THE ROLE OF POLITICAL AND INSTITUTIONAL FACTORS IN CENTRAL ASIAN TRADE INTEGRATION: EVIDENCE FROM THE GRAVITY MODEL

A Thesis

Submitted to the Master's Study Program of Economics at the Faculty of Economics and Business in partial fulfillment of the requirements for the degree of

Master of Arts in Economics (M.A.)

by

Malika Dilbarova

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UNIVERSITAS ISLAM INTERNASIONAL INDONESIA

DEPOK 2025

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ABSTRACT

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With the gravity model of trade, this thesis analyzes political and institutional influences on trade integration among Central Asian countries. It tests how these factors: GDP (economic size), FDI inflows, political stability, and control of corruption affect mutual trade transactions throughout twenty-four years in the region from 2000-2023. The research applies panel data regression analysis using multiple estimation methods: Pooled OLS, Fixed Effects (FE), Random Effects (RE), Poisson Pseudo Maximum Likelihood (PPML), and Driscoll-Kraay standard errors, which account for heteroskedasticity, autocorrelation, and cross-section dependence. Completeness checks and model selection tests such as the F-test, LM test, and Hausman test verify that fixed effects is the preferable estimator in terms of bias and inconsistency due to the correlation with unobserved heterogeneity and regressors. Other diagnostic checks, like the Breusch-Pagan test, along with a correlation matrix and VIF, were performed to evaluate the trustworthiness of the dataset alongside its validity. The findings include higher trade values due to increased GDP from the exporting country, as well as inflow of foreign direct investment, which are positive influences on proving gravity theory's core claims. Moreover, control of corruption has a strong positive impact on trade flows, which highlights institutional quality concerning its significance. On the contrary, political stability as well as GDP from importing countries tend to be non-influential or reveal contradictory impacts throughout various estimations. It explains the importance of non-economic factors such as governance and stability in determining trade relations. It also emphasizes the need for effective reform at the level of institutions to enhance transparency and improve the investment climate in order to promote regional economic cooperation. This study distinctly signifies evidence-informed strategies towards advancing intra-regional trade within Central Asia, whilst showcasing how enhancing domestic governance frameworks can rival improving infrastructure for facilitating trade diplomacy.

Keywords: Central Asia, Gravity Model, Political Factors, Mutual Trade Flows, Foreign Direct Investment (FDI), Political Stability, Control of Corruption.

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CHAPTER I

INTRODUCTION

1.1 Background

Economic integration is a compelling example of fostering regional growth (Roumkos et al., 2022). It stimulates trade, investment, and collaboration among countries, providing a basis for collective economic potential. Central Asia includes Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, which together possess tremendous economic promise as a result of their vast natural resources, strategic location at the confluence of major international markets, and shared cultural heritage. Despite such, Central Asia remains underdeveloped and economically fragmented. The intra-regional trade still constitutes a very low share of total trade, with each of the countries having stronger trade connections with China, Russia, and the EU (Pomfret, 2020; ADB, 2021).

Central Asian countries do not function as an integrated economic region but rather rely predominantly on bilateral agreements and external trade routes. This loose mosaic of trade relationships is symptomatic of more deep-seated structural and institutional barriers that continue to block the path towards regional integration. It must be noted that although the altercations like the Chinese Belt and Road Initiative (BRI) have been beneficial in integrating the region's infrastructure with international systems, the outcomes have not enhanced intra-regional relations. On the contrary, these initiatives have increased dependency on external non-regional actors, deepening regionally oriented economic frameworks. As noted by Krasavina (2019), while external economic linkages provide investment and market opportunities, they are often counterproductive in fostering a unified, self-reliant regional economic strategy.

The region's trade and intra-regional economic activities are economically stagnant due to an underdeveloped trade-related infrastructure triad, which includes efficient road and rail networks, border facilities, and streamlined customs. In addition, the absence of institutional frameworks, the lack of superordinate managing entities, and the differing national priorities of the five states block joint economic advancements. This underscores the need to analyze the previously existing intra-regional trade relations to identify the key features that have led to underperformance, focusing on the economic, institutional, and political aspects that emerge from current policies. This is done to advance understanding alongside developing mitigation policies, aiding in increasing rationalized integration in the region.

The scope of trade is vastly underused when compared to the region's economic interdependencies, which highlight the need for deeper trade integration. Kazakhstan and Turkmenistan have a lot of oil and natural gas reserves that can meet the energy needs of their neighbors. Uzbekistan has a strong agricultural and textile industry that allows it to send food and other goods to Kyrgyzstan and Tajikistan. These two countries are better at making hydropower and doing labor-intensive manufacturing. Trade integration in these areas can help people become more self-sufficient and make better use of their resources, which can lead to strong economic growth. Better trade ties would have other benefits, such as more diverse industries, bigger economies of scale, and better infrastructure across borders. The World Bank says that if trade barriers and regulations are actively brought into line, the region's GDP could grow by 5% over the next ten years. The goal of this thesis is to use the gravity model of trade to look at how political and institutional factors affect trade gaps within a region. The goal is to give policymakers information about Central Asia's economic resources.

While this thesis begins with the abstract premise of economic integration—trade, investment, harmonization of regulations, and coordination of institutions—its analytical focus is on trade integration. Trade is the most tangible and measurable element of regional economic integration and provides a very good perspective from which to quantify concrete advances in cooperation among Central Asian states (World Bank, 2020). By constraining attention to mutual trade flows, the study records the working of integration through empirical processes like the gravity model.

1.2 Problem Statement

Although Central Asia possesses rich resources and a shared history, their economies still lack integration, with intra-regional trade only constituting approximately 6% of total trade (Pomfret, 2020; Asian Development Bank [ADB], 2021). According to Pomfret (2019), trade flows within Central Asia are 36 times smaller than the global average. For instance, in a sample of 140 countries, the average bilateral trade volume between two countries was about $333 million around the world, but the average trade between Central Asian countries was only $9.2 million (ADB, 2021). The reason why this particular region is fragmented in such a manner due to political and institutional factors or other relevant aspects is insufficiently studied, justifying further research.

The existing gaps in trade infrastructure, particularly in transport and logistics, identify cross-border trade as one of the most challenging obstacles. This region has an incomplete system of roads and railways, modern border crossing terminals, and a lack of multimodal transport facilities. The Central Asian countries have relatively small GDPs (for example, the region's average GDP in PPP is about $37 billion, while the world's average is $373 billion). This limits trade volumes because bigger economies trade more. Gravity theory says that trade is proportional to the size of the economy (World Bank, 2022). The numbers show this: countries with bigger GDPs, like Kazakhstan, have more trade, while countries with smaller economies, like Tajikistan and Kyrgyzstan, trade less.

All five Central Asian countries are landlocked; thus, the region suffers from extremely high transaction costs as well as low productivity due to the stifling supply and demand of various goods and services (Shimizu, 2021; Sudan, 2022). Moreover, the relevant institutional infrastructure required to strengthen economic integration remains very weak. Most other regions have supranational integration, whereas Central Asia still lacks a powerful trade coordinating body or a unified policy system. Poorly defined policies, no comprehensive system of trade quotas, and inadequate dispute resolution systems contribute to the volatile trading climate, which harms deeper integration (OECD, 2023).

Another remaining challenge is non-tariff barriers (NTBs) like excessive customs checks, restrictive measures for imports, and ambiguous standing policies. Such forms of NTB impede trade and make it very difficult to establish a single market for the region (Shimizu, 2021). In this context, the trade relations of the region are largely bilateral and externally oriented, with China and Russia dominating trade and infrastructure investment. These relations, while beneficial in certain respects, have diverted attention from regional cooperation and lessened the impetus for integrated economic policy frameworks designed to synergize cross-national economic integration (UNESCAP, 2022; Pomfret, 2020). The core of the problem stems from conflicting national priorities as well as political and institutional factors, where mutual suspicion and divided interests hinder the creation of a unified strategy for regional progress. The absence of a definitive strategic focus perpetuates the stagnation of coordinated reform efforts.

Considering these issues, the purpose of this study is to estimate the level and the determinants of intra-regional trade in Central Asia using the gravity model of trade. By identifying structural and policy determinants of trade economy, such as economic mass, contiguity, border crossing policies, and substitute trade relations, the study anticipates formulating policy conclusions directed toward enhancing regional integration. Ultimately, the research aims to formulate actionable policy steps toward the institutional alignment, trade facilitative mechanisms, and infrastructure planning necessary to shift Central Asia from a loosely connected economic association to a cohesive, competitive, and resilient economic bloc.

1.3 Research Questions

1. How does the size of the economy (GDP) of Central Asian countries affect the flow of trade between them?
2. How does foreign direct investment (FDI) affect trade between Central Asian countries?
3. How does political stability affect trade between Central Asian countries?
4. How does control of corruption affect trade between Central Asian countries?

1.4 Research Objectives

1. To analyze how the size of an economy (GDP) affects trade between Central Asian countries.
2. To find out how foreign direct investment (FDI) affects trade integration in Central Asia.
3. To estimate how political stability affects trade between Central Asian countries within their region.
4. To investigate how controlling corruption affects trade between two countries in Central Asia.

1.5 Research Hypothesis

H1: The GDP of Central Asian countries has a big and positive effect on the trade flows between them.

H2: More foreign direct investment (FDI) in Central Asian countries is linked to more trade integration.

H3: Political stability has a positive effect on trade between Central Asian countries within the region.

H4: Better control of corruption leads to more trade between countries in Central Asia.

1.6 Significance of the Research

This study fills a significant gap in the literature on Central Asian trade by empirically examining the role of political and institutional factors in shaping intra-regional trade flows, using an adapted gravity model for the period 2000 to 2023. Unlike earlier studies, this research integrates variables—foreign direct investment (FDI) inflows, political stability, and control of corruption—to offer a more comprehensive and context-specific analysis of the factors influencing regional trade. Previous empirical research on trade in Central Asia has often relied on limited variables or different timeframes. For instance, many gravity model studies have focused on trade between Central Asia and external partners (Nurmakov, Sulaimanova, & Zhumakhanov, 2017; Kutan & Wyzan, 2005). Other works, such as Pomfret (2022) and regional assessments by multilateral agencies like the Asian Development Bank (2020), typically emphasize infrastructure or market access but do not empirically measure the influence of political alignment or shared governance conditions within the region.

Moreover, several studies have remained descriptive, lacking the quantitative depth needed to support actionable recommendations. For example, Dadabayeva and White (2018) highlight external dependencies and institutional weaknesses primarily through qualitative analysis, while Krapohl and Vasileva-Dienes (2019) discuss political fragmentation without applying quantitative methods. Some recent research touches upon institutional barriers and political risk in Central Asia but does not integrate these systematically into trade flow models (Brunnbauer, 2019; Ehrhart & Lasserre, 2020). Similarly, studies focusing on the Belt and Road Initiative's impact on Central Asia have concentrated on infrastructure investments rather than the combined effect of political alignment and institutional factors on trade (Liu & Dunford, 2016). Even in quantitative gravity model applications, such as those by Pomfret (2022) or Asian Development Bank reports (2020), the analysis primarily targets trade with major external economies rather than intra-regional flows.

This study stands out by covering 24 years and incorporating variables that capture not only economic fundamentals but also political and institutional proximity. By doing so, it directly addresses the internal trade dynamics of Central Asia, filling a notable research gap. The findings offer practical implications for policymakers in Central Asian countries. By identifying how non-economic factors, such as political stability and FDI inflows, contribute to or restrain trade, the study provides a clearer picture of which structural gaps require targeted policy attention. Governments can use these results to design more focused strategies for enhancing intra-regional trade, particularly through institutional streamlining and improved investment environments.

Regional organisations, including the Eurasian Economic Union and the Shanghai Cooperation Organisation, can benefit from the evidence provided to inform efforts to harmonise trade policies, enhance connectivity, and coordinate political positions. Likewise, development agencies and investors may find this research useful in identifying where to prioritise support for projects that strengthen integration and reduce asymmetries between member states. In methodological terms, the research contributes to the expansion of the gravity model by incorporating political and institutional variables tailored to the Central Asian context. This approach provides a replicable model for other emerging regions with similar structural and political complexities. Ultimately, the study advances both the academic and applied understanding of regional trade integration and offers timely insights into the barriers and opportunities for deeper cooperation within Central Asia.

1.7 Research Outline

This research is structured in five chapters, with each chapter covering a certain aspect that contributes to an explanation of the political and institutional framework of Central Asian trade integration by employing the gravity model. The first chapter serves as the introduction. At the start, it aims to set the scene, discussing the background, research problem, objectives, questions, significance, and hypotheses. It also addresses the region's economic disintegration, low intra-regional trade volume, and substantial reliance on external countries like China, Russia, and the European Union. The study rationale is explained through underscoring the need to know how institutional and political factors affect the attempts to implement trade integration in Central Asia.

The second chapter provides an important literature review of integration theories, gravity models of economics, and other pertinent empirical trade research. It cites comparative studies from the European Union and ASEAN and explains different models of integration. This chapter also explains the gaps in the literature regarding the associated geography and politics, with the absence of an institutional framework and gravity studies dominated by Central Asia. This literature review provides concepts that are crucial for supporting the study's frameworks and methodologies. The methodology of the research is elaborated in the third chapter. It defends the use of the gravity model, how it was bent to fit the region, and how the different constituents were chosen. This chapter also describes the sources of data, the sample period, and the econometric methods used: fixed effects, random effects, and the Poisson pseudo maximum likelihood (PPML) estimator. Further, it justifies the choice of the model using the Hausman test and discusses the model's bounds and the methodological shortcomings of the research.

The fourth chapter is devoted to the results and the interpretation of the findings concerning the research questions and the hypotheses. It analyzes how much the economic size, quality of governance, and control of corruption affect the trade flows between Central Asian countries. In this chapter, the reader can find both the statistical outcomes and the interpretation of the outcomes related to the integration process in the region. The final chapter covers the thesis, with the main findings explaining institutional restructuring and political alignment. It suggests strategies to strengthen trade integration at the regional level while simultaneously undermining the effectiveness of the institutional mechanisms.

CHAPTER II

LITERATURE REVIEW

The patterns of regional cooperation have already been explained using the integration of areas of economic cooperation. Nevertheless, the major political framework, institutional landscape, and socio-cultural environment in regions like Central Asia render these theories inadequate beyond established integration blocs. The regional discourse, particularly in Europe, is predominantly shaped by two classical theories: neofunctionalism and intergovernmentalism. However, the predominant political fragmentation and weak institutionalism, coupled with external power considerations in Central Asia, make these theories rather difficult to adopt.

2.1 Theoretical Framework

2.1.1. Neofunctionalism

Although neofunctionalism is based on the European experience, it offers conceptual insights into the way regional integration might proceed elsewhere. In this thesis, it is applied as one of the theoretical approaches to examine whether sectoral cooperation on trade or infrastructure can broaden into broader economic integration in Central Asia.

Neofunctionalism claims that the enhancement of cooperation in one particular area leads to integration in others, thus producing a synergetic effect of increasing regional integration. This has been one of the ideas that has provided rationalization to the historical development of the EU and, more importantly, during its crises. For example, measures such as the European Stability Mechanism (ESM) and the Banking Union were put in place in order to remedy weaknesses that were exposed during the Euro crisis; their existence also illustrates the types of evolutionary change that neo-functionalism expects (Nicoli, 2019). Even though neo-functionalism has offered useful insights into understanding the EU, some of its tenets have come under severe scrutiny. Its attempt to rationalize economic and institutional liberalism is inadequate in covering socio-political and cultural aspects that are crucial for regional integration. The theory describes integration as a self-contained, stepwise process, disregarding renditions of political rivalry, historical enmity, and social cleavage disruption. This limitation is particularly pronounced in Central Asia, where multiethnic societies, dictatorship regimes, and external dominance make integration difficult.

Moreover, neofunctionalism's excessive focus on Europe raises serious issues regarding its application across the world. It assumes a degree of institutional development, economic balance, and political determination that is not existent in the Central Asia region. Some critics, including Athanasopoulos (2020), claim that neo-functionalism not only minimize the impact of powerful countries in the region but also neglects how resources are accrued and expensed, which usually heightens the conflict within the region. In addition, Central Asia has relatively weak supranational institutions, adding to the criticism against the theory's main argument that the adaptation of institutions spurs the process of integration. The theory also does not conceptualize the disruptive character of external actors like Russia and China, whose conflicting priorities undermine regional initiatives. Neofunctionalism is primarily concerned with the ability of regions to develop in the midst of foreign and national politics, history, and cultures, but it would serve a much lesser purpose when made applicable to Central Asia, owing to the fact that such regions only seem to integrate internally through coercion.

