Chinese investment in transport and logistics could reduce trade costs and deepen Bulgaria's insertion into Eurasian value chains, while EU rules, geopolitical risks and GVC fragmentation require diversification, regulatory compatibility and cautious management of dependence. Together, these theories suggest that successful Sino-Bulgarian cooperation must combine regional-integration logics with value-chain upgrading strategies.

1.2.2. Economic Development and FDI Theories: Comparative Advantage, Endogenous Growth, and New Institutional Economics

This section reviews three strands of theory linking FDI and development and applies them to China–Bulgaria cooperation. Comparative advantage and factor-endowment theories (Ricardo, Heckscher–Ohlin, Mundell) explain where FDI goes: capital and technology tend to flow to locations with cheaper labour, resources or privileged market access, and "vertical" FDI slices value chains so that each stage is located where it has a cost or access advantage. In the BRI context, Chinese firms' investment in Bulgaria reflects China's capital and capacity surplus on the one hand, and Bulgaria's location and access to the EU single market on the other. Endogenous growth theory (Romer, Lucas) highlights how FDI can generate long-run growth through capital deepening, technology spillovers, competition and human-capital upgrading—provided the host country has sufficient absorptive capacity. New institutional economics (North, Williamson) stresses that property-rights protection, contract enforcement and governance quality shape both the volume and quality of FDI, and can themselves be affected by it. For Sino-Bulgarian cooperation, this implies that only when comparative advantages are matched, skills and absorptive capacity are strengthened, and Bulgaria's EU-based institutional framework is effectively leveraged can BRI-related FDI translate into durable, mutually beneficial growth.

1.2.3. The Role of Infrastructure in Facilitating Trade and Investment

This section summarises how infrastructure facilitates trade and investment. In trade theory and gravity models, better transport, logistics, energy and digital networks lower "iceberg" trade costs by reducing effective distance and improving reliability; empirical work such as Limão and Venables shows that poor infrastructure sharply raises transport costs and

depresses trade, while upgrades function as a form of "natural" trade liberalisation. New economic geography and market-access models (Krugman; Redding & Venables) further highlight how infrastructure reshapes economic geography by changing market access and generating network externalities along corridors.

From an FDI perspective, infrastructure is a core locational advantage in Dunning's OLI paradigm: reliable transport, power, communications and logistics reduce operating costs and uncertainty, support participation in global value chains and raise expected returns. Empirical studies (e.g. Wheeler & Mody; Mensah & Traoré) find a robust positive link between infrastructure quality—including digital infrastructure—and FDI inflows. In the BRI and China–CEEC context, corridor-oriented investments are therefore expected to lower trade costs, enhance Bulgaria's market access and attractiveness for FDI, and strengthen trade–investment linkages under EU regulatory constraints.

1.3. Strategic Policy Framework and Drivers of Sino-Bulgarian Economic Cooperation

1.3.1. China's Foreign Economic Strategy under the BRI: Connectivity, Infrastructure, and Global Outreach

This section situates the Belt and Road Initiative (BRI) as the flagship of China's new-stage foreign economic strategy, upgrading the earlier "going out" approach into a connectivity- and infrastructure-centred global outreach. Since 2013, China has used transnational corridors, transport and energy projects, and digital networks to reduce bottlenecks, export surplus capacity and equipment, support western-region development and energy security, and link its own growth with that of partner countries. Parallel "international capacity cooperation" and the promotion of Chinese standards extend manufacturing value chains abroad via industrial parks and joint ventures.

To support these projects, China has built a multi-layered financial architecture—AIIB, the Silk Road Fund, policy-bank credit lines and RMB arrangements—that complements existing IFIs and lowers infrastructure-financing barriers in emerging economies. The BRI has gradually been aligned with "dual circulation" and expanded from hard infrastructure to the Digital and Green Silk Roads and other public-goods domains, while being connected to regional frameworks such as RCEP and the China–CEEC format. In Europe, projects like the Piraeus port and the Hungary–Serbia railway, together with early MoUs and cooperation platforms in countries including Bulgaria, illustrate the BRI's role in deepening China's economic presence. Overall, the BRI marks a shift from one-way resource seeking to more

networked, two-way and (in rhetoric) mutually beneficial cooperation, with an increasing emphasis on quality and sustainability.

1.3.2. Bulgaria's Development Agenda within the EU Framework: Opportunities and Constraints

This subsection examines how Bulgaria's "Bulgaria 2030" strategy operates within the EU framework. The plan pursues three overarching goals—higher growth, demographic revitalisation and reduced inequality—through five axes , with FDI, industrial upgrading and digital–green transition as core instruments. Low flat taxes, relatively cheap labour and access to the EU single market are used to attract mainly EU investment, while leaving room for emerging partners such as China in niches linked to smart industry, green economy and connectivity.

At the same time, EU rules create tight opportunity boundaries. Structural and recovery funds, market access and EU green/digital agendas offer resources and guidance, but fiscal rules, state-aid and competition law, the Foreign Subsidies Regulation, climate standards and digital-security policies constrain Bulgaria's freedom to conclude large, politically sensitive deals with third-country investors (as seen in rail tenders and 5G equipment). As a result, Bulgaria can deepen cooperation with partners including China only where projects are compatible with EU norms, meaning that its development agenda is shaped by a constant balancing act between making full use of EU membership and carefully exploiting the limited flexibility it has in external economic relations.

1.3.3. Theoretical Foundations of Policy Compatibility in Sino-Bulgarian Economic Cooperation

This subsection outlines policy compatibility as a way to understand Sino-Bulgarian cooperation under different systems. First, developmental alignment means that BRI priorities (connectivity, infrastructure, FDI) broadly match Bulgaria's needs under "Bulgaria 2030", while Bulgaria's EU membership, location and market access serve China's goal of deepening its European network. This complementarity is made operational through strategy-docking and MoUs rather than abstract slogans.

Second, institutional fit and path dependence stress that EU-embedded rules and China's state-led model can clash, but also be partially reconciled when China pledges to respect EU norms and Bulgaria seeks room for manoeuvre inside them. Third, flexible institutionalization—soft law, loose formats like "16+1", political declarations instead of hard

treaties—provides a pragmatic carrier for cooperation within EU red lines. Together, these three dimensions explain how Sino-Bulgarian economic ties can progress incrementally despite institutional differences.

CHAPTER 2: EMPIRICAL ANALYSIS OF CHINA-BULGARIA ECONOMIC COOPERATION

2.1 Analysis of China-Bulgaria bilateral trade structure and complementary indicators

2.1.1 Definition and economic significance of RCA TCI index

This subsection defines the Revealed Comparative Advantage (RCA) and Trade Complementarity Index (TCI), and explains their economic relevance for analysing Sino-Bulgarian trade.

The RCA index proposed by Balassa (1965) measures whether a country has a revealed export advantage in a given product. It is defined as the ratio between (i) the share of product k in country i's exports and (ii) the share of the same product in world exports:

$$RCA_{ik} = \frac{X_{ik}/X_i}{W_k/W}$$

If $RCA_{ik} > 1$, country i is relatively specialised in exporting product k; values below 1 indicate a revealed disadvantage. Economically, RCA treats observed trade patterns as a proxy for underlying comparative advantage and provides a simple metric for identifying sectors in which a country is competitively specialised.

The TCI captures how well the export structure of country i matches the import structure of country j. At the product level, Drysdale (1969) relates complementarity to the product of export and import RCAs,

$$TCI_{ij}^k = RCA_{ik}^x \times RCA_{jk}^m$$

where RCA_{jk}^m measures country j's revealed import need for product k. High values indicate that i's export strengths coincide with j's import demand. Aggregating across products with global-trade weights (W_k/W) yields a weighted complementarity index,

$$C_{ij} = \sum_k \frac{W_k}{W}(RCA_{ik}^x \times RCA_{jk}^m)$$

which emphasises matches in large world markets.

RCA, TCI and C_{ij} are widely used to map trade specialisation, identify "natural partners", and locate scope for value-chain cooperation and export upgrading. In this dissertation, they provide a quantitative basis for assessing structural complementarity and potential deepening of China–Bulgaria trade.

2.1.2 Analysis of Sino-Bulgarian Industry Complementarity and Structural Evolution Based on SITC-RCA

This subsection uses 2015–2023 SITC-based RCA indices for China's exports and Bulgaria's imports to assess bilateral industrial complementarity. The identification logic is straightforward: if China's export RCA>1 and Bulgaria's import RCA>1 in the same SITC section, China has a revealed export strength while Bulgaria shows a relatively high import preference, indicating strong supply–demand matching and high cooperation potential; if only one side has RCA>1, or both are <1, the structural basis for trade is weaker.

Table 1：Revealed Comparative Advantage (RCA) of China by SITC Section, 2015–2023

RCA China	2015	2016	2017	2018	2019	2020	2021	2022	2023
SITC0	0.3984	0.4348	0.4289	0.4270	0.4086	0.3533	0.3334	0.3284	0.3287
SITC1	0.1748	0.1929	0.1821	0.1779	0.1616	0.1131	0.1053	0.1166	0.1363
SITC2	0.1762	0.1782	0.1699	0.1872	0.1755	0.1435	0.1412	0.1754	0.1682
SITC3	0.1177	0.1442	0.1647	0.1549	0.1588	0.1426	0.1191	0.1238	0.1631
SITC4	0.0575	0.0515	0.0670	0.0944	0.1033	0.0980	0.1111	0.1500	0.1741
SITC5	0.5204	0.5154	0.5578	0.5892	0.5618	0.5237	0.6366	0.7056	0.6413
SITC6	1.3612	1.3491	1.3170	1.3310	1.3695	1.3860	1.2631	1.3933	1.4150
SITC7	1.2786	1.2618	1.2948	1.3409	1.3132	1.3089	1.3751	1.3848	1.3268
SITC8	2.0322	1.9998	1.9959	1.9391	1.9091	1.8424	1.8985	1.9352	1.8916
SITC9	0.0186	0.0459	0.04109	0.04656	0.1555	0.2191	0.2527	0.2914	0.3418

Source: Author's own calculations.

Table 2：Revealed Comparative Advantage (RCA) of Bulgaria by SITC Section, 2015–2023

RCA Bulgaria	2015	2016	2017	2018	2019	2020	2021	2022	2023
SITC0	1.1623	1.2050	1.1889	1.1794	1.1901	1.2177	1.1823	1.1152	1.3067
SITC1	1.6752	1.7159	1.5886	1.7392	2.0208	2.1929	2.0528	1.8213	2.0940
SITC2	2.4328	2.0555	2.4086	2.4490	2.1722	2.5738	1.9668	2.2109	1.9359
SITC3	1.4942	1.3994	1.4908	1.1231	1.1719	0.9960	1.0550	1.1668	1.0055
SITC4	0.6895	0.6627	0.6082	0.6980	0.7479	0.9272	1.0456	2.2800	1.5761
SITC5	1.2381	1.2737	1.2273	1.1864	1.1903	1.1852	1.2050	1.1106	1.0875
SITC6	1.2799	1.3911	1.3283	1.3527	1.3555	1.3480	1.3156	1.2979	1.3507
SITC7	0.6859	0.6896	0.6656	0.7136	0.7066	0.7065	0.7364	0.7348	0.8136
SITC8	0.5651	0.6560	0.6358	0.6606	0.6698	0.6865	0.6947	0.6538	0.7313
SITC9	0.8615	0.8076	0.7818	0.8905	0.9765	0.8692	0.8599	0.6916	0.6464

The results show that SITC 6 (manufactured goods classified chiefly by material) is the core area of overlapping advantages. China's export RCA for SITC 6 is stably around 1.3–1.4, while Bulgaria's import RCA is also above 1, pointing to robust Chinese capacity in textiles, basic chemicals, metals and related products, matched by Bulgaria's sustained import dependence. Other categories (SITC 0–2, 7, 8) reveal either one-sided advantage or only emerging, still modest, complementarity.

Over time, China's manufacturing RCA pattern shifts from low-end, labour-intensive products (SITC 8, slightly declining) towards machinery and transport equipment (SITC 7, rising), with SITC 6 remaining solid. Bulgaria's import RCA moves away from primary products (SITC 2, 3) towards machinery and miscellaneous manufactures (SITC 7, 8), consistent with industrial upgrading and consumption expansion.

Overall, differences in factor endowments and the institutional setting jointly shape these RCA patterns, underpinning a stable "manufactures–raw materials/agri-products" exchange structure while opening space for future upgrading into more sophisticated manufacturing and infrastructure-related cooperation.

2.1.3 Dynamic evaluation of China-Bulgaria trade complementarity based on TCI index

The Trade Complementarity Index (TCI) measures how well one country's exports match another's imports; high values indicate "natural partners". Since 2015, China–Bulgaria TCI values have been high, confirming a pattern in which China mainly exports manufactures and Bulgaria supplies primary goods .

Table 3: Trade Complementarity Index (TCI) by SITC Section for China and Bulgaria, 2015–2023

TCI	2015	2016	2017	2018	2019	2020	2021	2022	2023
SITC0	0.463	0.524	0.510	0.504	0.486	0.430	0.394	0.366	0.430
SITC1	0.293	0.331	0.289	0.309	0.327	0.248	0.216	0.212	0.286
SITC2	0.429	0.366	0.409	0.459	0.381	0.369	0.278	0.388	0.326
SITC3	0.176	0.202	0.246	0.174	0.186	0.142	0.126	0.145	0.164
SITC4	0.040	0.034	0.041	0.066	0.077	0.091	0.116	0.342	0.274
SITC5	0.644	0.657	0.685	0.699	0.669	0.621	0.767	0.784	0.697
SITC6	**1.742**	**1.877**	**1.749**	**1.800**	**1.856**	**1.868**	**1.662**	**1.808**	**1.911**
SITC7	**0.877**	**0.870**	**0.862**	**0.957**	**0.928**	**0.925**	**1.013**	**1.018**	**1.080**
SITC8	**1.149**	**1.312**	**1.269**	**1.281**	**1.279**	**1.265**	**1.319**	**1.265**	**1.383**
SITC9	0.016	0.037	0.032	0.041	0.152	0.191	0.217	0.202	0.221

Complementarity is strongest in manufactures. For SITC 7 (machinery and transport equipment), TCI has risen to above 1 since 2021, while SITC 7 now accounts for more than half of Bulgaria's imports from China. SITC 6 (manufactures by material) and SITC 8 (miscellaneous manufactures) also record TCI well above 1, reflecting Chinese supply of basic materials and light industrial goods and Bulgaria's sustained import demand .