2.1.2. Intergovernmentalism

M. Borko’s comparative method suggests intergovernmentalism as a competing theory along with Europe’s regions, stating that dominant states and regional governance. In this view, cooperation stems from well-thought-out political decision-making strategies rather than from the initiatives of an all-powerful supranational body. Intergovernmentalism's docility aligns with the narrative of EU integration, translating into a nation-state due to intergovernmental compromise and negotiation (Hooghe & Marks, 2019). Nevertheless, it is also true that intergovernmentalism has its weaknesses. The concept’s preoccupation with formal agreements and state sovereignty disregards the contributions of informal structures, interests, and culture, as well as history, to regional integration. This limitation is especially conspicuous in Central Asia, which is still burdened by the Soviet political economy, distrustful habits among the states, and competing foreign patronage in a modern state.

Besides, this theory does not seem to offer satisfactory explanations for issues of unbalanced power relations in regional organizations. For instance, Kazakhstan and Uzbekistan are powerful countries; the weaker ones tend to be disregarded in making policy decisions. As for the latest intergovernmentalism, it adds something more, especially in relation to the growth of populism and dislike for integration. Hodson and Puetter (2019) state that this variety also explains why there is an increasing resort to informal and non-binding agreements, which is fully compatible with the pattern of the disintegrated and non-institutionalized approaches to Central Asian regionalism. However, this explains neither the role of Russian nor Chinese interests, whose policies in regional projects often define the time and the speed of the project's development. This lack demonstrates the importance of developing a theory that explains both positive and negative aspects.

These two hypotheses explain the patterns of cooperation that may be evident among Central Asian governments. Neofunctionalism illustrates how minor trade and infrastructure initiatives can foster cooperation among countries. This is beneficial for Central Asia, as nations can collaborate due to the mutual need for transportation and customs services. Intergovernmentalism demonstrates that national governments predominantly retain decision-making authority, particularly in a region where more powerful nations such as Kazakhstan and Uzbekistan frequently assume leadership roles. This thesis connects the political and institutional background to trade flows quantified by the gravity model through the application of both theories. This elucidates the reasons for the limited regional trade integration in Central Asia.

Neo-functionalism and intergovernmentalism provide different approaches to the question of economic integration. All theories are useful for understanding the processes of economic integration in Central Asia, where political factors such as past experiences, institutional settings, and the current corpus of nation-building are sides for regional integration. This thesis uses the gravity model of trade to look at these integration factors in a quantitative way. Chapter 3 (Methodology) discusses this model in more detail.

2.1.3. Gravity Model of Trade

The Gravity Model of Trade is a fundamental concept in international economics derived from Newton's law of gravitation. The volume of trade between two nations is directly proportional to their economic size (often assessed by GDP) and inversely proportional to the distance between them (Tinbergen, 1962; Anderson, 1979). Over time, this fundamental specification has expanded to encompass variables pertaining to institutions, politics, and infrastructure. This is referred to as the augmented gravity model (Anderson & van Wincoop, 2003). The augmented gravity model is particularly advantageous in Central Asia, where formal regional integration is feeble, while geopolitical and institutional influences remain robust. The model incorporates elements such as political stability, corruption control, and foreign direct investment (FDI) inflows, providing a more comprehensive understanding of trade determinants beyond mere economic size and distance. This enables a more realistic examination of trade patterns within a region, particularly when geography alone fails to elucidate the reasons behind low trade levels.

Distance is a crucial component of the standard gravity model; however, this study omits it for two primary reasons. Firstly, Central Asian nations are in proximity to one another, indicating that distance metrics remain rather consistent. This may distort the results due to multicollinearity. Secondly, the study prioritizes institutional and geopolitical elements due to their significant influence on regional integration. Excluding distance does not undermine the model's theoretical foundation; rather, it demonstrates its adaptation to align with contemporary research on underdeveloped or post-Soviet economies (Bacchetta et al., 2012; Egger & Lassmann, 2015).

2.2. Conceptual Framework

2.2.1. Economic and Regional Integration

A single market is deeply associated with the neoclassical school of thought, where the government's role in international trade consists of removing trade barriers. Srivastava et al. state the importance of firm-based resources in helping build strong customer and channel relationships as key drivers of economic integration and shareholder value creation (Srivastava, Shervani, & Fahey, 1998). Lindgreen et al. (2020) further suggest that such integration needs a variety of interdisciplinary approaches while formulating conceptual models, stressing how the markets are fluid and changing in nature (Lindgreen et al., 2020). From this viewpoint, there is also an expectation of moving away from rigid design frameworks toward more flexible structures that can embrace new kinds of participants and deal with complex and changing economic realities.

Institutional alignment suggests that policies across member states would have to be unified, and the establishment of strong governance frameworks would be important. For instance, Mele et al. (2015) argue for the need to marry orthodox economics with change-oriented governance to counterbalance complicated markets. Economic Performance and Market Dynamics: Helgesson and Kjellberg (2007) provide a performative model of markets, which depicts the market as being shaped by normative, representational, and exchange practices (Kjellberg & Helgesson, 2007). Resource

Allocation Enhancement: Market integration improves resource allocation and innovation. In a study, Srivastava et al. (1998) reveal that compact market structures curtail cash flow instability and improve profitability in the long run.

Table 2. 1 Comparative Analysis of Single Market Case Studies

Aspect	**European Union**	**ASEAN**	**African Continental Free Trade Area (AfCFTA)**
Institutional Framework	Strong regulatory alignment	Limited harmonization	Emerging governance models
Market Size	450 million consumers	650 million consumers	1.3 billion consumers
Key Challenges	Brexit, political divergence	Cultural diversity	Infrastructure gaps

Source: Author Computation

In the context of Central Asia, these integration models offer instructive contrasts. Unlike the EU or ASEAN, Central Asia lacks strong supranational institutions and often struggles with low intra-regional trade volumes. While the EU and ASEAN benefit from structured legal frameworks and policy harmonization, Central Asia's regional initiatives—such as the Eurasian Economic Union (EAEU)—areoften hindered by asymmetric power relations and distrust among member states. Therefore, the path to integration in Central Asia may require a more pragmatic approach that balances national sovereignty with coordinated infrastructure, trade facilitation, and governance reforms (Pomfret, 2014; Baikushikova et al., 2021).

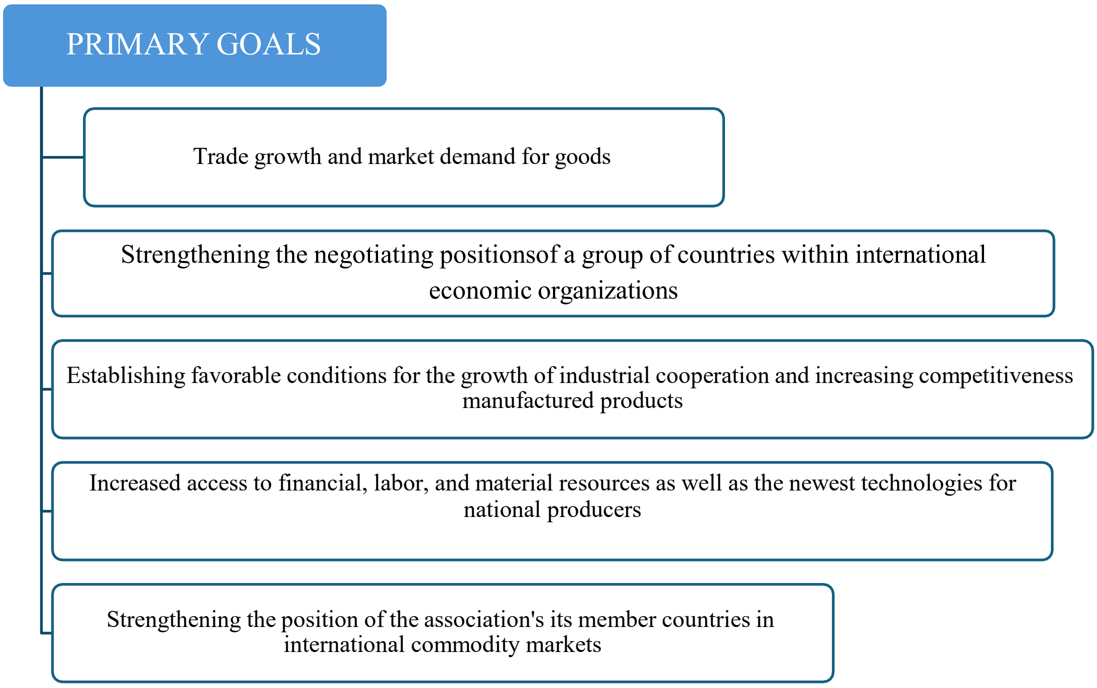
Insights emerging from these frameworks indicate that policymakers, as well as businesses, must envisage flexibility, resilience, and inclusiveness in the building of single markets. For example, using technology-based approaches in regulatory processes minimizes the need for integration and maximizes efficiency (Table 2.1). The conceptual outline of a single economy refers to the mutual correspondence existing among a social institution's orientation, the functioning of the market, and the creation of economic value. These insights help regions to make better use of integration efforts and grow their economies.

2.2.2. Theories and Impacts of Economic Integration

Economic integration encompasses various aspects of aligning economic policies and practices among different countries (Fig. 2.1). The process has been particularly important in the last few decades due to globalization pressures and a feeling among nations to become more economically competitive.

Economic integration comes in different forms, reflecting a progression from simple actions through various types of multilateral agreements up to agreements that establish economic and monetary union. The lightest form of integration is the Free Trade Area, whereby countries abolish tariffs among themselves but retain their external tariffs. This is an arrangement that allows for the liberalization of trade. Hence, countries in membership may benefit from increased volume since they would not have to sacrifice their trade policies. The next step beyond a free trade area is a customs union, which, in addition to incorporating the features of a free trade area, also presupposes the adoption of a common external tariff by the member countries on their imports from non-members. This type of integration is superior in terms of efficiency in resource allocation in that it reduces the extent of trade diversion. It promotes efficiency in allocating resources among the member states (Wexler, 1962).

The Common Market develops based on a customs union by adding free labor and capital mobility between members. Then, economic interdependence is increased, as well as economic unity. Moving even deeper, the Economic Union combines a common market with harmonized economic policy and regulations in the member states. This type of integration gives a deeper unification effect between the economies and policies. At the top level of integration is the political union, whereby countries share common political institutions in addition to economic policies. This is considered to be the most complex form of integration, as it unifies all economic and political regimes among the member countries. The accruing benefits from economic integration are immense and multivariate. Among these, the foremost advantage relates to market expansion. Firms can have their products marketed in wider markets for economies of scale, thereby reducing their costs and increasing profitability.



Source: Author Computation

Figure 2. 1 Aspects of economic integration

Moreover, it promotes more investment. Since the firms want to exploit wider markets, foreign direct investment flows into the member countries, stimulating economic activities and thereby creating jobs. Consumers will also benefit from integration since it leads to lower prices and a greater variety of goods and services available in the market. Cooperation can enhance competitiveness at the international level. Through strength, member countries' performance will be improved to position themselves in a better standing in international markets. Another important objective is the promotion of economic growth. Since integration forms a more extensive market, competition gets sharper, and innovation is faster, which is crucial during the process of economic growth.

Integration enables better resource use because countries can specialize in their comparative advantage areas. This benefit is reflected not only in higher productivity but also in overall economic efficiency. Furthermore, economic integration can also bring about political stability in the member countries. Economic involvement provides an avenue for the countries to work together politically, thus reducing friction and promoting regional stability. Remarkably, the European Union has maintained an integrated market while all its members have different political, economic, and social contexts. The EU relies on a strong institutional framework for settling disputes, such as the European

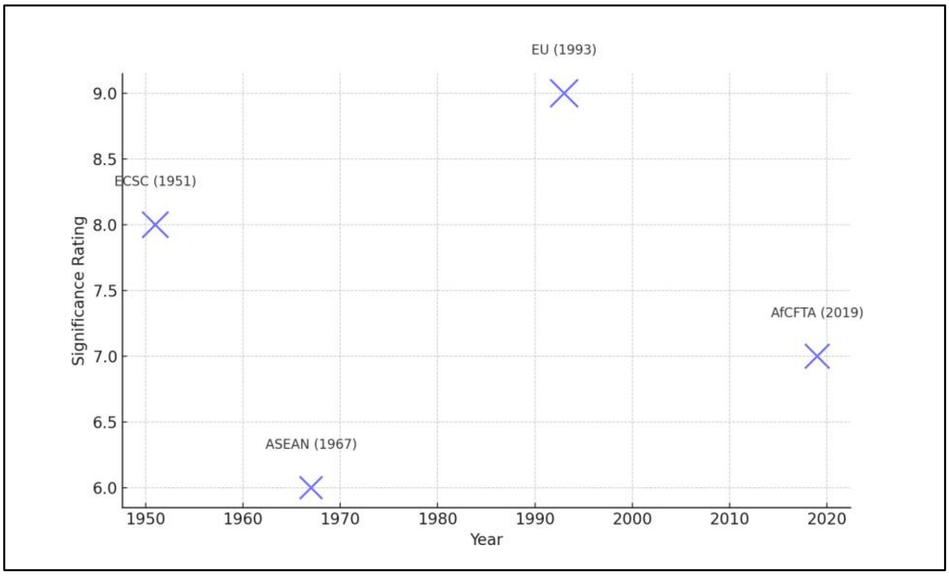
Commission and the Court of Justice of the European Union, to empower the institutions to adhere to common rules and principles under the Single Market model. The EU's lessons on enforcing competition policies, establishing regulatory standards, and adjudicating disputes could prove valuable to other regions wishing to integrate, for example, Central Asia (Pelkmans 2019).

Central Asia is unlike the EU, which has an extensive collaborative tradition that has seen cooperative institutions and clearly defined legal frameworks. Central Asia lacks mechanisms to enforce collaboration and policy coordination. Uncertainty and concerns foster a basic image of this fractured region, notwithstanding historical differences and the legacy of Soviet centralization (Adeoye, 2020). Research in economics and regional integration has progressed through the focus on the merging of economies, standardization of policies, and formation of cooperative agreements between countries. The frameworks developed in this area seek to answer the questions concerning goals, approaches, and results of integration, as well as the consequences of such actions for the entities included and not included in the integration.

The conceptual frameworks discussed above were mostly established in the context of European or global integration processes; however, they are significant for Central Asia. The region has aimed to improve commerce and collaboration amongst its members for a long time, but progress has been slow. Central Asia doesn't have strong regional structures or well-organized trade rules as the EU or ASEAN do. So, using these integration theories in Central Asia shows both the possible benefits of trade liberalization and the institutional problems that remain to be overcome in the way of further economic integration.

Regional integration began with the premise of minimizing barriers to trade and foreign investments and the movement of labor, which resulted in economic dependency. Viner and Meade’s customs unions theory deals with the relationship between tariff cuts and joint marketing and welfare (Popović, 2010). Balassa’s stages of integration, starting from free trade areas scaling up to economic and even political unions, give a wider scope as to how to understand the different levels of integration (Fratianni, 2006). These stages emphasize the dynamics of integration, of which high levels of institutional organization and policy coordination accompany more complex forms. The institutional and market-based integration has been profoundly researched. For instance, the European Union (EU) is a prime example of integration in which a strong political economy, a shared currency, and rules promote growth (Rivera-Batiz & Ginsberg, 1993). The African Continental Free

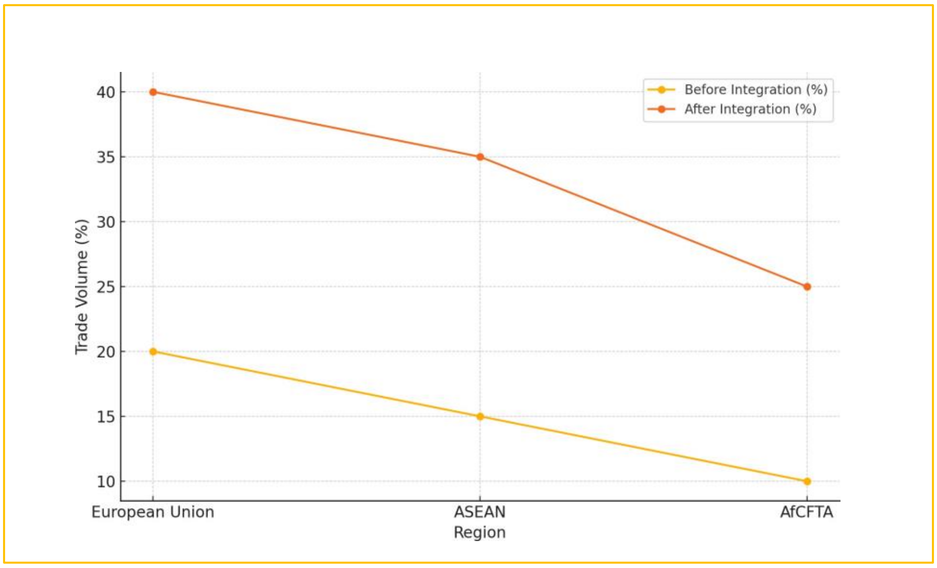
Trade Area (AfCFTA) and ASEAN show how regions that are still developing can utilize these models based on their socio-cultural and economic environment (Tang et al., 2015).