The weighted complementarity index C_{ij}, which aggregates product-level TCI using world trade shares, increases from 0.8233 in 2015 to 0.9229 in 2023. This shows that matching is improving in large global product groups such as machinery and major consumer and intermediate manufactures. Overall, China and Bulgaria are structurally complementary rather than strongly competitive, and current trade volumes still fall below the potential implied by their high and rising TCI and C_{ij}.

2.2 CEE-China trade integration and intra-industry trade: indicator system, evolution trajectory and structural drivers

2.2.1 Trade integration and intra-industry trade indicator framework: theoretical basis and application of TII and IIT

The Trade Integration Index (TII) measures how intensive bilateral trade is relative to a neutral benchmark. It compares the share of country *i*'s exports going to partner *j* with *j*'s share in world imports:

$$TII_{ij}^t = \frac{X_{ij}^t / M_j^t}{X_i^t / M_w^t}$$

A value above 1 indicates that *i* trades with *j* more intensively than implied by *j*'s weight in world trade, while a value below 1 signals relatively weak ties and untapped potential. Unlike gravity models, which explain trade flows with GDP, distance and other variables, TII is a normalized *outcome* indicator of integration. Combined with RCA, it helps distinguish *what* each country is competitive in (RCA) from *with whom* those advantages are actually realized (TII). Persistent TII<1 for a pair of countries suggests scope to deepen trade, especially where RCA patterns are complementary.

Intra-industry trade (IIT) captures two-way trade within the same industry, in contrast to classical inter-industry trade. The Grubel–Lloyd index for industry *i* is:

$$GL_i = 1 - \frac{|X_i - M_i|}{X_i + M_i},$$

ranging from 0 (pure one-way trade) to 1 (exports ≈ imports). Horizontal IIT refers to trade in similar-quality varieties; vertical IIT reflects trade in different quality/price segments of the same product group. In this chapter, TII (China–CEEC, with a focus on Bulgaria and Russia as a benchmark) and IIT/GL indices are used jointly to assess the depth of China–Bulgaria integration and to identify whether trade growth is driven mainly by inter-industry specialization or by rising intra-industry trade, that is, by increasing two-way trade within key manufacturing sectors..

2.2.2. Evolution of Central and Eastern European countries' imports from China and analysis of TII changes in 2015–2023

From 2015–2023, Central and Eastern European countries' (CEECs) imports from China grew steadily, with only a brief slowdown in 2020. China's early post-COVID recovery and its role as a key supplier of medical goods and electronics meant that most CEECs even recorded positive import growth in 2020, reinforcing China's position in regional supply chains. The rebound in 2021 and the new highs reached in 2022–2023 raised bilateral TIIs, signalling a gradual deepening of trade integration.
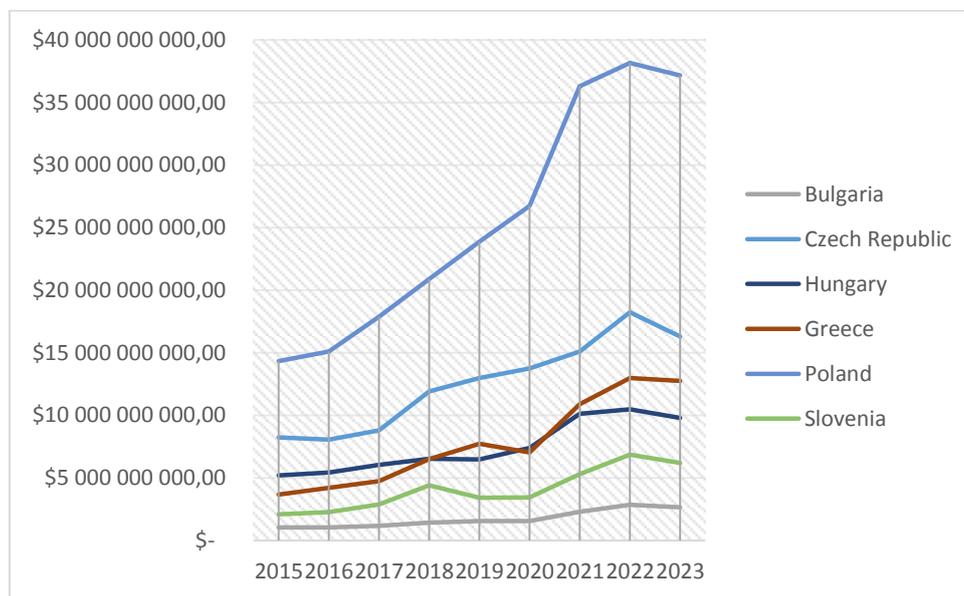
Figure 1: Trends in Imports from China by Selected Central and Eastern European Countries (2015–2023)

Source: United Nations Statistics Division. (2025). UN Comtrade

Within the region, dynamics are highly differentiated. Poland, as the largest CEEC economy and rail hub of the China–Europe Express, has seen imports from China more than double, driven mainly by machinery and electronics routed via overland corridors. The Czech Republic's manufacturing base relies increasingly on Chinese intermediate goods, while Hungary's surge in imports is closely linked to Chinese FDI in batteries, electronics and the Hungary–Serbia railway—an "investment-driven imports" pattern. Greece's jump reflects the role of Piraeus, upgraded by Chinese capital into a major Mediterranean gateway, as well as large orders placed with Chinese yards. Slovenia's imports have risen fast due to Koper's transit function and substitution of high-cost EU inputs with Chinese components. Russia is an outlier: sanctions after 2022 forced massive import substitution toward China, producing an extreme increase in both imports and TII.

Bulgaria's imports from China also increased, but more moderately. As a small, EU-oriented economy with limited Chinese FDI and no flagship BRI project comparable to Piraeus or Debrecen, Bulgaria has not experienced a trade "jump", yet retains clear upside potential if logistics links, e-commerce and industrial cooperation with Chinese firms deepen under the broader China–EU framework.

2.2.3. Analysis of CEE imports to China, TII changes and IIT structural constraints, 2015–2023

Between 2015 and 2023, trade integration between China and CEE countries clearly deepened but remained moderate. The regional average Trade Integration Index (TII) rose from about 0.43 to 0.56, showing that China's weight in CEE trade has increased, yet overall ties are still below the "neutral" benchmark of 1. At country level, three patterns are visible: a steady-rise group (Greece, Poland, Russia, Serbia) where TII grows fast on the back of energy trade, BRI flagships (e.g. Piraeus), or China–Europe rail corridors; a fluctuating group (e.g. Slovenia, Croatia), whose TII spikes with individual projects; and a declining group (the Baltic states), where political cooling and withdrawal from "16+1" have reduced China's trade role.

Table 4: Trade Integration Index (TII) between China and Central & Eastern European Countries, 2015–2023

COUNTRY	2015	2016	2017	2018	2019	2020	2021	2022	2023
ALBANIA	0.708	0.812	0.662	0.703	0.764	0.708	0.501	0.573	0.846
BOSNIA AND HERZEGOVINA	0.047	0.052	0.058	0.073	0.078	0.082	0.069	0.082	0.122
BULGARIA	0.254	0.273	0.263	0.294	0.309	0.296	0.328	0.336	0.331

CROATIA	0.341	0.349	0.364	0.365	0.375	0.402	0.384	0.351	0.378
CZECH REPUBLIC	0.416	0.424	0.417	0.498	0.544	0.537	0.470	0.527	0.477
ESTONIA	0.431	0.460	0.447	0.402	0.371	0.326	0.276	0.235	0.236
HUNGARY	0.407	0.440	0.447	0.431	0.414	0.438	0.482	0.449	0.441
GREECE	0.552	0.661	0.663	0.772	0.935	0.849	0.934	0.906	0.966
LATVIA	0.516	0.579	0.552	0.485	0.462	0.407	0.328	0.251	0.262
LITHUANIA	0.306	0.353	0.383	0.374	0.357	0.364	0.326	0.222	0.271
MONTENEGRO	0.466	0.355	0.392	0.459	0.294	0.317	0.215	0.402	0.297
NORTH MACEDONIA	0.096	0.099	0.078	0.090	0.107	0.121	0.129	0.126	0.157
POLAND	0.538	0.599	0.633	0.603	0.727	0.704	0.717	0.728	0.730
ROMANIA	0.322	0.346	0.342	0.356	0.355	0.373	0.379	0.381	0.393
RUSSIA	1.353	1.348	1.271	1.544	1.512	1.461	1.517	2.142	2.861
SERBIA	0.162	0.168	0.190	0.218	0.290	0.415	0.437	0.362	0.454
SLOVAKIA	0.272	0.286	0.257	0.211	0.242	0.239	0.286	0.262	0.250
SLOVENIA	0.575	0.637	0.715	0.944	0.672	0.634	0.715	0.787	0.674

Source: Author's own calculations

Bulgaria belongs to the "slow-rise, low-level" type. Its TII with China only increased from 0.25 in 2015 to 0.33 in 2023. This reflects gradual integration constrained by structural factors: a small, EU-oriented economy with over 70 % of imports from EU partners; limited Chinese FDI and no large BRI-type anchor projects; and logistics still dominated by sea and road, while rail links with China remain marginal. EU "de-risking" and investment screening further raise entry costs for Chinese capital and technology, keeping Bulgaria's China exposure cautious and incremental.

Intra-industry trade (IIT) indicators confirm these limits. The overall Grubel–Lloyd index for China–Bulgaria trade is only 0.31, meaning flows are still dominated by inter-industry exchange: Bulgaria mainly exports agricultural, resource and low-processed goods, while importing machinery, electronics and other manufactures. A few SITC groups (oils and fats, some material-based and miscellaneous manufactures) show higher IIT, but narrow Bulgarian specialization and large scale asymmetry prevent broad, two-way value-chain embedding. As a result, Bulgaria's TII is rising, yet on a thin industrial base, and future deepening will depend on export upgrading, product diversification and improved transport connectivity.

2.3 Dual-track empirical study of gravity model and machine learning: method framework, estimation results and comparative analysis

2.3.1 Theoretical and empirical design of gravity model and machine learning

Within the Belt and Road and 16+1 frameworks, China's trade with CEE has deepened, so the gravity model is used to quantify China–Bulgaria trade potential. In its basic form,

bilateral trade increases with partners' economic size and decreases with distance; the equation is estimated in log form.

This study builds a panel gravity model for China and its Eastern European partners. Dependent variables are China's exports to country *j* and imports from country *j*. Key regressors include lagged GDP per capita of both sides (market size), partner population, bilateral distance, partner FDI stock, unemployment and inflation, plus dummies for EU and Schengen membership. These institutional variables capture whether integration into the EU market facilitates China–Bulgaria trade.

To handle heteroskedasticity and zero trade flows, the paper uses a GLM with Tweedie distribution and log link. This keeps trade values non-negative, is robust to variance misspecification and allows maximum-likelihood estimation on all observations. Coefficients on logged variables are interpreted as elasticities; dummy coefficients show percentage shifts in trade associated with EU or Schengen status.

The specific model settings are as follows:

$$E(export_{ij}) = exp(\beta_0 + \beta_1 lnGDPpc_{j(t-1)} + \beta_2 lnPop_{jt} + \beta_3 lnDist_{ij} + \beta_4 lnFDI_{j(t-2)} + \beta_5 Unemp_{jt} + \beta_6 Inf_{jt} + \beta_7 lnGDPpc_{i(t-1)} + \beta_8 EU_{jt} + \beta_9 Schengen_{jt})$$

$$E(import_{ij}) = exp(\beta_0 + \beta_1 lnGDPpc_{j(t-1)} + \beta_2 lnPop_{jt} + \beta_3 lnDist_{ij} + \beta_4 lnFDI_{j(t-2)} + \beta_5 Unemp_{jt} + \beta_6 Inf_{jt} + \beta_7 lnGDPpc_{i(t-1)} + \beta_8 EU_{jt} + \beta_9 Schengen_{jt})$$

In parallel, two ensemble tree methods – Random Forest and XGBoost – are applied with the same covariates. They do not impose linear functional forms, capture nonlinearities and interactions, and provide variable-importance scores. Together, the gravity estimates offer interpretable elasticities, while the machine-learning models act as robustness and prediction checks on the determinants of China–Bulgaria trade.

2.3.2. Tweedie-GLM gravity model estimation and interpretation of two-way trade elasticity

For exports, diagnostics show a satisfactory fit. Partner population and lagged GDP per capita have clear positive elasticities, confirming the role of market size and income, while unemployment has a strong negative impact. Schengen membership almost doubles predicted exports, highlighting the effect of border-free logistics. Distance enters with a positive sign, suggesting that more distant CEE hubs with China–Europe rail corridors or major ports (Poland, Greece) enjoy scale economies that offset geographic frictions.

Table 5: Tweedie-GLM Estimation Results for the Export Equation

variables	coefficient	STD.ERROR	z-value	p-value	95% confidence interval	interpretation
ln_gdp_pc_scaled_lag1	**0.4468**	0.076	5.873	0.000	[0.298, 0.596]	**Significant positive impact**
ln_population_partner_scaled	**0.8827**	0.056	15.650	0.000	[0.772, 0.993]	**Significant positive impact**
ln_distance_scaled	**0.1450**	0.027	5.314	0.000	[0.091, 0.198]	**Significant positive impact**
ln_fdis_partner_scaled_lag2	−0.0616	0.072	−0.860	0.390	[−0.202, 0.079]	not statistically significant
unemployment_rate_scaled	**−0.4038**	0.043	−9.420	0.000	[−0.488, −0.320]	**Significant negative impact**
inflation_scaled	0.0371	0.028	1.303	0.193	[−0.019, 0.093]	not statistically significant
ln_gdp_pc_china_scaled_lag1	0.0345	0.043	0.810	0.418	[−0.049, 0.118]	not statistically significant
eu_membership	0.0667	0.125	0.534	0.593	[−0.178, 0.311]	not statistically significant
schengen	**0.6947**	0.080	8.667	0.000	[0.538, 0.852]	**Significant positive impact**

Source: Tweedie regression output.

The import equation has lower explanatory power but its coefficients outline a distinct mechanism. Partner GDP per capita shows a marked negative elasticity: as CEE economies grow richer and lose cost advantages, their exports to China contract. Lagged FDI stock has a large positive effect, consistent with an "invest first, export later" pattern in which new capacity later supplies the Chinese market. Distance, EU and especially Schengen dummies are all significantly positive, confirming that long-distance but institutionally integrated hubs dominate China's sourcing in the region. Overall, the Tweedie-GLM captures asymmetric determinants on the export and import sides and provides concise elasticities for the subsequent policy discussion.