Source: Author Computation

Figure 2. 2 Timeline of regional integration

Figure 2.3 illustrates a timeline of important events in the regional integration activities as concisely as possible. The initial integration step of the European economies was marked undeniably by the creation of the European Coal and Steel Community back in 1951, since it consolidated several industrial sectors within the member countries (Fratianni, 2006). Quite the same, the founding of ASEAN in 1967 was primarily concerned with enhancing the economic integration and political stability of Southeast Asian countries (Tang et al., 2015). Great Britain, France, Germany, Italy, the Netherlands, and Belgium started dividing their power through the Maastricht Agreement in 1992, which resulted in the establishment of the European Union in 1993, creating a single economic area while prompting great anticipation from the world (Rivera-Batiz & Ginsberg, 1993). Finally, the most recent event marking the integration efforts of the African nations into a greater trade-liberalized market was the setting up of the African Continental Free Trade Area in 2019 (Popović, 2010).



Source: Author Computation

APPENDIX 1FIGURE 2. 3 TRADE VOLUME

The clustered bar chart depicts the trade volume integration of the EU, ASEAN, and AfCFTA, showing both pre- and post-. The EU's single market's transformative power is unleashed, with the proportion of trade volume increasing from 20% to 40%. Findings are corroborated by Rivera-Batiz and Ginsberg in 1993. Furthermore, this growth is also clearly observable in ASEAN, where there has been an increase from 15% to 35% and is associated with cutting tariffs and expanding the economies. Tang et al., 2015. Even though AfCFTA is in the early stages, the trade growth from 10% to 25% suggests that it has great potential. This astounding growth rate was captured by Popović in 2010. This graph and text are a great example of how more stable integration leads to an increase in intra-regional trade, with the only variability being in the level of development achieved by that integration.

Integration changes the level of growth, technology, and resources greatly. Research conducted on inter-regional technology strategy also highlights the role of knowledge between member countries as the main driver of improvement of innovative activities and productivity of member economists (Dion, 2004). Also, economic geography theories prove that integration leads to the formation of agglomeration, which in turn leads to manufacturing and service centers in the region (Ludema & Wooton, 2000). As potential benefits exist, regional integration suffers from difficulties such as political variances, institutional weaknesses, and uneven distribution of the benefits among members. The neighborhood system of innovation approach is of a different nature; it resides in collaboration instead of investment or trade, investing in building capacity and sharing knowledge (Tang et al., 2015).

2.2.3 Mechanisms of Regional Cooperation in the Post-Soviet Space

The factors that shape regional collaboration within the post-Soviet space include the shifting political integration policies and the impact of both international and domestic stakeholders. Ever since the Soviet Union collapsed, the region has undergone several rapid integration attempts within the multipolarized competition between world powers, as well as ongoing efforts to form a viable system of cooperation. Russia's policy began with active attempts towards Western integration in the nineties. This changed with a focus on Soviet reintegration between 2009 and 2014, followed by the current promotion of the Greater Eurasia blueprint, which encompasses China, Turkey, India, and Iran. These transitions stemmed from the need to maintain great power status and to mitigate the damage from Western integration and regional initiatives after the Russian failures in Ukraine (Krickovic & Pellicciari, 2021). The post-Soviet countries implement diverse policies for integration, some more aggressive than others, and some more inwardly directed while others are expansionist. These directional policies are influenced by trade pacts, value and supply chains, and investment patterns, which are profoundly disparate in terms of regional economic integration (Alyev, Stoyanova, & Chimiris, 2023).

The process of trade integration is considered by many researchers as the first and most fundamental when it comes to regional economic integration (Balassa, 1961; Baldwin & Wyplosz, 2020). It shows how much countries trade with each other, reduce tariffs, and remove non-tariff impediments. Trade integration is analyzed here both as an expression of regional economic cooperation and as a dependent variable influenced by political and institutional determinants. The gravity model offers a rigorous methodological framework for the analysis of these trade flows.

The regional schematics of cooperation are further muddled by the surge of overlapping, shifting organizations like Russia and Belarus, which, while symbolizing the potential for deeper integration, highlight the difficulties in the management of political and institutional commitments. Concretely, these dynamics undermine its coordination and effectiveness (Malyshev, 2024). The cooperation strategies in the post-Soviet space are differentiated with enduring problems intertwined with history and identity, which fuel political competitions alongside evolving strategic alignments. Despite the tangible advancement of a few integration projects, the region continues to remain divided (Kudryashova, 2023). The cooperation processes tend to stem from the balance adjusted between economic incentives and fundamental power rather than shared ideals or a cohesive vision toward integration.

Central Asia is an entirely distinct area of the post-Soviet environment from the other subregions. Even though they all have some characteristics in common from the Soviet era, the Central Asian republics have followed their own political paths and rely heavily on their relationships with Russia and China. Central Asia still has many challenges with coordinating institutions, harmonizing trade, and governing as a group, unlike Eastern Europe, where integration attempts have been quite effective. There isn't a strong regional bloc in the area that can enforce rules well, and projects like the Eurasian Economic Union (EAEU) have had mixed effects, with Kazakhstan and Kyrgyzstan joining but Turkmenistan and Uzbekistan being cautious or neutral.

2.2.4. International Trade

Classic theories of trade, including Adam Smith's concept of absolute advantage and Davis Ricardo's concept of comparative advantage, provide insight into what engages the nations to trade. For instance, Ricardo's theory posits that even if one nation is relatively inefficient in the production of all goods, it can still gain from specializing in those goods in which it has a relative comparative advantage over other goods (Ricardo, 1817). These initial concepts were later elaborated by Heckscher and Ohlin, who advanced the factor endowment theory, explaining why different trading patterns depend respectively on the factor endowment or relative factor supply of a given country (Heckscher & Ohlin, 1933). The new trade theories, alongside the classical theories, delve into economies of scale and market imperfections; Krugman (1979) noted that international commerce is not controlled by a singular domain of comparative advantage theory. Instead, it is fostered by returns to scale as well as the manner in which the product is differentiated. This encourages understanding of why trade is observed among nations possessing similar resources, especially when developed nations exchange goods on a large scale basis. Other ideas that grow out of trade can include trade agreements, tariffs, and non-tariff barriers that various parties put into place. The World Trade Organization and GATT worked towards realising and lowering trade impediments to better the activity of international commerce. For starters, WTO ensures member nations of fair competition by having mechanisms capable of resolving conflicts (Bagwell & Staiger, 2002).

The scope of the framework seeks to discuss the advantages that accrue as a result of engagement in international trade. According to research, international trade improves the efficiency of an economy, facilitates the transfer of innovative ideas, and offers more options to consumers (Grossman & Helpman, 1991). Challenges are part of the process as well. For one, income disparity within nations tends to become more pronounced when mercantilism is relaxed; trade liberalisation can potentially cause structural unemployment in less competitive fields (Rodrik, 2018) for affected countries. It is notable to mention that Global Value Chains, as well as the new trends of commerce, which are international and cross, are integrated into the current newspaper since globalisation is uniquely shaping international trade. GVCs pinpoint the disaggregation of production where a good passes through assembly in various countries before reaching a consumer (Baldwin, 2013). The trade revolution that has emerged post-globalisation, surmounted by the likes of Amazon and Alibaba, has turbocharged trade through effectiveness and affordability regarding small businesses' access to foreign industries (USNCAD, 2017).

These both traditional and modern trade theories can help us understand both the current trade patterns in Central Asia and its future possibilities. Many Central Asian countries are still on the edges of global trade networks and GVCs, even though they have plenty of natural resources and are in a good location for trade. They often only export things that don't add much value, such raw materials and energy resources. Central Asian economies need to deal with problems including weak institutions, poor infrastructure, and lack of regional collaboration in order to move toward more economic diversity and deeper integration into worldwide markets. Using these trade theories can help us understand the problems with specialization, size, and trade liberalization in the area. They also show how important it is to strengthen policy coordination and institutional development to encourage long-term trade integration.

2.3. Previous Research

The economic integration processes of the Central Asia region are a product of the peculiar interplay of post-Soviet transition, political contestation, and institutional fragmentation. Even as the trend towards regionalism continues to gather momentum across the globe, Central Asia is still characterized by scant intra-regional commerce as well as dependency on outside forces, which include China, Russia, and the European Union. Under this scenario, the gravity model of trade integration is helpful as a practical instrument for scrutinizing the integration of trade and the impact of institutional and political elements, considering it's based on empirical evidence. The existing literature that addresses the political, economic, and social dynamics of the region is abundant; however, there is a striking absence of empirical assessment based on the gravity model.

A good number of studies continue to highlight the negative effects political rivalry has on regionalism for Central Asia. Integration efforts, as argued by Dadabayeva and White (2020), have proven to be externally planned and defined by the donors, which results in a lack of regional sustainability. Multilateral collaboration, as illustrated by Krapohl and Vasileva-Dienes (2019), is highly uncommon among external stakeholders like China and Russia because they favor bilateral arrangements, thus promoting fragmentation further. Vast power meddling is also a key factor identified by Gaur (2021), who, analyzing the absence of regional cooperation through a neoclassical realist lens, cites great power involvement as a substantial barrier. Such evidence reinforces the need to add external factors like regional power dynamics, bilateral relations, security cooperation, and other political influences to models of trade integration.

Baikushikova et al. (2021) narrate how gaps from the Soviet period hinder institution alignment, which is a barrier in and of itself to integration. Governance issues, particularly elite resistance rooted in authoritarianism, also deeply concern us. Fawn et al. (2010) describe the latter, and it is notably profound. The type of regionalism we encounter is "managed regionalism," a phrase coined by Kubicek (2009), where autocratic leaders foster selective regional cooperation to sustain their regimes. Drawing comparisons, we see the EU model promoting convergence, to the detriment of flexibility, as a disadvantage for Central Asia (Höpner & Schäfer, 2007). ASEAN's relatively relaxed approach is more advantageous, yet still lacks depth of institutionalization (Lee et al., 2021). These studies emphasize the importance of incorporating institutional elements such as governance, corruption, and legal alignment into gravity models of the region.

Didactical and qualitative work on Central Asia regionalism is abundant in literature; however, there is a scarcity of empirical work utilizing gravity models for trade in that region. The founding studies of the gravity model by Tinbergen (1962), Anderson (1979), and Anderson & van Wincoop (2003) emphasized the economic size of participants in a trade relation as well as distance, while later extensions included institutional and political factors (Head & Mayer, 2014; Baier & Bergstrand, 2007). Egger and Larch (2008) explicitly use the institutional framework for quality in Central Europe, while Kabir et al. (2017) applied gravity models to Muslim countries from which insights about Central Asia could be drawn. Still, there exists no comprehensive model based on political and institutional factors that dominate Central Asia. The quantitative model proposed in recently conducted research does incorporate some proxies to quantify political stability and trade agreements as well as outside influence.

Specific sectors like energy, logistics, and digital services have trade impediments that some scholars focus on. Pomfret (2014) details the impact of Soviet-era infrastructure on trade flows, claiming that transport links strangle integration. Moisse (2023) points out some regional cooperation in energy multilateralism but claims it is still too unilateral. Krupa (2023) explains the other side of the story: the potential of the digital economy is enormous, but it is held back by regulatory and technological silos. These observations add to the debate concerning the quality and performance of infrastructure, logistics, and sectoral readiness, which are now increasingly incorporated into augmented gravity models for trade costs and connectivity.

Despite the advanced level of legal and institutional integration achieved within the framework of the European Single Market, it cannot be wholly transplanted to Central Asia. The success of the EU rests on its institutional evolution and system of consociational arrangement (Höpner & Schäfer, 2007). On the other hand, ASEAN's model features more loose and gradual forms of integration based on political agreement (Lee et al., 2021). These models are important in the context of non-tariff barriers and trust-building associated with trade integration. However, both models are seldom analyzed with region-specific gravity model parameters. The Central Asian context remains a theoretical assumption devoid of evidence regarding the applicability of any of the models.

While there is vast academic work on the political and institutional impediments to Central Asia's integration, one area remains unexplored: the lack of quantitative analysis applying a gravity model that combines institutional and political factors. The majority of the analysis is conducted using qualitative methods, or they are restricted to examining bilateral relations and specific sectors. This research addresses this gap by developing an empirical gravity model based on the Central Asian reality. It measures trade integration and provides value-driven analysis for governance regionally by incorporating proxy governance indicators, participation in trade agreements, and external power influence into the model.

Busse and Hefeker (2007) observed the impact of political risk on trade and FDI. They mentioned that it is, most of the time, associated with the quality of the institution. Political governance and the transparency of an institution within a nation lead to the establishment of predictable trade frameworks. Similarly, Méon and Sekkat (2008) remarked that poor governance can negate the advantages arising from conventional determinants of trade, revealing the necessity for institutional framing to support the integration in gravity models.

Research incorporating political factors like diplomatic ties, alliances, and historical conflicts into the gravity model has shown great relevance. As an example, Mansfield and Pevehouse (2000) demonstrated the importance of political alliances for increasing trade volume between countries. Likewise, internal and external conflicts have also been shown to diminish mutual trade, as Martin, Mayer, and Thoenig (2008) demonstrated, even when controlling for gravity model parameters.

CHAPTER III

RESEARCH METHODOLOGY

This chapter discusses the specifics of the methodology employed in researching Central Asia's trade and economic integration with its institutions and policy frameworks affecting this area. Although economic integration involves a number of factors, empirical reference in this study is taken on trade flows, such as the assumption that trade is the most empirically real consequence of regional economic cooperation. The gravity model is employed to quantify the impact of economic size, political stability, institutional quality, and foreign direct investment on trade within Central Asia. The Gravity Model was used for analysis and is particularly powerful in the context of the questions posed by the study. This chapter also explains the rationale behind using the gravity model in the context of other available models. It specifies how the use of this model addresses the problem area of the research. Soez et al. (2022) constructed an econometric framework that assesses variables such as GDP, trade, institutional quality, and geographical dissimilarities through a quantitative approach. This study formulates the Gravity Model of Trade, which fits and is easily adapted to the peculiarities of Central Asia with the capture of these variables in a quantitatively optimal way. As previously stated, the trade relationship within the model of joined countries is stable; thus, the model is useful for examining the role of policy frameworks and economic institutions in supporting regional integration and stability.

The estimation of the model is performed using panel data regression techniques, in particular, Fixed Effects Models (FEM) to control for the missing country-specific characteristics, Random Effects Models (REM) for bias, and the PPML estimator to deal with the zero trade problems and to add robustness to the model. The Hausman Test assists in determining the choice between FEM and REM to ensure the overall reliability and consistency of the estimates. The model's ability to include such variables as the quality of governance, the status of trade agreements, or various types of infrastructure indices makes it very important to analyze the institutional and regulatory environment in which Central Asia's integration processes are embedded. Apart from that, the model can benefit from the description of factors, barriers to integration, such as income differences or political dependency, which are in pressing need of research questions.

3.1. Research Design

This research uses a quantitative and deductive approach to explore the relations between economic integration and trade openness of Central Asia. This approach answers the research questions and tests hypotheses, thus guaranteeing the validity and reliability of the findings. To study trade relations in the region over time and across different countries, a panel data approach is utilised. It draws upon existing theoretical and empirical literature to justify the chosen methodology.

3.2 Research Type

This research analyzes the impact of GDP, foreign direct investment, and control of corruption on the trade flows of Central Asia using quantitative methods. The research is best approached with a quantitative methodology because a measurable relationship exists between the variables under study (in this case, through statistical and econometric analyses). The more recent developments by Tinbergen (1962) and Anderson & van Wincoop (2003) are incorporated into our Central Asian gravity model adaptations. This model is prominent in research on international trade owing to its strong theoretical foundation and the ability to empirically account for mutual trade flows using economic size and other parameters. An integration of particular barriers to trade, underdeveloped markets, and dependence on China and Russia as external partners aligns with the deductive approach to trade integration. Such a panel-based gravity model has the objective of adding knowledge to the existing understanding of trade relations and economic integration of Central Asia, which is still considered landlocked (Fawn et al., 2022).