Table 6: Tweedie-GLM import equation estimation results

variables	coefficient	STD.ERROR	z-value	p-value	95% confidence interval	interpretation
ln_gdp_pc_scaled_lag1	**−0.7503**	**0.116**	**−6.450**	**0.000**	**[−0.978, −0.522]**	**Significantly negative**
ln_population_partner_scaled	0.0134	0.107	0.125	0.901	[−0.196, 0.223]	not statistically significant
ln_distance_scaled	**0.4365**	**0.059**	**7.434**	**0.000**	**[0.321, 0.552]**	**Significantly positive**

ln_fdis_partner_scaled_lag2	1.0291	0.115	8.912	0.000	[0.803, 1.255]	Significantly positive
unemployment_rate_scaled	−0.2301	0.079	−2.927	0.003	[−0.384, −0.076]	Significantly positive
inflation_scaled	0.1328	0.058	2.294	0.022	[0.019, 0.246]	Significantly positive
ln_gdp_pc_china_scaled_lag1	0.2407	0.066	3.623	0.000	[0.110, 0.371]	Significantly positive
eu_membership	0.9132	0.256	3.568	0.000	[0.412, 1.415]	Significantly positive
schengen	1.2680	0.194	6.543	0.000	[0.888, 1.648]	Significantly positive

Source: Tweedie regression output.

2.3.3. Nonlinear prediction with random forest and XGBoost: model performance, residual structure and SHAP interpretation

This subsection introduces a nonlinear prediction framework for China's trade with CEE-17 using Random Forest and XGBoost, based on the same gravity-type covariates as the Tweedie-GLM (income, population, distance, lagged FDI, inflation, unemployment, China's GDP per capita, EU and Schengen dummies). Panel data for 2008–2023 are split into training, validation and test sets, and hyper-parameters are tuned to control overfitting. For exports, Random Forest achieves the best predictive accuracy, while XGBoost performs slightly worse but remains robust. For imports, XGBoost marginally outperforms Random Forest. Residual diagnostics show that Random Forest errors are close to symmetric and concentrated around zero, whereas XGBoost displays heavier tails and a tendency to over-predict small flows and under-predict very large ones.
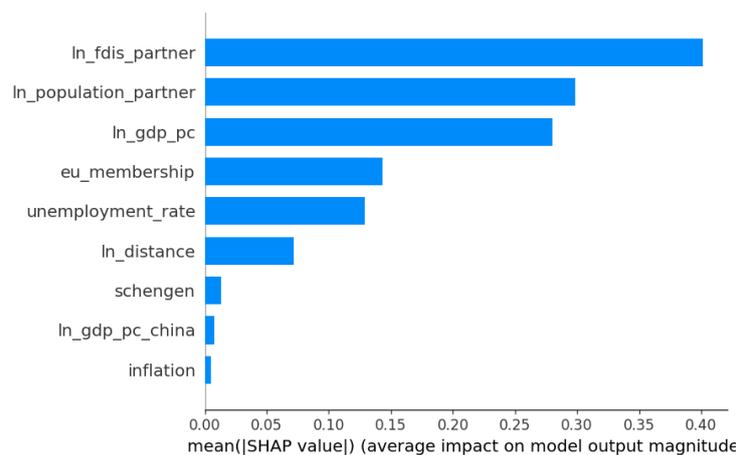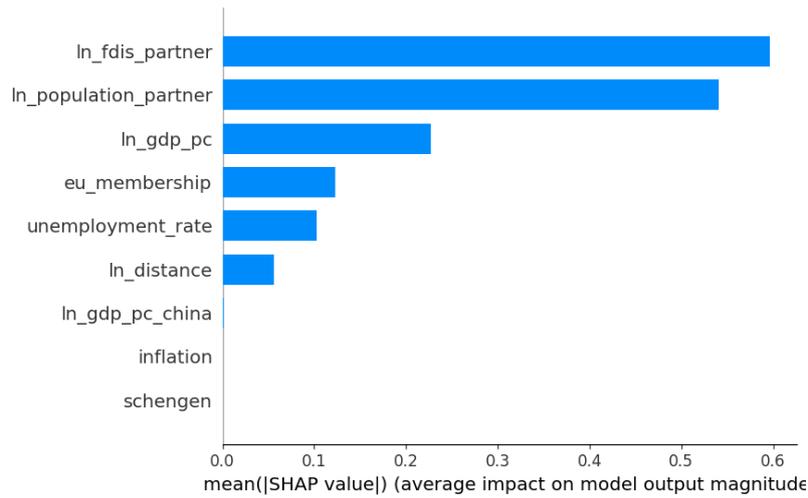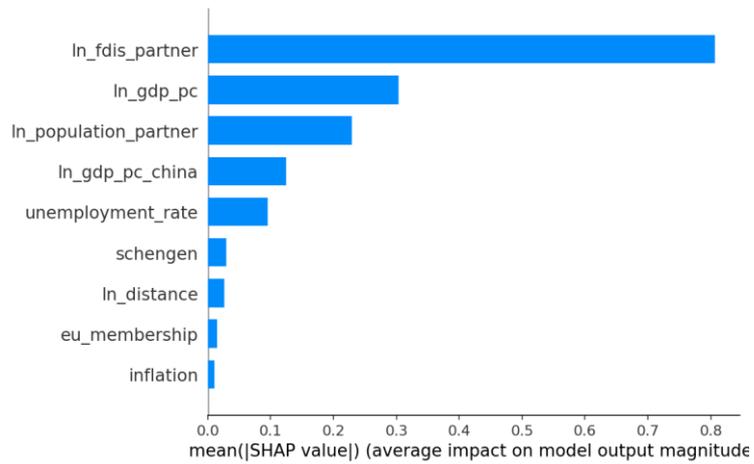

Figure 2: SHAP Feature Importance for the XGBoost Export Model (Mean |SHAP Value|)
Source: XGBoost Model Output Results
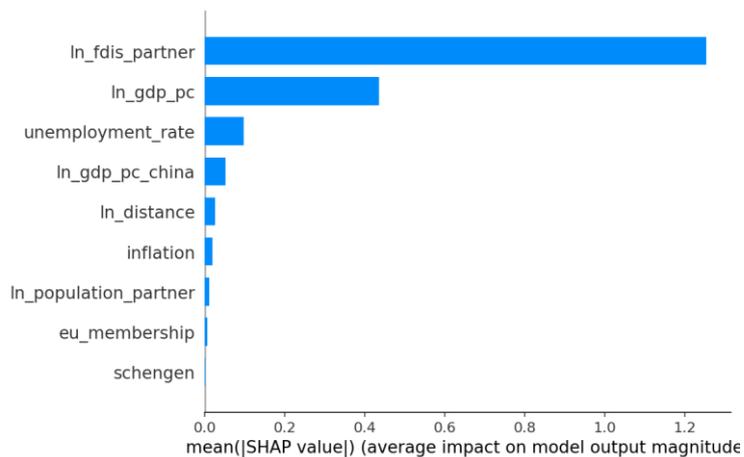
Figure 3: SHAP Feature Importance for the RF Export Model (Mean |SHAP Value|)

Source: Random Forest Model Output Results

Figure 4: SHAP Feature Importance for the XGBoost Import Model (Mean |SHAP Value|)

Source: XGBoost Model Output Results

Figure 5: SHAP Feature Importance for the RF Import Model (Mean |SHAP Value|)

Source: Random Forest Model Output Results

SHAP global importance measures confirm and refine the gravity results. In both algorithms, lagged FDI is the most influential predictor, followed by partner population and income, indicating a strong "investment–trade complementarity" combined with market-size and income effects. Institutional variables (EU, Schengen) and unemployment also matter but rank below these core drivers, while distance and inflation provide only limited extra information once nonlinear interactions are captured. Overall, the machine-learning models improve out-of-sample fit and, via SHAP, corroborate the central role of FDI, market size and institutional integration in shaping China–CEE trade, while revealing nonlinearities and tail effects that standard gravity estimations cannot capture.

CHAPTER 3: CHALLENGES, PROSPECTS, AND POLICY RECOMMENDATIONS

3.1 Structural Constraints: Trade Imbalances, Logistics Bottlenecks, and Regulatory☐ Compliance Risks

3.1.1 Imbalance in trade structure and IIT constraints

The intra-industry trade (IIT) index between China and Bulgaria is only 0.3125, indicating that bilateral trade is dominated by vertical inter-industry exchange rather than differentiated two-way flows. Disaggregated values show a "raw-materials-for-finished-goods" pattern: IIT for agricultural and other raw materials is close to zero, and for machinery remains low because Bulgaria imports Chinese equipment and vehicle parts but exports few components.

This reflects mirror comparative advantage. China is competitive in machinery and consumer goods, while Bulgaria's strengths lie in copper, vegetable oils and similar primary products. With a small market—around 0.15% of China's exports to the EU—Chinese firms have little incentive to develop Bulgaria-specific varieties or local supplier networks, so trade is locked into "raw materials out, finished goods in".

Econometric results echo this diagnosis. In the Tweedie gravity model, partner population and per capita GDP have the largest, highly significant elasticities, while lagged FDI and EU membership are insignificant, implying that exports are driven mainly by Bulgaria's final demand rather than by industrial chain embedding. In the machine-learning models, FDI, population and income dominate feature importance, whereas distance and Schengen status add little explanatory power. Overall, Bulgaria functions as a raw-material supplier and terminal consumer market with weak mid-stream processing links. Without targeted investment in local processing and component production under the BRI and "16+1"

frameworks, China–Bulgaria trade is likely to remain stuck in a low-IIT, one-way vertical structure.

3.1.2 Logistics and infrastructure bottlenecks

Bulgaria's logistics system faces a "triple constraint" of over-reliance on sea transport, weak rail links and the absence of a genuine rail–maritime hub. In 2023, 70.4% of China's exports to Bulgaria moved by sea, while rail accounted for only 0.49%. Once Black Sea routes are disrupted by conflict-related congestion or freight spikes, the whole chain suffers delay and cost shocks, and Varna/Burgas lack the depth and capacity to function as regional transshipment centres.

On land, rail density and quality are far below those of Central European hubs. Much of the network is single-track, speed-restricted and built in the 1970s, so commercial speeds are low and schedules unreliable. Unlike Małaszewicze in Poland or the Budapest hub in Hungary, Bulgaria has no integrated dry port with unified customs and seamless rail–road transfer, and therefore cannot capture China–Europe block-train scale economies. In the gravity and SHAP results, this shows up as very low marginal contributions of distance, EU and Schengen dummies: institutional advantages are largely cancelled by hard-infrastructure gaps.

Road infrastructure reinforces these weaknesses. Motorway density is below the EU average, a large share of national roads require major repair, and accident rates are among the highest in the Union. The 2023 Logistics Performance Index score (3.2, vs 3.6–3.7 for Poland and Greece) confirms customs delays and mediocre infrastructure. Together, these bottlenecks limit Bulgaria's role as a reliable corridor for China–CEE trade, depress the share of rail, and weaken its ability to attract high-value, intra-industry flows, thereby constraining both IIT and TII.

3.1.3 EU Regulation, Geopolitics and Green Compliance Risks

Since 2019 the EU has built a dense regime of FDI screening, the Foreign Subsidies Regulation (FSR), the Carbon Border Adjustment Mechanism (CBAM) and the Minimum Wage Directive, all framed by a broader "economic security" and de-risking strategy. For Chinese firms this means higher and more uncertain compliance costs on three fronts: foreign funding transparency, carbon and environmental reporting, and social and labour standards.

The first FSR in-depth probe against CRRC Qingdao Sifang's bid to supply 20 electric push-pull trains to Bulgaria shows how this regime works in practice: even commercially

attractive, state-backed offers can be forced into withdrawal once subsidy scrutiny is triggered. For small host economies such as Bulgaria, this creates a "double filter": national openness is no longer sufficient, as large projects must also survive EU-level review.

In our gravity estimates, EU membership no longer yields a significant positive export effect once income, population and Schengen are controlled for, while Schengen remains strongly positive. Combined with fat-tailed residuals in GLM and XGBoost models, this suggests that new green and security-driven rules have become a form of hidden trade cost. Future China–Bulgaria cooperation must therefore internalise "green compliance risk" as a core constraint alongside traditional market size and distance factors.

3.2.1 Export Demand, Domestic Consumption Upgrading, and High-End Import Dividends

Gravity and machine-learning results in this study show that China's per capita GDP has a significant positive elasticity on imports from CEE, confirming that rising income and a growing middle class are key drivers of high-end import demand. As households move from basic to quality-oriented consumption, imported food, cosmetics, healthcare products and durable goods are no longer niche luxuries, but routine options in middle-class lifestyles.

Official statistics indicate that China has ranked as the world's second-largest importer for more than a decade, and per capita disposable income almost doubled between 2015 and 2024. This combination of "income growth + structural upgrading" is further amplified by cross-border e-commerce, bonded warehouses and streamlined customs procedures, which lower search and logistics costs for niche foreign brands. Platforms such as Tmall Global and integrated logistics networks have dramatically reduced the fixed costs of market entry for small exporters from Central and Eastern Europe.

For CEE economies, including Bulgaria, this generates a clear "high-end import dividend". On the demand side, Chinese consumers show rising interest in origin-labelled wines, organic foods, wellness products and distinctive manufactured goods. On the supply side, China's own overcapacity and low-carbon transition in sectors such as steel and automotive create incentives to align domestic upgrading with high-quality inputs and components from Europe. Taken together, the empirical elasticity of China's per capita GDP, the expansion of cross-border e-commerce and the middle-class consumption shift jointly explain why import demand for higher-quality goods from CEE is likely to remain structurally strong in the medium term.

3.2.2 Investment–Trade Complementarity Amplification Effect

Econometric and SHAP results show that FDI is the single strongest driver of China–CEE trade. In the Tweedie-GLM import equation, lagged FDI has the largest positive elasticity, and in both Random Forest and XGBoost it ranks first in global SHAP importance. When CEE economies attract more Chinese (or global) FDI, their exports to China rise disproportionately, confirming a clear "invest first, export later" pattern.

The mechanism is vertical integration plus knowledge spillovers: when Chinese multinationals build plants or acquire firms in CEE, they bring capital, technology and export channels, expand local capacity and then use that base to ship components, finished goods or green-energy products back to China and the wider EU. CATL's battery gigafactory in Debrecen, for example, relies on inputs and know-how from China while Hungary exports high-value cells to European carmakers.