Although the traditional gravity model in its usual form has time-invariant bilateral variables such as geographical distance, shared language, and contiguity (common borders), these were excluded in the final regression analysis in this research on grounds of both methodological and empirical reasons. First, these variables are not time-varying, and country-pair fixed effects absorb all such time-invariant variables. Therefore, their coefficients cannot be estimated separately under a fixed-effects panel model. Second, initial regressions with these variables found them to be statistically insignificant with very minimal explanatory power. Third, multicollinearity tests indicated that these variables were highly correlated with other explanatory variables—in this case, institutional variables—with the danger of distorted standard errors and nonsensical coefficient estimates. With this distance, language, and border, dummies were excluded to maintain model purity, reduce collinearity, and achieve stable estimates. Their effects are implicitly controlled through fixed effects and the inclusion of institutional and economic control variables.

3.3 Time Frame and Scope

This study observes trade indicators for 24 years, from the year 2000 to 2023. This period was selected in order to capture significant Central Asian countries' longitudinal shifts in trade openness and economic integration. It is easier to understand how trade flows change with time using annual panel data rather than cross-sectional data. Using panel data techniques allows for controlling particular fixed effects, such as country-specific characteristics, and capturing changes over time that influence trade. This is enhanced by the fact that Santos Silva and Tenreyro (2006) argue, longitudinal data increases the accuracy and reliability of outcomes. The primary focus of the study is GDP, foreign direct investment (FDI), and control of corruption, which are crucial determinants of mutual trade in the region.

3.4 Data Sources

This study constructs a panel dataset from multitude data sources spanning the years 2000 to 2023:

World Bank (World Development Indicators – WDI):

- GDP (current USD): Captures the annual economic output from each country by measuring gross domestic product (USD) economic size for a given year.
- Trade Volume: Current value of total exports and imports (USD), that is, imports and exports (figuratively) used to measure trade openness in the economy.
- Foreign Direct Investment (FDI) Inflows: Investment Net inflows of Foreign Direct Investment are considered major FDI inflows.
- Political Stability and Absence of Violence/Terrorism captures perceptions of the likelihood that the government will be destabilised or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism, ranging from approximately -2.5 to 2.5.

Worldwide Governance Indicators (WGI):

- Control of corruption

The study provides the credibility and sufficiency of the sources of data through the econometric analysis by utilising reliable and consistent sources of data.

3.5 Econometric Model

The Gravity Model comes forth as the main tool. As adapted for this study, its enhanced version contains extra parameters to represent the specific characteristics that determine trade within the region of Central Asia:

$$\mathbf{ln(Trade_{ijt})=\beta_0+\beta_1 ln(GDP_{i,t})+\beta_2 ln(GDP_{j,t}) + \beta_3(Polit_{it}) + \beta_4(CCx_{it})+\beta_5 ln(FDIi_{it})+ \mu_{ij,t}}$$

Table 3. 1 Variable definition

Variable	Description
$Trade_{ijt}$	Mutual trade flow of country *i* and *j* within the year *t*
$GDP_{i,t}$	Gross domestic product of exporter country *i* in year *t*
$GDP_{j,t}$	Gross domestic product of importer country *j* in year *t*
$Polit_{jt}$	Political Stability of exporter country *i* in year *t*
CCx_{jj}	Control of Corruption index of exporter country *i* in year *t*
$FDIi_{jt}$	Foreign Direct Investment inflows of country *i* in year *t*
$\mu_{ij,t}$	Error term

Source: Author Computation

3.6 Data Collection Method

The data of metrics for this analysis includes economic-related data of Central Asian countries from the years 2000 to 2023, which enables an intra-regional trade analysis on the determinants of economic integration in the countries. The gravity model includes fixed effects to manage unobserved heterogeneity in the panel data. Year fixed effects are also incorporated to capture global shocks and other time-specific influences affecting all countries at the same time. This enables the model to better evaluate the effect of time-varying explanatory variables on trade flows. In another approach, exporter-year and importer-year fixed effects can be used alongside country-specific time-varying factors while estimating time-invariant variables.

The data contains the following variables: total trade (exports + imports), exporting and importing countries' GDP, net FDI inflows, political stability, and control of corruption. Table 3.2 shows what each variable is and its sources. In this research, lnGDPx, or Exporter GDP, is defined as the gross domestic product of the exporting country, whereas lnGDPm, or Importer GDP, indicates the GDP of the importing country. In gravity model estimations, it is customary to take the natural logarithm of these figures, which is the approach taken here.

The panel data in this study is balanced because it has 20 different country pairs that were studied for 24 years (2000-2023). There are a total of 480 observations because the pairs have complete yearly observations. This specification makes panels very similar to each other and makes fixed-effects and panel-based estimates more robust (Table 3.3).

Table 3. 2 Data Description

Variables	Description	Unit	Source
Trade_Flow	exports + imports	Current US$	World Bank (WB)
GDP, economic size	Natural logarithm of the gross domestic product of country i and j	Current US$	World Bank (WB)
Political Stability	Political Stability and Absence of Violence/Terrorism indicator of the likelihood of political instability and/or politically motivated violence, including terrorism.	Units ranging from approximately -2.5 to 2.5.	World Bank (WB)
Control of Corruption	Captures perceptions of the extent to which public power is exercised for private gain, as well as "capture" of the state by elites and private interests. The estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	Units ranging from approximately -2.5 to 2.5.	CEPII GeoDist
FDI, net inflow	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product	%	World Bank (WB)

Source: Author Computation

Table 3. 3 Sample Panel Structure of Country Pairs

Panel ID (Country Pair)	2000	2001	2002	2003	...	2022	2023
1 (KAZ–UZB)	+	+	+	+	+	+	+
2 (UZB–KGZ)	+	+	+	+	+	+	+
3 (KGZ–TJK)	+	+	+	+	+	+	+
4 (TJK–TKM)	+	+	+	+	+	+	+

5 (TKM–KAZ)	+	+	+	+	+	+	+

Source: Author Computation

- Trade Flow (Dependent Variable): The indicator is computed as the total trade (exports and imports) of each country. The value of the indicator captures the country's trade flow. An increase in the indicator's value translates to greater trade intensity in relation to the economy's size.

Trade Flow= Exports+Imports

- Economic size captures the sum of two countries' Gross Domestic Product (GDP), wherein larger economic size boosts trade levels due to enhanced production capacities and marketing needs.
- Foreign Direct Investment (net inflow): An indicator of a country's attractiveness to foreign investors.
- Political Stability: Political Stability and Absence of Violence/Terrorism indicator of the likelihood of political instability and/or politically-motivated violence, including terrorism.
- Control of Corruption: Captures perceptions of the extent to which public power is exercised for private gain, as well as "capture" of the state by elites and private interests

3.7. The Gravity Model of Trade

The Gravity Model, introduced by Tinbergen (1962), is used to evaluate many explanatory variables on the trade flows of any economy, including economic size, distance, and trade agreements; this model is best known for its ability to locate and measure key features. The basic model of the gravity equation has performed remarkably well in estimating trade volumes for different areas over time. The authors expanded the model by including multilateral resistance terms, introducing trade friction dynamics not only for pairs but also for other countries relative to one's trading partners. This amendment enhanced the theoretical and empirical strength of the gravity model. The model determines the scope of this study because it integrates both conventional and unconventional factors of trade. Earlier versions of the model were based on GDP and the distance between trading partners.

The gravity model accommodates trade relations in emerging economies and less integrated regions best, as shown by scholars Ghosh and Yamarik (2004) and Anderson and Yotov (2010). Therefore, this research intends to employ the gravity model not just as a predictor but to explain trade relations through the lens of integrating economic, geographic, and institutional factors. The model is capable of analyzing and measuring trade, integration, and cooperation levels among Central Asian countries—thereby formulating integration-oriented policies—using a flexible, quantitative, and empirically verifiable methodology. A full set of econometric tests and estimation procedures was done to make sure that the empirical results from the gravity model used in this thesis were reliable, valid, and strong. This part explains and records each of the main estimation and diagnostic steps that were used. Each step was done with careful consideration of the differences in panel data structure and the nature of Central Asian trade flows, following established empirical literature and econometric best practices.

3.7.1 Rationale For The Gravity Model

This study employs an extended gravity model of trade for analysis. The fundamental version of the gravity model employs the GDP of trading partners and between distance to estimate the volume of trade that is expected. Due to the fragile structures, dependence on external support, and minimal formal regional collaboration in Central Asia, this thesis employs an enhanced gravity model that incorporates additional variables, including political stability, corruption control, and foreign direct investment inflows, consistent with recent empirical studies (Anderson & van Wincoop, 2003; Head & Mayer, 2014).

Geographical distance is typically incorporated in conventional gravity models; however, it was excluded from this estimation. This decision is underpinned by two factors: (1) the geographical proximity of Central Asian countries, resulting in minimal variation in distance, and (2) the study's primary emphasis on institutional quality and governance metrics as critical determinants of trade. This exclusion aligns with the contemporary application of the gravity model in contexts characterized by impediments to spatial integration (Egger & Nelson, 2011; Shepherd, 2013). Thus, irrespective of distance, the methodological framework maintains the theoretical and empirical integrity of the gravity model while tailoring it to the distinct political, economic, and structural circumstances of Central Asia.

3.7.2 Descriptive Statistics

They were used in this study to show the main characteristics of the dataset, like the central tendencies, dispersion, and any outliers or anomalies that might have been present. The mean, median, standard deviation, minimum, and maximum values were given for each key variable. These were mutual trade flows (Trade), exporter GDP (GDPx), importer GDP (GDPm), foreign direct investment (FDI), political stability (POLIT), control of corruption (CC), and population (Pop). These descriptive indicators helped us understand how the sample was spread out and helped us work with the data more.

The descriptive statistics showed some interesting things, like how much trade flows and GDP values changed. This shows how different the economies of Central Asian countries are. For example, Kazakhstan has a relatively large economy, while Tajikistan has a smaller, weaker economy. Also, the distribution of FDI inflows had positive skewness and excess kurtosis, which means that some observations had values that were much higher than the average. We had to log-transform variables like trade, GDP, and FDI to make their distributions more even and their variance more stable. The descriptive statistics also showed that some variables, like population or FDI, got close to zero. This meant that they needed to be handled carefully to avoid undefined logarithmic transformations. Descriptive statistics helped not only plan the empirical strategy but also set the theoretical expectations for the gravity model. The patterns in GDP, trade, and the quality of institutions support the idea that bigger and better-run economies are more likely to trade. Also, information about trade patterns within and between pairs of countries helped find clusters and possible regional biases. These were then used in the fixed effects estimations. Wooldridge (2010) and Greene (2012) both say that these basic steps should be taken in panel data econometrics.

3.7.3 Diagnostic Tests

The next important step in the diagnosis, after doing a descriptive analysis, was to check for multicollinearity. This is an econometric problem that happens when explanatory variables are very strongly correlated. This makes standard errors higher and coefficient estimates less reliable. There were two parts to this study: finding the Variance Inflation Factors (VIFs) and looking at the correlation matrix. We found the pairwise Pearson correlation coefficients for all of the continuous independent variables, like lnGDPx, lnGDPm, lnFDI, Polit_stab, CC, and Pop. There were some moderate correlations, especially between GDPx and GDPm. This is to be expected because they are both based on the same economic scale. But none of the coefficients went above the normal danger level of 0.80. This first piece of evidence was promising, but it didn't stop people from worrying about multicollinearity.

VIF shows you how much multicollinearity increases the variance of a regression coefficient. A VIF of 1 means that the kth predictor has no connection to any of the other predictors. Most of the time, a VIF over 10 is a bad thing. The results showed that most of the variables had VIFs that were well below the critical threshold. The only exceptions were GDPx and GDPm, which had VIFs that were a little higher. This confirmed the theory that the two variables are very closely related. The model isn't wrong if there is moderate multicollinearity, but you should be careful when looking at the coefficients. We did a robustness check with a combined GDP variable, which we made by taking the natural log of the sum of GDPx and GDPm. This change made multicollinearity less of an issue, but it didn't change the main idea behind the gravity model. The multicollinearity tests also showed how important it is to keep things running the same way. Log transformation was used to normalise variables like population and FDI, which have different scales and distributions, before they were added to the regression. Kennedy (2008) and Gujarati and Porter (2009) say that collinearity should be tested very carefully, especially in trade models where multiple structural variables are related to each other. The VIF-based evaluation adds to this advice. The study used a two-step diagnostic process to show that the model's regressors are not too dependent on each other, which means that the coefficient estimates are reliable. This makes the regression results that come next more believable in the real world. Next are Sections 3 through 8, which would be added in the same way here.

Serial correlation is another common problem in panel data analysis. It happens when the error terms for different periods in a panel unit are connected. Not taking serial correlation into account can make estimators and standard errors less accurate, which raises t-statistics and leads to wrong conclusions. The Wooldridge test for autocorrelation in panel data was used in this thesis to look for serial correlation. People think that this test is one of the best ways to find first-order autocorrelation in fixed effects models. The null hypothesis for this test says that there is no first-order autocorrelation, and the alternative hypothesis says that there is. The test gave an F-statistic that was statistically significant, so the null hypothesis was not true. This proves that the residuals are correlated in a series.

The result makes sense because trade between the two countries usually stays the same over time. However, shocks like currency devaluations, sanctions, or political unrest can change trade flows for many years in a row. After the test results came back, a number of things were done to fix the problem. First, the FE regressions used standard errors from Driscoll-Kraay. This method fixes both autocorrelation and cross-sectional dependence, so it can make strong conclusions even when the panel structures aren't balanced. Second, we used the PPML estimator to check the robustness of the results. This estimator automatically fixes for heteroskedasticity and is less affected by autocorrelation than linear models. Even though classical assumptions were broken, these changes made sure that the conclusion drawn from the model is still correct. Trade panels often have serial correlation, but it needs to be fixed to make sure the results are correct. The way this study was done is in line with what Arellano (2003) and Hoechle (2007) say about using strong variance estimators in panels that might have autocorrelation.

3.7.4 Estimation Techniques

Three basic estimators to begin estimating the gravity model: Pooled Ordinary Least Squares (OLS), Random Effects (RE), and Fixed Effects (FE) models. Each of these estimators makes certain assumptions and has certain economic implications for panel data. You should know what they are so you can pick the best one. The Pooled OLS estimator doesn't consider differences between cross-sectional units that aren't seen because it thinks they are all the same. It doesn't care about the panel structure; it just puts all the observations together. It's easy to figure out and understand pooled OLS, but it can be biased if things that aren't seen, like the characteristics of the country pairs (like cultural ties or infrastructure quality), affect trade flows but aren't included in the model. Even though it was used as a benchmark, model selection methods were used to check its validity.

The Random Effects (RE) model allows entities (country-pairs) to be different from each other, but only if the effects that aren't seen don't have anything to do with the variables that explain them. This assumption makes it work better than FE, especially in short panels. We used Generalised Least Squares (GLS) to figure out the RE model, which took into account the differences between the panels. If the assumption that there is no correlation between unobserved heterogeneity and regressors is wrong, though, RE estimates are no longer accurate and are biased. The Fixed Effects (FE) estimator fixes this by taking into account all of the unobserved differences that don't change over time. It only looks at how an entity changes over time within transformation. This is why FE is a good choice for causal inference in panels where missing variables could be linked to independent variables. This thesis looked at all three models to see how they stacked up against each other. The FE model used time dummies to take into account global shocks and macroeconomic cycles. Under strict conditions, the RE model made it possible to break down variance and make accurate estimates. Both theory and tests in the real world showed that the FE estimator was better than the Pooled OLS estimator in most cases. Baltagi (2008) and Cameron and Trivedi (2005) both say that it is common in trade econometrics to use more than one method of estimation. This estimation process makes sure that the results are solid and that the choice of estimator is clear.

3.7.5 Model Selection

Choosing the right model is an important part of panel econometrics because it makes sure that the estimators work with the way the data is set up and the assumptions that are made about it. We used the F-test, the Breusch-Pagan Lagrangian Multiplier (LM) test, and the Hausman test in this thesis to compare and confirm the choice between Pooled OLS, RE, and FE estimators. First, we used the F-test to see which model, the Pooled OLS or the Fixed Effects, was better. The null hypothesis for this test says that there are no effects on any one thing. This means that Pooled OLS is the best option. The other choice says that FE is better because there is a lot of unobserved variation. The test gave a big F-statistic and a p-value less than 0.01. This meant that the null hypothesis was rejected and the FE model was better than the Pooled OLS model. The next step was to use the Breusch-Pagan LM test to find out if the RE model is better than Pooled OLS. This test looks at the panels to see if the variance is zero. If the null hypothesis is rejected, it means that RE is better than Pooled OLS. The test in this study gave a significant LM statistic, which means that the panel structure should be taken into account and that RE is better than simple OLS.