Policy tools further amplify this complementarity. Industrial parks under the 16+1 framework, policy-bank finance from Exim Bank and Sinosure, and growing RMB settlement all tie outward projects to cross-border goods flows and lower transaction risk. For Bulgaria and its neighbours, attracting targeted Chinese FDI in mid-stream manufacturing and renewables is therefore not a substitute for trade, but the most effective way to climb China–CEE value chains and turn investment into sustained export growth.

3.2.3 Logistics Corridors and Digital Infrastructure Upgrades

Under the Belt and Road framework, CEE is experiencing a dual upgrade of overland corridors and digital infrastructure, which reshapes how China–Europe trade is organized. The rapid expansion of China–Europe freight trains has turned rail into a "third pillar" between sea and air, combining lower carbon emissions with stable transit times and creating new hub opportunities along the southern routes.

For China–Bulgaria cooperation, the land–sea corridor via Piraeus and the Balkans is key. Trains and trucks moving from the Greek port through North Macedonia, Serbia and Hungary can easily extend to Bulgaria, where Black Sea and Danube ports offer natural interfaces with the inland rail network. If Bulgaria accelerates railway modernization, expands intermodal capacity and develops digital port platforms, it can shift from a peripheral destination to a genuine transit hub for China–EU cargo, especially as geopolitical risks weaken the traditional northern route.

In the digital sphere, Bulgaria still lags the EU average in connectivity, e-government and enterprise digitalisation, but this gap also represents catch-up potential. China's Digital Silk Road experience in 5G, cloud services and smart logistics, together with existing ICT and education cooperation (e.g. Huawei training centres), provides a realistic basis for scalable projects. As long as future cooperation remains compatible with EU security and data-protection rules, Bulgaria can use Chinese technology and financing to speed up digital upgrades, reinforcing its role as both a logistics and data hub in Southeast Europe.

3.3 Policy Recommendations: Logistics Networks, Compliance Strategies, and Cultural Exchange

3.3.1 Interconnectivity and Hub-and-Spoke Logistics Networks

Building on the gravity / SHAP results and Section 3.1–3.2, this subsection turns Bulgaria's logistics bottlenecks into a hub-and-spoke strategy that combines "hard" and "soft" connectivity.

First, upgrade Black Sea gateway ports. Varna and Burgas should move from simple destination ports to regional hubs by expanding berth depth and handling capacity, building port-based logistics parks and improving rail–road links. Drawing on the Piraeus experience, selective Chinese participation in terminal operation and hinterland logistics could raise efficiency while respecting EU rules.

Second, modernise rail corridors. Priority should go to the Varna–Sofia–Serbia border axis and its connection to the Belgrade–Budapest line, creating a continuous Black Sea–Balkan–Danube–Central Europe corridor that converts Bulgaria's "medium distance" into real time- and cost advantages.

Third, diversify Eurasian routes. By linking Varna/Burgas to the Trans-Caspian "Middle Corridor" and developing a 16+1 logistics centre in Sofia, Bulgaria can serve as a southern land–sea alternative to Russia-centred routes, enhancing resilience of China–Europe supply chains.

Finally, strengthen institutional and financial coordination: one-stop customs, data sharing with neighbours, alignment with TEN-T and the EU–China Connectivity Platform, and blended financing using EU funds, EIB loans, Chinese policy banks and PPPs. Together, these measures would turn Bulgaria into a functional Eurasian hub rather than a peripheral endpoint.

3.3.2 Compliance Strategies for Foreign Investment under the EU's New Regulatory Framework

The EU's new toolkit – including the Foreign Subsidies Regulation, CBAM, the Minimum Wage Directive and upcoming instruments on forced labour and supply-chain due diligence – has turned EU membership from a pure "market integration dividend" into a mixed signal for Chinese investors. In our gravity model, the EU membership dummy is no longer significantly positive, reflecting the fact that carbon, labour and subsidy rules now offset much of the institutional convenience traditionally associated with the Single Market.

For China–Bulgaria cooperation, this calls for "compliance-by-design". On the carbon side, Chinese investors should localise or upgrade high-emission production lines, adopt EU-compatible product carbon footprint accounting, and build a track record during the CBAM transition phase so that, after 2026, declarations are routine rather than a shock. On the social side, firms need robust HR and supply-chain due diligence: clear minimum-wage policies, overtime and social insurance compliance, and a documented "zero forced labour" policy aligned with the forthcoming EU ban and CS3D requirements.

Financial architecture can also lower regulatory friction. Co-financing with the EIB, AIIB or other multilateral lenders, and structuring projects in euros, can reduce both funding costs and political suspicion about opaque subsidies. Bulgaria's planned euro adoption in 2026 will further stabilise the macro-environment and simplify settlement, but will also raise the bar on transparency and prudential standards. Chinese companies therefore need to treat ESG, disclosure and stakeholder engagement not as optional extras, but as core conditions for long-term, low-risk presence in Bulgaria and the wider EU.

3.3.3 Initiatives to Strengthen China–Bulgaria Cultural Soft Connectivity

China's active diplomacy has not yet translated into a better public image in Bulgaria, partly because official narratives rooted in a shared socialist past clash with local memories. Cultural soft connectivity is therefore a necessary complement to trade and investment.

First, the two sides could create a joint cultural centre linking museums, theatres and creative studios to run co-curated exhibitions, artist residencies and translation projects, gradually forming a more balanced shared narrative. Second, a bilingual online platform could aggregate documentaries, virtual museums and short videos on bilateral themes, with clear rules for data and copyright protection, so that audiences access first-hand content rather than only third-party reporting. Third, a cross-media lab involving Bulgarian outlets and Chinese

international media could offer training in fact-checking and stereotype-aware reporting and support more nuanced coverage. Finally, building on existing Confucius Institutes and exchange schemes, a dedicated scholarship programme and city-to-city twinning would expand long-term people-to-people contacts.

Taken together, these initiatives would help move the relationship towards genuine "heart-to-heart" communication: cultural familiarity becomes affinity-based soft power, reducing political mistrust and creating a more favourable climate for tourism, trade and investment.

CONCLUTION

Over the past seven decades, China–Bulgaria relations have evolved from episodic, politically framed contacts to an institutionalised, multi-level partnership embedded both in the EU single market and in the Belt and Road / "16+1" frameworks. This "double embedding" mirrors key insights from regional integration, global value chain and FDI theory: rules-based integration, infrastructure upgrading and cross-border production networks jointly reduce transaction costs, expand markets and create room for gradual value-chain upgrading.

The trade-structure analysis (RCA, TCI, IIT) shows clear mirror complementarity: China is competitive in electromechanical products, textiles, home appliances and consumer manufactures, while Bulgaria specialises in rose oil, organic wine, dairy products and non-ferrous metals. Yet low IIT/TII indicate shallow two-way value-chain embedding. Tweedie-GLM and machine-learning results consistently identify FDI, population and per capita income as the main drivers of bilateral flows, while the marginal role of simple "EU membership" and geographical distance has weakened. SHAP rankings further confirm that "investment–market size–institutional convenience" forms the core mechanism, but also expose the hard constraint of Bulgaria's small market and missing midstream industrial base.

Overall, China–Bulgaria trade is constrained by three intertwined shackles: a strongly vertical "raw materials vs. finished goods" pattern and a rising Bulgarian deficit; logistics bottlenecks (over-reliance on sea routes, low rail density, lack of inland hubs); and growing green and social-compliance risks under FSR, CBAM, minimum wage and due-diligence rules. Without targeted correction, these factors risk locking bilateral exchange into a one-way, low-value ladder.