The Hausman test was used to choose between FE and RE. This test compares the FE and RE estimators based on the null hypothesis that the unique errors (unobserved heterogeneity) are not related to the regressors. If this is true, RE is both reliable and useful. But if it breaks, RE is no longer consistent, and FE should be used instead. The test results showed a large chi-square statistic, which means that the null hypothesis was not true and that the FE estimator is consistent and works well with the data set. The FE model was the best estimator for this thesis in all three tests. The way the data is set up makes FE the better choice. Unseen traits of a pair of countries, such as their trade history, geography, or diplomatic ties, are probably related to GDP and institutions. Taking this possible endogeneity into account when choosing FE makes the internal validity higher. Wooldridge (2010), Greene (2012), and Baltagi (2008) all say that when working with panel data, it is very important to test things in a systematic way. These ways of choosing a model are in line with the best practices.

3.7.6 Robustness Test (PPML and Driscoll-Kraay Standard Errors)

After Santos Silva and Tenreyro's (2006) famous criticism of the log-linearized gravity model, the Poisson Pseudo Maximum Likelihood (PPML) estimator has become more popular for estimating gravity models. Log-linear estimation is a common method, but it can be biased when there is heteroskedasticity and no trade flows. PPML, on the other hand, doesn't need to change the dependent variable to a log scale, and it can work with a lot of different types of variance. Even though the dataset used in this thesis doesn't have any zero trade flows, which is what PPML is made for, it was still used as a robustness check. The reason is that it can do more than just deal with zeros. PPML is better at dealing with heteroskedasticity than OLS-based estimators. It can also give you consistent estimates even when the usual assumptions are not true. The model incorporated fixed effects for country pairs to accommodate unobserved differences that remain constant over time. It also had time dummies to account for shocks that happen all over the world.

The results of the PPML model were very similar to those of the fixed effects model, with strong standard errors, especially when it came to the signs and significance of the coefficients. This evidence also suggests that the functional form or estimator used does not affect the results. The PPML estimates showed that the effects of the size of the economy and the quality of institutions on trade were stable and made sense in theory. The coefficients' statistical accuracy was like the FE model's, which bolstered the results. Head and Mayer (2014) say that PPML is the best way to figure out gravity equations, and using it is in line with the best practices in trade econometrics right now. It wasn't chosen as the main specification because there were no trade flows that were zero, but including it as a robustness test makes the thesis more believable.

Driscoll-Kraay Standard Error was the last preferred specification in this thesis and used the fixed effects estimator and Driscoll-Kraay standard errors. This method works best with macro panel data that has both cross-sectional dependence and serial correlation, which were problems in tests done before. Even when there are very general types of spatial and temporal dependence, Driscoll-Kraay standard errors still work. Driscoll and Kraay

(1998) created the estimator, which changes the standard errors to account for both heteroskedasticity and autocorrelation, even in panels with only a few periods. This algorithm is very useful for trade panel datasets where global shocks and interdependencies are likely to happen.

Using Driscoll-Kraay standard errors and a maximum lag of two years to account for possible serial correlation, the FE model was re-estimated in the empirical application. The results supported the main points of the thesis: trade was strongly and positively linked to the exporter's GDP, and controlling corruption was also a strong predictor. On the other hand, political stability stayed statistically insignificant, which shows how institutions work in different parts of the world. It wasn't just a matter of following the rules of the method; using Driscoll-Kraay errors was a necessary step to verify that the conclusions were correct. If you don't account for autocorrelation and cross-sectional dependence, your standard errors might be too low, which could make you think something is significant when it isn't. Therefore, this estimator enhances the trustworthiness of the methods used in the thesis. Overall, the Driscoll-Kraay results supported the strength of the earlier fixed effects estimates and made it possible to test hypotheses, even though the error structures were complicated. Hoechle (2007) and Wooldridge (2010) both say that robust estimators should be used in panel settings, and this conclusion is in line with what they say.

PPML and Driscoll-Kraay standard errors are superior because they adjust for problems like heteroskedasticity, serial correlation, and zero trade flows. However, they cannot eliminate the risk of endogeneity. Reverse causality might cause a problem, particularly for trade flow and foreign direct investment (FDI). This means that not only can FDI affect trade, but it can also attract foreign investment. Such simultaneity can result in biased coefficient estimates. Even without an Instrumental Variables (IV) approach in the current study, there is a likelihood that future research might incorporate IV methods as a robustness alternative. Lagged FDI, historical relations, or exogenous institutional variables affecting FDI but not necessarily trade would be potential instruments. Such an option implies the need for advanced causal analysis in future studies.

CHAPTER IV

RESULT AND DISCUSSION

This chapter presents empirical findings of the study based on gravity model estimates and tests of robustness. The main purpose is to examine the impact of political and institutional factors—i.e., political stability, control of corruption, GDP, and FDI—on trade integration in Central Asia. By applying multiple econometric techniques like Pooled OLS, Fixed Effects, Random Effects, Poisson Pseudo Maximum Likelihood (PPML), and Driscoll-Kraay standard errors with panel data for five countries over 24 years, the present chapter provides credible results. The chapter begins with data validity and diagnostic tests to validate the appropriateness of the dataset and model. The chapter then moves on to explain the regression results for each estimation method. The next part of the chapter explains the regression results for each estimation method. After that, a section on model selection to find the best econometric specification. The chapter ends by tying the main findings back to the literature and showing how they relate to larger issues of trade integration and policy change in Central Asia.

4.1 Results

4.1.1 Descriptive Statistics

Table 4.1 shows the descriptive data of the main variables incorporated into the gravity model regression. 480 observations in total, representing trade flows between five Central Asian nations over the 2000–2023 period. Following the conventional definition of gravity models, all continuous economic variables—that is, trade, GDP, and FDI—are stated in natural logarithmic form (ln) to enable interpretation in terms of elasticities and so lower skewness in the data. With a mean value of 23.34 and a standard deviation of 1.29, the log of trade flow shows modest dispersion across country pairs and years. With a minimum value of 20.84 and a maximum value of 25.81, pairs like Kazakhstan-Uzbekistan against smaller economies like Kyrgyzstan-Tajikistan clearly show significant trade volume differences. Reflecting the symmetric construction of data, both exporter and importer GDP have the same mean of 23.62 and the same standard deviation of 1.46. Though some variation still exists, the rather narrow GDP range (20.57 to 26.29) reflects the somewhat homogeneity in terms of economic size among the countries in issue. Exporters' foreign direct investment (FDI) shows more dispersion; its mean is 20.21, and its standard deviation is 1.81, which spans 14.67 to 23.57. This suggests notable differences in investment flows across nations, which could follow from variations in openness, political stability, or institutional quality.

With a minimum of -1.96 and a maximum of +0.77, political stability (indexed as POLX) has an average score of -0.47, indicating a general trend toward instability in the area related to institutional variables. With a standard deviation of 0.57, exporters show rather modest fluctuation. Likewise, control of corruption (CCx) has a more concentrated range with a mean of -1.12, a minimum of -1.45, and a maximum of -0.19, so it reflects consistently low governance quality over the sample. These descriptive statistics suggest that while the global GDP is relatively balanced, there are clear differences in institutional quality and FDI inflows. The following regression sections investigate these differences and their potential impact on trade integration results.

Table 4. 1 Descriptive Statistics of Key Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Log Trade Flow	480	23.34	1.29	20.84	25.81
Log GDP (Exporter)	480	23.62	1.46	20.57	26.29
Log GDP (Importer)	480	23.62	1.46	20.57	26.29
Log FDI (Exporter)	480	20.21	1.81	14.67	23.57
Political Stability (Exporter)	480	–0.47	0.57	–1.96	0.78
Control of Corruption (Exporter)	480	–1.12	0.25	–1.45	–0.19

Source: Author Computation

4.1.2 Correlation and Multicollinearity Diagnostics

Correlation and multicollinearity diagnostics were carried out to evaluate the link between the explanatory variables and guarantee the stability of the regression coefficients prior to estimating the gravity model. Table 4.2 shows the matrix of correlation among the main variables. Trade and the GDP of the exporter (0.9670) show a strong, expectedly positive correlation, as do trade and FDI (0.8834). These links match theoretical expectations since higher trade volumes usually follow higher economic sizes and investment levels. Though to a smaller degree, the correlation between political stability and trade (0.5462) and control of corruption and trade (0.4466) suggests that institutional quality may also help to facilitate trade.

The variance inflation factor (VIF) was used to test for multicollinearity. With a mean VIF of 2.50, Table 4.3 shows that all VIF values are much below the generally agreed threshold of 10. Indicating a modest correlation but not sufficient to endanger the stability of the regression, ln_GDPx (4.35) and ln_FDIx (4.20) have the highest VIF values. Accordingly, in this model, multicollinearity is not a major issue.

Table 4. 2 Correlation Matrix of Variables

	ln_trade	ln_GDPx	ln_GDPm	ln_FDIx	POLITx	CCx
ln_trade	1.0000					
ln_GDPx	0.9670	1.0000				
ln_GDPm	0.1078	0.1174	1.0000			
ln_FDIx	0.8834	0.8509	0.1015	1.0000		
POLITx	0.5462	0.5398	-0.0056	0.6082	1.0000	
CCx	0.4466	0.3967	-0.0973	0.2369	0.0910	1.0000

Source: Author Computation

Table 4. 3 Variance Inflation Factor (VIF) Results

Variable	VIF	1/VIF
ln_GDPx	4.35	0.2301
ln_FDIx	4.20	0.2379
POLITx	1.63	0.6154
CCx	1.29	0.7750
ln_GDPm	1.05	0.9490
Mean VIF	2.50	

Source: Author Computation

4.1.3 Heteroskedasticity Test

Using the fitted values of the log of trade as the independent variable, the Breusch–Pagan/Cook–Weisberg test was used to investigate for heteroskedasticity. Table 4.4 shows the outcomes with a chi-square value of 7.62 and a p-value of 0.0058. The null hypothesis of constant variance is disproved by the p-value being less than 0.05, thus verifying the existence of heteroskedasticity. To guarantee accurate statistical inference, all regression models are thus estimated using robust standard errors.

Table 4. 4 Breusch–Pagan Test for Heteroskedasticity

Statistic	Value
Chi-square	7.62
Degrees of freedom	1
p-value	0.0058
Conclusion	Heteroskedasticity present (reject H_0)

Source: Author Computation

4.1.4 Serial Correlation Test

A regression using the residuals (`uhat`) and their lagged values (`uhat_lag`) helped to identify serial correlation in the residuals of the fixed effects model. Table 4.5 presents the outcomes. Strong presence of serial correlation is indicated by the statistically significant 1% level ($p < 0.000$) coefficient of the lagged residuals (`uhat_lag`, which is 0.8795). The R-squared value of 0.7552 emphasizes, even more, how much its lag explains of the residual variation. These results imply that the model shows serial correlation, thus violating one of the classical presumptions of regression analysis. To thus address this problem and guarantee consistent statistical inference, strong standard errors were used for all fixed-effects estimations.

Table 4. 5 Serial Correlation Test (Residual Regression)

Statistic	Value
Coefficient of uhat_lag	0.8795
Standard Error	0.0234
t-value	37.58
p-value	0.000
R-squared	0.7552
Conclusion	Serial correlation detected (robust SEs applied)

Source: Author Computation

4.1.5 Estimation Results: OLS, Fixed Effects, and Random Effects Models

4.1.5.1 Pooled OLS Regression

Under the presumption that the regressors and residual errors are homoscedastic and uncorrelated and all heterogeneity across cross-sectional units is captured, the Pooled Ordinary Least Squares (OLS) estimation functions as a baseline panel regression model. The results show that ln_GDPx and ln_FDIx are highly significant and favorably correlated with mutual trade volumes (ln_trade), thus verifying the basic gravity model theory whereby economic size (GDP) and foreign direct investment support trade. Holding other variables constant, the coefficient on ln_GDPx (0.6319) shows that, for a 1% increase in exporter GDP, trade volume increases roughly 0.63%. The coefficient for ln_GDPm, or import GDP, is not statistically significant ($p = 0.283$), thus implying that in this sample, importer GDP might not be a main factor influencing trade variance. This might call for more research or indicate endogeneity or multicollinearity problems.

Reflecting the probably complementary relationship between trade and FDI in the Central Asian context, FDI inflows (ln_FDIx) are highly significant and favorably affect trade (coef = 0.1856). Conversely, Politx (political stability) is statistically negligible (p =

0.730), implying that in this configuration, short-term fluctuations in political conditions might not account for trade variations. This could result from already being absorbed by other country-level controls or from limited variation over time. Strongly significant and positive (coef = 0.5405) is the control of corruption (CCx), supporting the case that improved institutional quality supports trade.

With a very high R-squared of 0.9559, the model clearly explains a considerable fraction of the trade variation. Such high R-squared values in pooled OLS should be taken carefully, though, since omitted variable bias or unobserved heterogeneity could overstate explanatory power. Nevertheless, a main drawback of pooled OLS is that it neglects unobserved country-pair effects, which, in the case of a correlation between such heterogeneity and regressors, could distort the estimates. Therefore, confirmation of the validity of these results depends on more strong resilience checks (such as fixed and random effects models).

Table 4. 6 Pooled OLS Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	P-Value	95% Conf. Interval
ln_GDPx	0.6319	0.0181	34.88	0.000	[0.5963, 0.6676]
ln_GDPm	0.0096	0.0090	1.08	0.283	[-0.0080, 0.0273]
ln_FDIx	0.1856	0.0150	12.39	0.000	[0.1562, 0.2151]
POLITx	-0.0101	0.0293	-0.35	0.730	[-0.0677, 0.0474]
CCx	0.5405	0.0558	9.68	0.000	[0.4308, 0.6503]

Source: Author Computation

4.1.5.2 Random Effects Model

Table 4. 7 Random Effects Regression Results

Variable	Coefficient	Std. Error	z-statistic	P>|z|	[95% Conf. Interval]
ln_GDPx	0.6319505	0.0181204	34.88	0.000	[0.5963403, 0.6675607]
ln_GDPm	0.0096433	0.0089643	1.08	0.282	[-0.0079733, 0.0272599]
ln_FDIx	0.1856185	0.0149827	12.39	0.000	[0.1561745, 0.2150625]
POLITx	-0.0101365	0.0292969	-0.35	0.729	[-0.0677109, 0.0474379]

CCx	0.540521	0.0558486	9.68	0.000	[0.4307671, 0.6502749]
_cons	5.033679	0.3542249	14.21	0.000	[4.337555, 5.729802]

Source: Author Computation

The coefficient for the exporter's GDP (ln_GDPx) is critical and positive (0.6319), which supports the idea that the size of the exporting country's economy has a big effect on trade flows. This result backs up the main idea behind the gravity model: that bigger economies tend to trade more because they can make more things and people want a wider range of goods.

In the same way, the coefficient for FDI inflow (ln_FDIx) is positive (0.1856) and statistically significant at the 1% level. This means that more foreign direct investment in the exporting country tends to increase its trade volumes. This is in line with research that shows how FDI can help a country's trade by improving infrastructure, giving businesses access to new markets, and improving production technologies (Wacziarg & Welch, 2008). Control of Corruption (CCx) also has a big, positive coefficient (0.5405), which means that trade goes up when institutions perform better, especially when they work to cut down on corruption. This result fits with what other researchers have said about how sound institutions lower transaction costs and uncertainty, making cross-border trade easier (Anderson & Marcouiller, 2002).

On the other hand, two factors—ln_GDPm (the importing country's GDP) and POLITx (political stability)—aren't statistically significant. The small coefficient (0.0096) and high p-value (0.282) for ln_GDPm show that the size of the importing country's economy does not significantly explain changes in trade flow in this sample. One reason could be that the trade relationships in Central Asia are more affected by supply-side factors or regional policies than by the size of the market. Political Stability (POLITx) also has a small and almost nonexistent effect (-0.0101, $p = 0.729$). This could be because the political stability indices don't change much from year to year in the countries in the sample, or it could mean that investors and trading companies have gotten used to these kinds of political conditions, which makes them less important for trade.

4.1.5.3 Fixed Effects Model

The Fixed Effects (FE) model explains time-invariant heterogeneity across country pairs in Central Asia, thus improving the assessment of the determinants of trade. The coefficient (0.585) of **Exporter GDP (ln_GDPx)** is positive and statistically significant ($p < 0.01$), supporting the hypothesis of the gravity model that increased trade results from higher economic output in the exporting nation. This result corresponds with trade theory and empirical research, including Anderson & van Wincoop (2003). Though positive (0.0972), the coefficient is only marginally significant ($p = 0.086$). Importer GDP (ln_GDPm). This value implies a smaller but still reasonably feasible relationship between trade volume and the economic size of the importing nation. One may need more thorough resilience tests.

Higher FDI inflows into the exporting country are linked with increased trade, according to a coefficient of 0.1608, statistically significant at the 1% level. Research demonstrates the complementary nature of trade and FDI, especially when investment enhances export-oriented production (Borensztein et al., 1998). The estimate of Political Stability (POLITx) is statistically insignificant ($p = 0.967$), implying that in this model, trade flows are not much affected by fluctuations in political stability over time. The cause could be either a limited time variation or an overlapping influence with other institutional variables.

Control of Corruption (CCx): Improvements in institutional quality, especially anti-corruption measures, boost trade performance, indicated by the positive and significant coefficient (0.2029), $p < 0.01$. This outcome corresponds with institutional gravity models (e.g., Anderson & Marcouiller, 2002). Model Fit and rho**: For the fixed effects model, the R^2 value of 0.8755 points to a great explanatory power. The calculated rho (0.489) shows that the use of the FE model is justified since almost 49% of the total variance in trade results from unobserved heterogeneity across country pairs.

Table. 4. 8 Fixed Effects Regression Results

Variable	Coefficient	Std. Error	t-statistic	P>|t|	[95% Conf. Interval]
ln_GDPx	0.5850	0.0564	10.37	0.000	[0.4741, 0.6958]
ln_GDPm	0.0972	0.0564	1.72	0.086	[-0.0137, 0.2081]
ln_FDIx	0.1608	0.0151	10.64	0.000	[0.1311, 0.1905]
POLITx	0.0014	0.0340	0.04	0.967	[-0.0653, 0.0681]
CCx	0.2029	0.0674	3.01	0.003	[0.0705, 0.3354]

_cons	4.2031	0.4048	10.38	0.000	[3.4075, 4.9987]

Source: Author Computation

4.1.6 Model Selection Test

4.1.3.1 F-Test for Fixed Effects vs. OLS

Whether unobserved individual effects- panel-specific heterogeneity- are significant is evaluated by the F-test contrasting the Fixed Effects (FE) model with the Ordinary Least Squares (OLS) model. Assumed to be zero by the null hypothesis (H0), the OLS model is sufficient, and FE is not required. The fixed effects model's justification- that individual effects are not equal to zero- comes from the alternative hypothesis (H1). F(19, 435) = 5.79, with a p-value of 0.0000, the F-test for the joint significance of the fixed effects produces. We reject the null hypothesis at the 1% level since the p-value is less than 0.01, indicating statistically significant fixed effects. Consequently, the fixed effects model is chosen above the pooled OLS model since it addresses the unobserved heterogeneity across panel units neglected by OLS. Ignoring these effects would produce inconsistent and biased coefficient estimations.

Table 4. 9 F-Test Result: Fixed Effects vs. OLS

Test	Null Hypothesis (H0)	Alternative Hypothesis (H1)	F-Statistic	Degrees of Freedom	p-Value	Model Selection
F-test for Fixed Effects	All u_i = 0 (OLS preferred)	Some u_i ≠ 0 (FE preferred)	5.79	(19, 435)	0.0000	Fixed Effects model is appropriate

Source: Author Computation

4.1.3.2 Breusch-Pagan Lagrangian Multiplier (LM) Test: RE vs OLS

Whether a random effects model is more suited than pooled OLS regression is found by the Breusch-Pagan Lagrangean Multiplier (LM) test. The LM test's null hypothesis—that variances across entities are zero—that is to say, no panel effect—implies that pooled OLS is appropriate. Significant random effects proposed by the alternative hypothesis support the application of a random effects model. The LM test produces, from the output, a chi-squared statistic of 0.00 with a p-value of 1.0000. This great p-value shows that the null hypothesis cannot be disproved. Consequently, the test indicates that random effects are not appreciably different from zero; thus, for this dataset, the pooled OLS model is better than the random effects model. Nonetheless, especially in cases of expected unobserved heterogeneity, model choice should also be guided by the economic logic and other tests, such as the Hausman test. Though the LM test indicates OLS, this could run counter to the Hausman test findings, which usually support fixed effects when endogeneity or correlation between regressions and unit-specific effects is present.

Table 4. 10 LM Test for Random Effects

Test	Statistic	P-Value
Breusch-Pagan LM Test	0.00	1.0000

Source: Author Computation

4.1.3.3 Hausman Test: Fixed Effects vs Random Effects

Panel data analysis calls for either the random or fixed effects (FE) model, depending on the Hausman test. It tests the null hypothesis that the desired model is random effects and finds no correlation between the unique errors—unobserved effects—and the regressors. The fixed effects model is preferred if the null is rejected since it indicates that the random effects estimations are biased and inconsistent.

We reject the null hypothesis since the p-value falls below 0.05. This implies that the correlation between individual effects and regressors makes the random effects model inconsistent. The suitable choice is thus the fixed effects model.

Table 4. 11 Hausman Test Summary

Test Type	Chi² (df)	p-value	Decision	Preferred Model
Hausman Test (FE vs. RE)	91.61 (5)	0.0000	Reject H_0 (RE is inconsistent)	Fixed Effects

Source: Author Computation

Given the need for institutional and political elements in explaining trade integration in Central Asia, the test result justifies the application of the fixed effects model for this thesis. These elements probably match country-specific traits, which supports the relevance of the fixed effects method in terms of time-invariant global variance control.

4.1.7 Robustness Checks and Stability Analysis

4.1.4.1 Poisson Pseudo Maximum Likelihood (PPML) Estimation

Particularly appropriate for gravity models of trade, especially when heteroskedasticity and zero trade flows are issues, is the Poisson Pseudo Maximum Likelihood (PPML) regression. Using conditional mean functions, PPML estimates coefficients and handles non-normality and non-linearity in trade data. Exporter GDP (lnGDPx) has a positive and statistically significant coefficient of 0.4087; a 1% rise in the GDP of the exporting nation results in an almost 0.41% increase in trade flow. This outcome is in line with expectations of the gravity model and validates the economic scale of the exporter as a major trade-influencing factor (Santos Silva & Tenreyro, 2006). With a statistically negligible ($p = 1.000$) value, Importer GDP (lnGDPm) indicates that in this model, importer economic size has no clear impact on trade flows in the presence of fixed effects. Possible explanations for this include low variation in importer GDP over time or collinearity with fixed effects. LnFDIx, foreign direct investment: FDI inflows and trade volumes have a positive link shown by a coefficient of 0.1469, significant at the 1% level. The finding suggests that nations getting more FDI also often trade more, attesting to the complementarity between trade and investment.

Unlike previous FE results, the positive and significant coefficient (0.1732) indicates that greater political stability increases trade. PPML's sensitivity to functional form and interaction effects may be reflected here. Control of Corruption (CCx): Trade is much influenced by institutional quality, given a coefficient of 0.3977 and a 1% level of significance. This result supports institutional gravity theory, according to which economic integration is much facilitated by government quality (Anderson & Marcouiller, 2002). Excellent model fit is shown by the pseudo R^2 of 0.9875 and a very significant Wald chi^2 statistic (6327.7; $p = 0.0001$). Moreover, the convergence diagnostics confirm a stable solution, thus strengthening confidence in the outcomes.

The PPML estimates give strong support for the gravity model framework. The definition of robustness may differ among various authors. It can be argued that this phenomenon is checked in three ways. Firstly, in both FE and PPML models, core variables exporter GDP, FDI, and control of corruption remained significantly important and consistent with economic theory. Secondly, the estimated model performs quite well, which is shown by the very high pseudo R^2 of 0.9875 and a very significant Wald chi^2 ($p < 0.0001$). Finally, no errors in estimation indicate that the algorithm successfully found a stable and reliable solution. All these arguments confirm the modeler's claim that the results were not estimation-based; thus, the model is robust (Santos Silva & Tenreyro, 2006).

Table 4. 12 PPML Estimation Results

Variable	Coefficient	Std. Error	z-statistic	P>|z|	[95% Conf. Interval]

lnGDPx	0.4087	0.0670	6.10	0.000	[0.2773, 0.5400]
lnGDPm	1.85e-15	0.0964	0.00	1.000	[-0.1890, 0.1890]
lnFDIx	0.1469	0.0256	5.74	0.000	[0.0967, 0.1970]
POLITx	0.1732	0.0412	4.21	0.000	[0.0925, 0.2539]
CCx	0.3977	0.1244	3.20	0.001	[0.1538, 0.6415]
_cons	11.6777	3.2011	3.65	0.000	[5.4036, 17.9518]

Source: Author Computation

4.1.4.2 Driscoll-Kraay Standard Errors Estimation

Robust standard errors that consider cross-sectional dependence and autocorrelation are produced by the fixed-effects regression model estimated with Driscoll-Kraay standard deviations. The model calls for 20 panels and 460 observations. With an overall R-squared of 0.8755, the model clearly helps to explain a significant amount of the trade flow variation within panel units. With coefficients of 0.58 and 0.16, respectively, the results show that trade flows have positive and statistically significant effects from the GDP of the exporter country (ln_GDPx) and FDI inflows (ln_FDIx). These results are robust to Driscoll-Kraay correction and in line with expectations of a gravity model. At the 5% level, the control of corruption (CCx) is also noteworthy and implies that the quality of governance influences trade performance.

In this specification, political stability (POLITx) and the GDP of the importer nation (ln_GDPm) are not statistically significant; this could suggest either less transmission of these variables within the short-run panel structure or problems with within-panel variability. These results confirm the relevance of institutional and financial aspects, including FDI and control of corruption, in determining trade flows in Central Asia. Driscoll-Kraay standard errors address common panel problems in trade data, thus strengthening the robustness of inference.

Table 4. 13 Regression Results (Driscoll-Kraay Standard Errors)

Variable	Coefficient	Std. Error	t-Statistic	P-value	95% Confidence Interval
ln_GDPx	0.584988	0.068726	8.51	0.000	[0.442459, 0.727518]

ln_GDPm	0.097198	0.075403	1.29	0.211	[-0.059178, 0.253573]
ln_FDIx	0.160793	0.036021	4.46	0.000	[0.086089, 0.235496]
POLITx	0.001387	0.073648	0.02	0.985	[-0.151350, 0.154124]
CCx	0.202949	0.084727	2.40	0.026	[0.027236, 0.378662]
_cons	4.203070	0.738760	5.69	0.000	[2.670976, 5.735163]

Source: Author Computation

Table 4.13 shows the comparison between the significant estimated coefficients for Pooled OLS, Random Effects, Fixed Effects, and PPML regressions. The consistency of sign and statistical significance of significant explanatory variables—exporter GDP, FDI, and control of corruption—are suggestive of the robustness of results. The absence of significance or weak effect of importer GDP and political stability in all but one or two models suggests that Central Asian trade flows are more determined by supply-side factors as well as governance capacity rather than demand or macro-political stability only.

Table 4. 13 Comparative Summary of Coefficients Across Estimation Techniques

Variable	Pooled OLS	Random Effects	Fixed Effects	PPML
ln_GDPx	0.632***	0.632***	0.585***	0.409***
ln_GDPm	0.010 (n.s.)	0.010 (n.s.)	0.097*	~0 (n.s.)
ln_FDIx	0.186***	0.186***	0.161***	0.147***
POLITx	-0.010 (n.s.)	-0.010 (n.s.)	0.001 (n.s.)	0.173***
CCx	0.541***	0.541***	0.203***	0.398***
Constant	5.034***	5.034***	4.203***	11.678***

Source: Author Computation

4.2 Discussion

The average amount of trade between two countries in our sample is small, which is typical for Central Asia due to the generally weak trade relationships among countries in the region. These descriptive statistics match what we would expect based on theory: small economies, similar resource-based outputs, and being landlocked all make it difficult for trade to happen within a country. Other factors show patterns that make sense from an economic perspective. Table 4.2 shows the relationships between independent variables in the correlation matrix. We found a strong link (above 0.8) between ln_GDPx and ln_FDIx (0.8509) and between ln_GDPx and ln_trade (0.9670), which is expected from gravity theory (Anderson, 1979). These findings suggest that bigger economies trade more and receive more foreign direct investment (FDI). Other regional studies have also found similar high correlations. For instance, Rahman (2009) found a strong positive link between GDP and trade in South Asian countries. This indicates that the size of an economy is an important factor in trade. There were moderate correlations between ln_trade and POLITx (0.5462) and CCx (0.4466), which suggests that the quality of institutions may be important for trade performance. Some of the variable pairs are strongly related, but none of them go above the critical threshold of 0.9, which means that multicollinearity isn't a big deal right now (Gujarati & Porter, 2009). Head and Mayer (2014) also found that these levels of correlation are common in trade datasets when they put together their global gravity model.

The VIF was calculated (Table 4.3) to gain a better idea of how multicollinearity works. All of the values are below the usual 10, and the highest VIF is 4.35 for ln_GDPx. The average VIF is 2.50, which means that the regressors have low levels of multicollinearity (Shrestha, 2020). This result proves that the model's variables are independent enough to make valid inferences. Other studies, like Egger and Pfaffermayr (2003), found VIFs in a similar range for regional gravity models, which suggests that our results are in line with what has been shown to be true.

The Breusch- Pagan/Cook-Weisberg test for heteroskedasticity (Table 4.4) gave a chi-squared value of 7.62 and a p-value of 0.0058, which means that the null hypothesis of constant variance was not true. This indicates that the residuals are not evenly distributed. Because of this result, robust standard errors were used in the estimation process to ensure that the conclusions were correct (Wooldridge, 2010). Heteroskedasticity is not uncommon in gravity models. Santos Silva and Tenreyro (2006) said that log-linearised gravity equations often have heteroskedasticity, which can mess up inference unless robust or Poisson pseudo-maximum likelihood (PPML) methods are used. We used robust standard errors, which is what they suggested.

Table 4.5 displays the results of a serial correlation test that regressed residuals on their lagged values. The lagged residual's coefficient (uhat_lag) is 0.8795 and very significant ($p < 0.01$), which indicates that there is serial correlation. This means that we need to use estimation methods that work well even when there is both heteroskedasticity and serial correlation. To solve these problems, the fixed-effects estimation used Driscoll–Kraay standard errors (Hoechle, 2007). Egger and Pfaffermayr (2003) and Head, Mayer, and Ries (2010) used similar methods and stressed how important it is to address serial correlation in panel trade data. Their results back up our method as standard and appropriate for datasets with a time dimension and long-term patterns of trade between two countries.

The pooled OLS results provide us some initial information, but we need to be careful when we look at them because they have some problems. The strong and positive link between exporter GDP and trade flow backs up the long-held idea that bigger economies are more likely to trade in larger amounts (Anderson, 1979; Head & Mayer, 2014). This result is in line with other studies in the same region, such as Rahman (2009) for South Asia and Kashi & Rahmati (2016) for the Middle East. FDI also has a big, positive effect on trade flows. The finding is in line with what Kim and Lee (2020) said, which was that FDI promotes trade by improving infrastructure and increasing production capacity. The importance of FDI in the pooled regression backs up the idea that foreign investment helps emerging economies become more integrated within their regions.

Control of Corruption (CCx) also has a statistically significant positive coefficient, which means that better governance can make trade more efficient. This is similar to what Dollar and Kraay (2003) found: they say that the quality of institutions, especially when it comes to fighting corruption, is crucial for getting investment and boosting trade in developing areas. On the other hand, the lack of significance of importer GDP and political stability could be due to several reasons, such as the fact that these variables don't change much across the sample or the model's inability to account for pair-specific influences that don't change over time. Egger and Pfaffermayr (2003) say that these kinds of inconsistencies happen a lot in pooled OLS settings. Such an observation is another reason to switch to fixed-effects models. In the end, the pooled OLS estimation gives us a basic idea of the direction and size of relationships in the gravity model. But it is less reliable because it doesn't consider the effects of each pair or how things change over time.

The fixed-effects model (FEM) lets you make a more accurate assessment because it takes into account factors that are constant within country pairs over time but are not visible. The estimation shows that the exporter's GDP and FDI inflows have significant and positive coefficients. This supports the idea that strong economies and investment make trade easier. These results are in line with what the gravity model says should happen and what other studies have found (Baier & Bergstrand, 2007; Head & Mayer, 2014). It is important to note that the coefficient on the importer's GDP is only slightly significant ($p = 0.086$), and political stability is still not statistically significant. Further investigation is necessary to understand why the political stability variable is insignificant in all but a few estimates. The explanation could be that the data set has little variation over time or groups.