Looking ahead, the upside is still substantial. China's expanding middle class and consumption upgrading create new space for Bulgarian niche agri-food and resource-based products. Strong FDI–trade complementarity makes it possible to move from simple trade to joint production, R&D and supply-chain management, especially if Bulgaria leverages euro adoption, tax advantages and its Black Sea–Balkans–Danube location. Upgrading ports and rail corridors, integrating into diversified Eurasian routes, improving customs and financing mechanisms, and deepening cultural "soft connectivity" can together transform geographic potential into real hub status.

If both sides maintain strategic focus and align "hard connectivity", "soft connectivity" and high-standard green and social compliance, China–Bulgaria cooperation can move beyond a traditional buyer–seller relationship towards an "innovation community" spanning R&D, production, logistics and consumption—and offer a concise, replicable model of high-quality, mutually beneficial cooperation within the wider EU–China economic framework.

III. REFERENCE OF SCIENTIFIC AND SCIENTIFIC-APPLIED CONTRIBUTIONS IN THE DISSERTATION

First. The dissertation offers a systematic reconstruction of China–Bulgaria economic relations within the wider context of EU integration and the Belt and Road / "16+1" framework. By combining historical materials, policy documents and statistical series, it develops the analytical concepts of "double embedding" and of "hard / institutional / soft connectivity". These concepts are used consistently throughout the empirical analysis and offer a coherent interpretative lens grounded in regional integration and global value-chain theories.

Second. It applies the Revealed Comparative Advantage (RCA), Trade Complementarity Index (TCI), Trade integration index (TII) and Intra-Industry Trade (IIT) indicators at the two-digit SITC level, yielding an empirically grounded assessment of structural trade patterns and bilateral value-chain integration that extends beyond the descriptive analyses that dominate the existing literature**.**

Third. Methodologically, the dissertation proposes a mixed modelling framework that combines a Tweedie-GLM gravity model with random-forest and XGBoost algorithms, supplemented by SHAP-based interpretation. The integrated use of Tweedie-GLM elasticities and SHAP importance measures enables a triangulated assessment of the roles of lagged FDI, population, income, distance and institutional factors – an approach still rarely applied in studies of China-CEE trade.

Fourth. The dissertation identifies three constraints to China-Bulgaria trade - vertical "raw-materials versus finished-goods" structure; logistics and infrastructure constraints; and rising regulatory and geopolitical frictions – and demonstrates their quantitative relevance across both econometric and machine-learning methods.

Fifth. Based on the results obtained from the scientific research, recommendations have been presented for improving the effectiveness of infrastructural, financial, and institutional connectivity, with the goal of establishing a mechanism for sustainable cooperation.

IV. LIST OF PUBLICATIONS OF THE DOCTORAL STUDENT

1. Hu, J. (2023). Challenges and countermeasures of agricultural investment cooperation between China and Bulgaria. *Global and Regional Dimensions of International Economic Relations*, 8–16. https://dlib.uni-svishtov.bg/handle/10610/4721

2. Hu, J. (2024). Economic impact of BRI infrastructure on China–Bulgaria relations: Current situation and prospects. *Global and Regional Dimensions of International Economic Relations*, (1), 8–18. https://doi.org/10.58861/tae.grdier.2024.01

3. Hu, J. (2025). Infrastructure and resources: The evolving dynamics of Sino-Congolese cooperation under the Belt and Road Initiative. *Global and Regional Dimensions of International Economic Relations*, (2), 7–18. https://doi.org/10.58861/tae.grdier.2025.01

4. Hu, J. (2025). Research on the determinants of bilateral trade between Romania and its major trading partners: Panel data analysis based on the GLS gravity model. EURINT: Debating Europe – New Approaches, Action Tools and Integration Scenarios, 12, 133–151. https://doi.org/10.47743/eurint-2025-PAS

V. LIST OF PARTICIPATIONS IN NATIONAL AND INTERNATIONAL SCIENTIFIC CONFERENCES AND FORUMS

1. **Conference:** 27th Scientific Conference "Global and Regional Dimensions of International Economic Relations"
   With paper: Challenges and countermeasures of agricultural investment cooperation between China and Bulgaria.
   Date & Place: 13–14 May 2023, Bulgaria
2. **Conference:** 28th Scientific Conference "Global and Regional Dimensions of International Economic Relations"
   With paper: Economic impact of BRI infrastructure on China–Bulgaria relations: Current situation and prospects.
   Date & Place: 18–19 May 2024, Bulgaria
3. **Conference:** 17th Annual European Public Policy Conference
   Date & Place: 28–29 March 2025, Brussels, Belgium
4. **Conference:** 29th Scientific Conference "Global and Regional Dimensions of International Economic Relations"
   With paper: Infrastructure and resources: The evolving dynamics of Sino-Congolese cooperation under the Belt and Road Initiative.
   Date & Place: 10–11 May 2025, Bulgaria
5. **Conference:** 14th EURINT International Conference
   With paper: Determinants of Bilateral Trade Between Romania and Its Major Trading Partners: A Panel Gravity Model with GLS Estimation
   Date & Place: 15–18 May 2025, Iasi, Romania
6. **Conference:** 5th EIBC International Conference
   With paper: Determinants of Bilateral Trade between China and Central and Eastern European Countries: A Comparative Analysis Based on Econometric and Machine Learning Approaches
   Date & Place: 12–14 June 2025, Iasi, Romania
7. **Conference:** International Conference on Economics, Business & Management (ICEBM 2025)
   With paper: The impact of China's Waste Import Ban and Basel Convention Amendments on Global Plastic Waste Trade: A Difference in Differences Approach
   Date & Place: 25–26 September 2025, Varna, Bulgaria
8. **Conference:** 1st Colloquium of PhD Students in KreativEU Doctoral Programmes
   With paper: Fast Diagnostics of Infrastructure–Trade Coupling: Robust OLS Evidence from Romania and Bulgaria
   Date & Place: 19–21 November 2025, Targoviste, Romania
9. **Conference:** Economic Development and Policies: Realities and Prospects. Sustainability in the Conditions of Global Transformations
   With paper: EU Minimum Import Price: Implementation and Removal — Evidence on Chinese PV Module Exports to the EU
   Date & Place: 24 November 2025, Sofia, Bulgaria

VI. RERENCE OF MEETING THE MINIMUM NATIONAL REQUREMENTS FOR OBTAINING THE EDUCATIONAL AND SCIENTIFIC DEGREE OF DOCTOR UNDER THE REGULATIONS ON THE IMPLEMENTATION OF THE LAW ON ACADEMIC STAFF DEVELOPMENT IN THE REPUBLIC OF BULGARIA

National requirement in number of points: 30,00

Number of **articles**, published in non-refereed peer-reviewed journals or published in edited collective volumes:2

Number of points for the author: 20,00

Number of **papers,** published in non-refereed peer-reviewed journals or published in edited collective volumes: 2

Number of points for the author: 20,00

Total points: 40,00

VII. DECLARATION OF ORIGINALITY OF THE DISSERTATION

The presented dissertation in a total volume of 221 pages on the topic:

ECONOMIC AND TRADE COOPERATION BETWEEN CHINA AND BULGARIA WITHIN THE FRAMEWORK OF "16+1 COOPERATION" AND "ONE BELT, ONE ROAD"

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28 November 2025

Doctoral Student:.....................

(Jingxin Hu)