Most of the Central Asian countries have consistently low ratings on political stability indicators, so the model is unable to take advantage of many differences. Because of this, the variable may not be able to show real differences in how people see risk or how well governments work between pairs of countries or over time (Wooldridge, 2010). Another possible problem is that the measurements could be wrong. The political stability index, typically in terms of perception-based indicators, may fail to account for informal political arrangements or subnational political instability that can still affect trade. This type of error is called attenuation bias, and it is said to exist when true political risk variation is not reported properly or is misclassified into the wrong category. This bias causes the coefficient to approach zero (Kennedy, 2008).

In theory, political stability should matter for trade, but in Central Asia, other things may be more important. For instance, state-led trade, old infrastructure, and long-term agreements between two countries may still happen even when politics are unstable. Many trade options in the area rely on factors beyond a market-based assessment of stability in isolation. Geopolitics and regional blocs play a role as well (Pomfret, 2019). That may make trade less sensitive to short-term political worries. Finally, there may also be an effect from missing variable bias. If other variables that affect political stability are not included in the model, for example, the quality of logistics, red tape at borders, or intergovernmental trust, then these would decrease the efficacy of this variable to explain. In the future, scientists might apply these types of controls or parcel up political indicators into smaller components, such as the health of institutions, the policy uncertainty, or the resilience of regimes, to understand how significant each one is relative to others.

The unimportance of the importer's GDP is not surprising in regional environments like Central Asia. The same evidence was discovered by Rahman (2009) in South Asia and Fidrmuc and Fidrmuc (2003) in Central and Eastern Europe, where trade flows were more influenced by the economic scale of the exporter and supply-side factors than import-side demand. The evidence suggests that in some transitional or emerging regions, structural constraints and scarce market diversification inhibit import reactions to income change. In this case, trade flows are not well explained by changes in the importer's economy or government. Control of Corruption (CCx), on the other hand, is still important because it shows that the quality of institutions is a major factor in trade performance. The Control of Corruption variable also consistently contributes significantly and positively, reflecting how important institutional quality is for Central Asian trade integration. This is especially true in a part of the world where rent-seeking, informal institutions, and bureaucratic inefficiency have made cross-border trade arduous (OECD, 2022).

Enhanced corruption control is likely to boost trade by clearing customs, lowering the transaction costs of illicit transactions, and promoting the formalization of trade flows. Research has demonstrated that corruption at border points can lead to significant delays and unpredictable expenses for both exporters and importers (World Bank, 2021). In places like Uzbekistan and Kyrgyzstan, specific changes to digitizing customs and cracking down on corruption have been linked to clear improvements in trade logistics and efficiency (ADB, 2023). Furthermore, better governance means that rules are more predictable and contracts are enforced, which are both important for international companies to do business with each other for a long time. When there are anti-corruption frameworks, reforms to public procurement, and ways for institutions to be held accountable, it makes things less uncertain and makes it easier for regions to work together more closely, especially in sectors that are high-value or time-sensitive (De Jong & Bogmans, 2011). Therefore, the high coefficient on corruption control is not merely statistically significant but also economically significant in the actual world. It shows that certain reforms in governance can lead to enormous increases in trade volumes in certain areas, particularly in transition economies and landlocked economies, where policy credibility and institutions are still in the process of building.

Fixed-effects results are more reliable than pooled OLS results because they reduce omitted variable bias caused by pair-specific factors that can't be seen, like geography or long-term policy frameworks. The F-test for individual effects and the Hausman test both showed that the fixed-effects estimator was better than pooled OLS and random-effects models. Fixed-effects estimation is very advantageous for figuring out how changes that happen over time, like GDP growth or institutional reforms, affect trade while keeping the unique traits of each country pair the same. The strength of the GDP and FDI variables further supports their role in promoting trade integration in Central Asia.

The Random Effects (RE) model is another way to estimate panel data. It assumes that the differences between country pairs that aren't seen are not related to the explanatory variables. This assumption lets you use time-invariant variables, which makes RE a suitable addition to Fixed Effects (FE) analysis. The coefficients obtained from the RE model typically fall between those derived from the pooled OLS and FE models. This pattern fits with what we would expect based on theory, since RE includes both within and between variation. The coefficient on ln_GDPx (0.6319) is crucial in our results and fits with what the gravity model says: bigger economies trade more. ln_FDIx also has a strong, positive, and significant effect, which shows that trade is linked to foreign investment in a beneficial way.

The variable CCx (Control of Corruption) is also positive and important, which means that trade is easier in places with stronger institutions. On the other hand, ln_GDPm (GDP of the importing country) and POLITx (political stability) don't have any statistical significance. This means that changes in the size of importers' economies and the stability of their governments may not have had a big effect on trade flows in Central Asia during the study. A Hausman test was used to determine the validity of the RE model, and the result was significant ($p < 0.01$). This result indicates that the RE assumptions are not true because the random effects are probably related to the explanatory variables. Because of this, the FE model is better for getting consistent results. The RE model, on the other hand, still gives us useful information. The signs and sizes of the coefficients are in line with what economic theory and other studies have found, which makes the results even stronger. The RE model isn't the best, but it can be used as a robustness check because it works well and can estimate the effect of factors that don't change over time. In conclusion, the fixed effects model is better for making inferences because it is more consistent. However, the random effects model supports and adds to these results. The results indicate that the size of the economy, the quality of institutions, and the flow of investment are all very important for trade integration in Central Asia.

The results of the three model selection tests all point to the same conclusion: the fixed effects model is the best choice for this study. The F-test shows that unobserved heterogeneity between country pairs is statistically significant, which means we need to go beyond pooled OLS. The LM test says that RE may not be better than OLS, but we can't be sure that it will work well with small samples. The Hausman test shows that random effects can't be used because there is a correlation between unobserved effects and explanatory variables. These results make it clear that controlling for unobserved heterogeneity is crucial in Central Asian trade, where institutional, political, and geographical factors are very different from one country to the next. This approach makes it possible to get a better estimate of the effects of time-varying variables like GDP, FDI, political stability, and control of corruption.

A lot of research backs up this conclusion. Head and Mayer (2014), for example, say that gravity models are very likely to have omitted variable bias if they don't include fixed effects. In the same way, Egger and Pfaffermayr (2003) show that fixed effects estimators make coefficient estimates in gravity models more accurate by getting rid of unobserved pair-specific effects. Hsiao (2014) also says that fixed effects models work best in panels with a small number of cross-sectional units but a long time dimension. This approach fits well with the way the current dataset is set up. This makes the policy suggestions that come from the analysis more trustworthy. Using fixed effects also helps this thesis fit in with the methodological standards of the best empirical work in the field, which makes its contribution to the literature on regional economic integration even stronger. In the end, the model selection tests indicate that the fixed effects model is the best way to show the basic structure of trade relationships in Central Asia. This choice makes the empirical findings more believable and ensures that the analysis is a strong basis for both theoretical insights and practical policy advice.

Two important robustness checks were done to ensure that our results were strong: (a) the model using Poisson Pseudo Maximum Likelihood (PPML) and (b) Driscoll–Kraay standard errors for panel estimates. These checks address possible problems with zero trade flows, heteroskedasticity, and cross-sectional dependence that could change our OLS/FE/RE results. When it comes to gravity modeling, the Poisson pseudo-maximum likelihood (PPML) estimator is a strong alternative to log-linearized OLS and panel models, especially when there are zero trade flows and heteroskedasticity. Santos Silva and Tenreyro (2006) pointed out that using OLS on log-transformed trade data can yield biased results when there is heteroskedasticity, which is a common problem with trade data.

PPML was used in this study to address these issues and improve the results' real-world reliability. The PPML results mostly match what we would expect from the gravity model, but they also show some differences. First, the coefficient for the exporter's GDP is positive and statistically significant. This means that when the exporting country's economy grows, so does trade between the two countries. This result backs up the main idea of the gravity theory, which says that bigger economies tend to do more international trade because they can produce and trade more. The exporter GDP coefficient is only about 0.41, which is lower than the typical unitary elasticity found in many global gravity studies (Head & Mayer, 2014). This suggests that in Central Asia, the relationship between GDP and trade may be less strong because of other problems like poor infrastructure, inefficient institutions, or reliance on outside sources. On the other hand, the importer's GDP coefficient is almost zero and not statistically significant. This unexpected result goes against what the gravity theory says, which is that the sizes of both exporters’ and importers' economies drive trade flows.

The importer's GDP may not matter due to Central Asia's trade structure. It could mean that the region's demand for imports is less responsive to income, maybe because people don't have many different needs or because supply-side problems make it hard for trade to happen even when income goes up. It could also mean that trade in the area is mostly driven by factors on the export side, like production surpluses, strategic partnerships, or trade decisions made by the government, rather than by demand from importers. This pattern shows that trade in the area is not equal, which calls for more qualitative research. Foreign direct investment (FDI) flows positively and significantly correlate with trade flows in the country that exports goods. The finding backs up what other researchers have said about how inward FDI improves a country's ability to produce goods, transfer technology, and compete, which in turn boosts exports (Egger & Pfaffermayr, 2004). The result shows that FDI is a key driver of trade in Central Asia, where it has grown a lot, especially in energy and infrastructure. This is because it improves the capacity of the supply side. This implies that policies aimed at enhancing investor confidence and promoting regulatory stability have the potential to facilitate trade in numerous ways.

The coefficient for the political stability variable is strong and statistically significant. This is an important finding that shows how governance and political stability affect trade performance. Countries with more stable politics are more likely to keep long-term trade relationships, attract investments, and follow through on their policies. This result indicates that Central Asia needs to strengthen its institutions to support regional trade integration. This is because the quality of governance and political stability in Central Asia vary significantly. It is similar to what Anderson and Marcouiller (2002) found, which was that trade flows are lower when there is insecurity and poor governance, even when standard gravity variables are taken into account. The variable for controlling corruption is also positive and important, which supports the idea that high-quality institutions make trade easier.

Countries that do a better job of fighting corruption are likely to have clearer customs rules, lower costs of doing business, and more trust between trading partners. This is in line with what real-world studies have found: that problems with governance, like corruption, red tape, and informal payments, make it challenging for developing and transition economies to trade (De Jong & Bogmans, 2011). Therefore, making the rules and enforcement systems better in Central Asia could have big benefits for trade. Interestingly, the constant term in the model is large and statistically significant. This means that the model only captures some of the changes in trade flows. This is what we expect, since gravity models usually omit a lot of complicated, changing factors like trade agreements, logistics efficiency, and tariff levels, especially when they can't be measured or aren't available for all pairs of countries. The size of the constant term might also show how long-lasting unobserved relationships are, like cultural ties or informal networks, which aren't part of the formal specification. The PPML results support several theoretical ideas from the gravity model and also show that trade in Central Asia works in ways that are specific to that region. The results indicate that the size of an economy has an uneven effect on trade (it has a strong effect on exporters but a weak effect on importers). They also show how important it is for institutions to be of high quality, especially when it comes to political stability and controlling corruption. These ideas are especially useful for policymakers in Central Asia. They suggest that changes to how the government works at home, along with making it easier for trade and attracting investment, could greatly improve trade between countries in the region. Furthermore, the PPML method makes these results more believable by taking into account possible biases caused by heteroskedasticity and zero trade observations, which are problems that traditional log-linear estimators are known to have (Santos Silva & Tenreyro, 2006).

The Driscoll–Kraay (DK) estimator is a way to resolve panel data models that deals with two common problems in econometrics: serial correlation and cross-sectional dependence. These problems are common in macro-panel settings, like those used in gravity models of trade, because of shared global shocks, long-lasting trade relationships, and policy environments that are linked to each other (Hoechle, 2007). Changes in oil prices, geopolitical tensions, or infrastructure projects impacting the entire region could potentially influence trade between Central Asian countries. The DK method makes sure that inference is still valid even when there are cross-unit correlations over time by producing heteroskedasticity- and autocorrelation-consistent (HAC) standard errors.

The results of the estimation show that the main explanatory variables in the gravity model are still strong, especially when errors that are correlated across country pairs and time are taken into account. The coefficient for the exporter's GDP is still positive and significant, with a value of about 0.58. This supports a key idea of the gravity model: bigger economies export more because they can make more things, are more efficient, and have more things to sell (Head & Mayer, 2014). This coefficient is important for explaining trade flows in Central Asia because it has a high value and stays the same across different estimation methods (OLS, FE, PPML, and DK). Furthermore, the size of the elasticity—less than one but still significant—suggests that GDP increases export capacity, but with diminishing returns. This could be because infrastructure or institutional bottlenecks make it harder for trade to grow. Even though the coefficient on the importer's GDP is positive, it is not statistically significant at the 5% level. This conclusion fits with what PPML and fixed-effects models found before, which showed that the demand-side part of the gravity equation is not very strong in Central Asia. One reason is that Central Asian countries have low income elasticity of imports because they can't diversify their consumption and production. Furthermore, trade decisions may be more affected by things like supply-side dynamics, trade agreements, or government policies than by market demand alone. This finding also shows that trade relations are not equal: GDP growth may drive exports, but imports stay the same because of policy or infrastructure problems.

From the exporter's perspective, there is a positive and significant correlation between FDI and trade. This supports the idea that FDI improves productivity, brings in new technologies, and boosts export performance (Egger & Pfaffermayr, 2004). In Central Asia, where most of the FDI is in energy, mining, and infrastructure, the evidence shows that there is a real connection between foreign investment and growth that is focused on exports. The estimated coefficient of approximately 0.16 indicates that a 1% increase in FDI inflow corresponds to a 0.16% increase in trade flows, assuming all other factors remain unchanged. This backs up the suggestion that changes to the investment climate, especially those that bring in foreign direct investment (FDI) that helps with exports and productivity, can help trade integration. The political stability index, on the other hand, has a coefficient close to zero and is not statistically significant.

This finding is different from the PPML results, which showed that political stability was positive and significant. The DK estimator corrects for errors that are correlated across countries and over time, which could account for some of the differences between institutions. This analysis also shows that political changes in Central Asia, while unstable, may not have as big an effect on trade right now as infrastructure or investment factors. On the other hand, the fact that political stability doesn't change much over time (because the region's scores are generally low and stagnant) might make it useless for capturing changes in trade within the panel under DK correction.

The control corruption variable is still positive and statistically significant, which supports the idea that the quality of governance, especially when it comes to openness, enforcing the law, and improving the bureaucracy work, is important for trade. The coefficient (~0.20) suggests that better control of corruption has a big effect on trade flows, probably by lowering transaction costs and making people more confident in regulatory environments. This conclusion is in line with what De Jong and Bogmans (2011) found, which was that corruption makes international trade less likely by making things less certain and making people less likely to interact formally across borders. In Central Asia, where informal networks and a lack of transparency in government are still common, reforms that aim to reduce corruption could open up trade opportunities that are currently hidden.

Similar to earlier models, the intercept remains significant. It captures factors that weren't seen or were left out that affect trade, like cultural proximity, historical ties, or other fixed traits that the covariates don't show. Because the DK model doesn't use pair fixed effects, such variation is to be expected and doesn't make it less useful for explaining things. In general, the Driscoll-Kraay results make the gravity model estimation in this thesis even more trustworthy. Key factors like exporter GDP, FDI, and control of corruption remain significant across all estimators, showing how important they are in explaining trade integration in Central Asia.

The DK adjustment makes inferences more accurate by reducing the bias that can come from country pairs being dependent on each other and common shocks. This is an important factor to consider in regional studies. Driscoll–Kraay standard errors work best with medium T–small N panel data structures, like the one in this thesis (20 panels over 24 years). Using them in this way is in line with the best practices in recent trade econometrics literature (Hoechle, 2007; Ditzen, 2018). The model takes into account both serial autocorrelation (which happens when trade relationships last a long time) and cross-sectional dependence (which happens when regional shocks or integration efforts like BRI or EAEU happen). In short, the DK estimator supports the main empirical point of this study: economic and institutional factors, not demand-side factors or political instability, are what drive trade integration in Central Asia. The results suggest that the government should focus on improving the investment climate, fighting corruption, and increasing export capacity to speed up trade within the region. We didn't add graphs like scatterplots of projected vs. actual trade or trade over time because we didn't have enough space or time. You may use these in future work to see how well the model fits and how trades are going. Graphs such as scatterplots comparing predicted and actual trade, as well as trade across time, were omitted due to constraints in space and time. These may be utilized in future research to evaluate the model's performance and the status of trades.

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Conclusion

The goal of this study was to look into how political and institutional factors affect trade integration in Central Asia. The gravity model of trade was used as a method. The first chapter discussed the idea of bringing Central Asian economies together. It discussed the region's problems with its institutions, infrastructure, and politics, which make it challenging for countries to work together. On the other hand, the empirical analysis primarily focused on measuring trade integration between the two countries. Trade is often the best and most obvious indicator of whether efforts to bring economies together are successful, according to Baldwin, R., & Wyplosz, C. (2020). The theoretical framework did include economic integration, but the estimates in Chapter 4 used trade flow as the main dependent variable. These findings helped us understand the economic, institutional, and political aspects of working together in a region better.

The study explored how GDP, foreign direct investment (FDI), political stability, and control of corruption affected trade between Central Asian countries over 24 years. The study tested a number of panel estimation methods, such as Pooled OLS, Fixed Effects, Random Effects, PPML, and Driscoll-Kraay standard errors, to provide strong empirical insights into the structural and institutional factors that affect trade performance in a region that is often seen as economically fragmented. The results of this thesis are in line with what theory says and add to the conversation in both policy and academia. First, the GDP of the country that is exporting goods was always a significant and positive factor in trade flows. FDI also had a statistically significant and positive effect on trade, which shows how important investment inflows are for increasing export capacity and business connections. Control of corruption, which is a measure of the quality of institutions, was important in most models. This evidence suggests that better governance directly leads to more trade. The political stability variable, on the other hand, did not yield statistically significant results. This conclusion suggests that its effect might be indirect or less important than other structural variables that are more relevant right now.

The fixed effects model, which was tested with several selection tests, including the Hausman test, was found to be the best estimator. This confirmed the need to account for unobserved heterogeneity within country pairs. In short, these results show that the exporter's GDP and FDI have a big effect on trade within the region and that institutional quality (as measured by control of corruption) also has a significant effect. However, in this dataset, political stability was found to be statistically insignificant. These results show how important economic scale, investment, and strong institutions are for making trade easier between Central Asian economies. This study's primary contribution lies in its examination of trade determinants within a political context that has not received as much attention as others. Gravity models have been used a lot in global trade, but in the Central Asia region, they remain limited, especially when they include institutional factors like political stability and corruption control. This thesis fills that gap by providing an analysis based on robust evidence derived from strong econometric modeling. Furthermore, using strong methods like PPML and Driscoll-Kraay corrections makes sure that the results are reliable even when there is heteroskedasticity and serial correlation, which are common problems in trade datasets.

The study's theoretical implications include a stronger understanding of how institutional quality changes the relationship between economic size and the gravity model's main idea that size matters. The fact that controlling corruption has a big effect on trade flows is in line with the institutional economics literature, which highlights the importance of governance in determining market outcomes. This means that traditional trade models need to take governance indicators into account.

The results suggest that policymakers should focus on policies that fight corruption and bring in foreign investment to boost trade in the region. As part of a strategy for regional integration, trade policies in Central Asia would do well to include governance reform as a key part. The sample only includes five countries over a period of 23 years, which makes it challenging to apply the results to other countries. Also, some variables that might be considered, like the quality of infrastructure, tariffs, and non-tariff barriers, were left out because there was insufficient data. Still, the method used—especially the use of fixed effects and robust standard errors—makes sure that the results are statistically sound and useful for policy. The results are even more trustworthy because of the robustness checks with PPML and Driscoll-Kraay. These methods make up for some of the study's structural flaws by reducing model misspecification and improving internal validity.

In conclusion, this study shows that economic and institutional factors are crucial for understanding trade integration in Central Asia. Exporter GDP, foreign direct investment, and control of corruption all make trade flows much better. To improve trade integration in Central Asia, policymakers should focus on strengthening institutions, bringing in foreign direct investment (FDI), and encouraging macroeconomic growth. To gain a better understanding, future research should look at more variables, contemplate dynamic panel models, and look at other regional contexts that might be advantageous. This thesis is an important step in the quantitative study of trade integration in Central Asia. It adds to both the body of empirical literature and the process of making trade policy.

5.2 Policy Recommendations

The findings enable several policy conclusions to be drawn that would enhance regional integration based on intra-regional trade. The most stable result for all the regressions is the positive and statistically significant effect of corruption control on trade flows. This highlights the indispensable role of governance reform as the basis of trade integration. It would be in the interest of the governments in Central Asia to work on anti-corruption, administrative transparency, and an independent judiciary to attract the confidence of investors and partners. The creation of independent anti-corruption agencies, the streamlining of procurement, and the digitization of customs operations are concrete first steps. Moreover, the alignment of legislative and regulatory arrangements between countries will reduce transaction costs and provide traders with greater certainty.

The strong correlation between the exporter's GDP and trade flows illustrates the value of scale in trade performance. Policymakers must incorporate trade articulations into broader domestic development agendas that pursue industrialization, value chain insertion, and productivity expansion. Support for export-based industries, as well as addressing domestic supply-side constraints, would boost the growth in production capacity needed to raise the value and range of goods exchanged within the region. The effect of FDI on trade flows was large and positive, corroborating its twin functions of capital accumulation and cross-border economic integration. To draw long-term and regionally effective investment, the countries of Central Asia should ease the investment process, ensure the investors' rights, and sign the regional investment agreements providing mutual guarantees and dispute resolution mechanisms. Establishing regional SEZs or cross-border industrial parks could also drive investment in sectors that support trade, logistics, manufacturing, and agribusiness. Infrastructure improvements and lower tariffs alone won't make trade integration in Central Asia happen. This study shows that both governance and the quality of institutions are crucial. Subsequently, a successful strategy for trade integration must be multi-faceted, bringing together economic scale, investment support, institutional reform, and regional cooperation. Central Asia could change from a group of loosely connected economies into a strong and integrated regional trade bloc if its leaders work together and make decisions based on facts.

5.3 Limitations of the Study and Future Research

To understand the results of this study and guide future research, it's important to know what its main problems are. First, the gravity model used is strong and well-known in the field of international trade. But it makes some assumptions that may not be entirely true about how trade works in transition economies like those in Central Asia. Second, the model's institutional variables, such as political stability and control of corruption, are based on proxy indicators from global datasets. In the research, these proxy indicators might not accurately reflect the differences and realities of each Central Asian country. For example, the political stability index combines many types of risk and may not take into account things like tensions between different ethnic groups or bad management.

Corruption indexes often show how well the government works. This limit could lead to errors in measurement and might not fully show how institutions affect trade. Trade-intensive countries may have more effective governments due to their increased exposure to international norms or the influence of foreign investors. Lastly, this thesis was mostly about trade between Central Asian countries. It didn't include China, Russia, or the European Union, which are outside players. The political and economic power of these countries could have an effect on trade in the area. People in the same area often work together because of their investments, strategic alignments, and trade agreements. A model that examined trade flows within and between regions would help us understand trade and regional interdependence.

There are many ways to contribute to research on trade integration in Central Asia, given the study's limitations. Researchers should first look at using more specific ways to measure the quality of institutions. They could also assess the government's efficiency, the courts' independence, and institutions' actual operations. In the future, it may be useful to look at trade flows by sector (like agriculture, manufacturing, and services) to see how different institutional and political factors affect each one. Some areas, such as construction and energy, may be more prone to corruption, while others, such as cross-border finance and digital trade, may be more affected by political stability. Insights from certain areas could help make more focused policy suggestions.

Next, combining the quantitative results with qualitative research and case studies would enhance their usefulness. While gravity models can identify significant patterns, they often fail to explain the underlying reasons for the observed numbers. We could learn more about the political reasons, institutional barriers, and informal rules that affect trade behavior by adding structured interviews, reviews of policy documents, or ethnographic case studies to econometric analysis. Future studies could look into how trade in a region is affected by the presence of big players from outside it, like China and Russia. This could mean looking at how trade in a region affects things like its political alignment, its reliance on foreign aid, or its participation in regional trade and investment agreements. These kinds of models could show how politics affects how people work together or compete in a region. In the end, researchers can obtain a better picture of trade integration in Central Asia by using more detailed data, different approaches, sectoral and spatial analyses, and mixed methods.

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APPENDIX

Appendix 1. Multicollinearity

	ln_trade	ln_GDPx	ln_GDPm	ln_FDIx	POLITx	CCx
ln_trade	1.0000					
ln_GDPx	0.9670	1.0000				
ln_GDPm	0.1078	0.1174	1.0000			
ln_FDIx	0.8834	0.8509	0.1015	1.0000		
POLITx	0.5462	0.5398	-0.0056	0.6082	1.0000	
CCx	0.4466	0.3967	-0.0973	0.2369	0.0910	1.0000

Appendix 2. VIF

Variable	VIF	1/VIF
ln_GDPx	4.35	0.230123
ln_FDIx	4.20	0.237873
POLITx	1.63	0.615362
CCx	1.29	0.775049
ln_GDPm	1.05	0.949900
Mean VIF	2.50	

Appendix 3. Serial Correlation

Source	SS	df	MS
Model	47.1982304	1	47.1982304
Residual	15.3030678	458	.033412812
Total	62.5012982	459	.136168406

Number of obs	=	460
F(1, 458)	=	1412.58
Prob > F	=	0.0000
R-squared	=	0.7552
Adj R-squared	=	0.7546
Root MSE	=	.18279

uhat	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
uhat_lag	.8794896	.0234005	37.58	0.000	.833504	.9254752
_cons	-.0004803	.0085231	-0.06	0.955	-.0172295	.016269

Appendix 4. Fixed Effect

```
Fixed-effects (within) regression               Number of obs     =        480
Group variable: panelid                          Number of groups  =         20

R-squared:                                      Obs per group:
     Within  = 0.8905                                         min =         24
     Between = 0.9588                                         avg =       24.0
     Overall = 0.9311                                         max =         24

                                                F(5, 455)         =     739.68
corr(u_i, Xb) = 0.4890                          Prob > F          =     0.0000

------------------------------------------------------------------------------
    ln_trade | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
     ln_GDPx |   .5530273   .0489767    11.29   0.000     .4567787    .6492759
     ln_GDPm |   .1195029   .0496336     2.41   0.016     .0219635    .2170423
     ln_FDIx |   .1588101   .0142667    11.13   0.000     .1307733     .186847
      POLITx |   -.001419   .0323003    -0.04   0.965    -.0648952    .0620573
         CCx |   .1941344   .0653092     2.97   0.003     .0657892    .3224795
       _cons |   4.464412     .37301    11.97   0.000     3.731376    5.197448
-------------+----------------------------------------------------------------
     sigma_u |  .28393223
     sigma_e |  .24417341
         rho |  .57486143   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(19, 455) = 6.11                     Prob > F = 0.0000
```

Appendix 5. Model Selection

```
Fixed-effects (within) regression               Number of obs     =        460
Group variable: panelid                          Number of groups  =         20

R-squared:                                      Obs per group:
     Within  = 0.8755                                         min =         23
     Between = 0.9686                                         avg =       23.0
     Overall = 0.9386                                         max =         23

                                                F(5, 435)         =     612.00
corr(u_i, Xb) = 0.4776                          Prob > F          =     0.0000

------------------------------------------------------------------------------
    ln_trade | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
     ln_GDPx |   .5849884   .0563987    10.37   0.000     .4741405    .6958362
     ln_GDPm |   .0971978   .0564391     1.72   0.086    -.0137295     .208125
     ln_FDIx |   .1607927   .0151079    10.64   0.000     .1310992    .1904863
      POLITx |   .0013871   .0339511     0.04   0.967    -.0653415    .0681157
         CCx |   .2029489   .0673741     3.01   0.003     .0705296    .3353682
       _cons |    4.20307   .4047941    10.38   0.000     3.407474    4.998665
-------------+----------------------------------------------------------------
     sigma_u |  .23987007
     sigma_e |  .24530017
         rho |  .48880925   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(19, 435) = 5.79                     Prob > F = 0.0000
```

.

```
. * 6b. LM test: RE vs OLS

.
. xtreg ln_trade ln_GDPx ln_GDPm ln_FDIx POLITx CCx, re

Random-effects GLS regression                   Number of obs     =        460
Group variable: panelid                         Number of groups  =         20

R-squared:                                      Obs per group:
     Within  = 0.8677                                         min =         23
     Between = 0.9907                                         avg =       23.0
     Overall = 0.9559                                         max =         23

                                                Wald chi2(5)      =    9829.42
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
    ln_trade | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
     ln_GDPx |   .6319505   .0181204    34.88   0.000     .5964352    .6674657
     ln_GDPm |   .0096433   .0089643     1.08   0.282    -.0079263    .0272129
     ln_FDIx |   .1856185   .0149827    12.39   0.000      .156253     .214984
      POLITx |  -.0101365   .0292969    -0.35   0.729    -.0675574    .0472844
         CCx |    .540521   .0558486     9.68   0.000     .4310597    .6499823
       _cons |   5.033679   .3542249    14.21   0.000     4.339411    5.727947
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  .24530017
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

.
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        ln_trade[panelid,t] = Xb + u[panelid] + e[panelid,t]

        Estimated results:
                         |       Var     SD = sqrt(Var)
                ---------+-----------------------------
                ln_trade |   1.618199       1.272085
                       e |   .0601722       .2453002
                       u |          0              0

        Test: Var(u) = 0
                             chibar2(01) =     0.00
                          Prob > chibar2 =   1.0000
```

Appendix 6. Hausman Test

```
. * 6c. Hausman test: FE vs RE

.
. estimates store re_model

.
. xtreg ln_trade ln_GDPx ln_GDPm ln_FDIx POLITx CCx, fe

Fixed-effects (within) regression               Number of obs     =        460
Group variable: panelid                         Number of groups  =         20

R-squared:                                      Obs per group:
     Within  = 0.8755                                         min =         23
     Between = 0.9686                                         avg =       23.0
     Overall = 0.9386                                         max =         23

                                                F(5, 435)         =     612.00
corr(u_i, Xb) = 0.4776                          Prob > F          =     0.0000

------------------------------------------------------------------------------
    ln_trade | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
     ln_GDPx |   .5849884   .0563987    10.37   0.000     .4741405    .6958362
     ln_GDPm |   .0971978   .0564391     1.72   0.086    -.0137295     .208125
     ln_FDIx |   .1607927   .0151079    10.64   0.000     .1310992    .1904863
      POLITx |   .0013871   .0339511     0.04   0.967    -.0653415    .0681157
         CCx |   .2029489   .0673741     3.01   0.003     .0705296    .3353682
       _cons |    4.20307   .4047941    10.38   0.000     3.407474    4.998665
-------------+----------------------------------------------------------------
     sigma_u |  .23987007
     sigma_e |  .24530017
         rho |  .48880925   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(19, 435) = 5.79                     Prob > F = 0.0000

.
. estimates store fe_model

.
. hausman fe_model re_model, sigmamore

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |   fe_model     re_model       Difference       Std. err.
-------------+----------------------------------------------------------------
     ln_GDPx |    .5849884     .6319505       -.0469621        .0590743
     ln_GDPm |    .0971978     .0096433        .0875545         .061182
     ln_FDIx |    .1607927     .1856185       -.0248258        .0070356
      POLITx |    .0013871    -.0101365        .0115236        .0229198
         CCx |    .2029489      .540521       -.3375721        .0482668
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtreg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  91.61
Prob > chi2 = 0.0000

.
.
.
. *===============================*
```

•

Appendix 7. PPML

```
HDFE PPML regression                              No. of obs      =        480
Absorbing 3 HDFE groups                           Residual df     =         19
Statistics robust to heteroskedasticity           Wald chi2(5)    =    6327.70
Deviance             =  2.44662e+11               Prob > chi2     =     0.0000
Log pseudolikelihood = -1.22331e+11               Pseudo R2       =     0.9875

Number of clusters (panelid)=         20
                               (Std. err. adjusted for 20 clusters in panelid)
```

trade	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
lnGDPx	.4086632	.0670085	6.10	0.000	.2773289	.5399974
lnGDPm	1.85e-15	.0964287	0.00	1.000	-.1889969	.1889969
lnFDIx	.1468715	.0255902	5.74	0.000	.0967156	.1970273
POLITx	.1732289	.0411642	4.21	0.000	.0925485	.2539092
CCx	.3976882	.1244132	3.20	0.001	.1538428	.6415336

Appendix 8 .Driscoll-Kraay standard errors

```
Regression with Driscoll-Kraay standard errors    Number of obs     =       460
Method: Fixed-effects regression                  Number of groups  =        20
Group variable (i): panelid                       F(  5,     22)    =    186.15
maximum lag: 2                                    Prob > F          =    0.0000
                                                  within R-squared  =    0.8755
```

ln_trade	Coefficient	Drisc/Kraay std. err.	t	P>|t|	[95% conf.	interval]
ln_GDPx	.5849884	.0687263	8.51	0.000	.4424588	.7275179
ln_GDPm	.0971978	.0754026	1.29	0.211	-.0591777	.2535733
ln_FDIx	.1607927	.0360214	4.46	0.000	.086089	.2354965
POLITx	.0013871	.0736482	0.02	0.985	-.1513499	.1541241
CCx	.2029489	.0847269	2.40	0.026	.0272361	.3786617
_cons	4.20307	.7387595	5.69	0.000	2.670976	5.735163