Trade agreements, Complex network and Foreign Direct Investment: An application of a three-dimensional panel model

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ABSTRACT

This study examines the influential role of foreign direct investment (FDI) in 11 developing countries by analyzing the impact of three key groups of variables: membership in trade agreements, network index measures, and economic indicators. Utilizing panel data from eleven selected countries, namely BRICS, Shanghai Cooperation Organization (SCO), Developing Eight (D_8), and Economic Cooperation Organization (ECO), over the period 2009–2023, the analysis employs a three-dimensional panel model. Findings reveal that membership in the ECO trade bloc has a statistically significant and positive effect on FDI among its member countries, whereas the impacts of other regional trade agreements are not significant. Among the network indices, both degree centrality and PageRank demonstrate significant positive effects on FDI, underscoring the importance of network connectivity. Furthermore, economic variables such as GDP per capita, trade openness, and governance quality positively influence FDI inflows, while inflation exhibits a negative relationship. The results underscore the critical importance of regional trade integration, enhanced network connectivity, and economic stability in attracting FDI. These insights offer actionable policy recommendations for improving FDI inflows, particularly for countries like Iran, by emphasizing strengthened trade agreements, network development, and economic reforms.

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1. Introduction

$\mathcal{L}$imited financial resources and capital constraints have prompted countries to address these challenges through various investment models and the mobilization of private sector capital (Abd Elrahman & Asaad, 2021). In such contexts, leveraging diverse financial instruments, private sector expertise, borrowing, guarantees, and other financing mechanisms becomes essential (Fedorova et al., 2018). Among these strategies, Foreign Direct Investment (FDI) emerges as one of the most effective means of attracting international financial resources (Krugman & Obstfeld, 2009). Recognized globally as a key driver of economic development, especially within emerging economies, FDI offers numerous benefits, including job creation, technology transfer, diffusion of modern management and business practices, access to international markets, and improved access to global financing (Coe et al., 2017; Coe & Yeung, 2015; Fruman & Forneris, 2016). Since the early 1980s, countries pursuing market-oriented reforms have experienced notable influxes of foreign capital, often driven by export-led growth strategies. This trend has fostered advancements in trade liberalization, investment flows, macroeconomic stabilization, and overall economic growth (Tatoglu & Glaister, 1998). The increasing volume of FDI has attracted scholarly attention, leading to extensive investigations into its impact on economic growth. Empirical evidence suggests a positive relationship, whereby FDI contributes to economic expansion through capital accumulation, technological spillovers, and the transfer of skills and knowledge—aligning with exogenous growth theories. Studies also highlight FDI's role in enhancing a country's knowledge base and technological capabilities (Mahembe & Odhiambo, 2014; Elboiashi, 2011; Herzer et al., 2008). Trade agreements, particularly preferential trade agreements (PTAs), have been identified as pivotal facilitators of FDI, embodying the processes of globalization. As of today, all World Trade Organization (WTO) members have ratified at least ten such agreements, spanning sectors like investment, intellectual property rights, labor regulations, environmental

standards, and immigration policies (Antràs & Staiger, 2012). Bhagwati (1995) famously termed the proliferation of these agreements the "spaghetti bowl phenomenon," reflecting their complex and often overlapping nature at unilateral, bilateral, regional, and multilateral levels. Baldwin et al. (2008) noted that decisions related to multilateral trade negotiations are often influenced by "collusive and domino effects," where countries adopt liberalization measures to avoid falling behind economically. Trade liberalization agreements not only facilitate the movement of goods and services but also promote investments by reducing trade and investment barriers, thus enabling multinational corporations to allocate resources efficiently across borders. These agreements often include negotiated investment terms that encourage cross-border capital flows, fostering stronger financial integration. Furthermore, such agreements enhance political and organizational cooperation, serving as diplomatic tools to bolster economic ties. Kawai and Wignaraja (2010) emphasize that trade agreements help signatory countries align their regulatory and institutional frameworks, which can reinforce political legitimacy and create a more stable environment for foreign direct investment.

This study advances existing literature by employing a complex networks framework to analyze FDI dynamics. Specifically, it examines the influence of membership in prominent regional trade blocs—including BRICS, the Shanghai Cooperation Organization (SCO), Developing Eight (D_8), and Economic Cooperation Organization (ECO), on FDI inflows through a three-dimensional panel model. The rationale for selecting these trade areas is rooted in Iran's memberships, with particular attention to how these agreements influence FDI, modeled as a third dimension within the analysis.

A key contribution of this research is its novel methodological approach: the integration of complex network analysis with a three-dimensional panel data model to assess Iran's FDI landscape.

The paper structure proceeds as follows: after this introduction, a literature review synthesizes theoretical foundations and empirical findings, followed by

a methodology section that details the model specification, data extraction procedures, stationarity tests, and estimation results. The final sections present discussion and conclusions aimed at optimizing FDI inflows.

2. Literature Review

Markowitz (1990) delineates the evolution of Foreign Direct Investment (FDI) theories into two principal phases:

A) Development of investment theories by Keynesian and neoclassical economists, focusing on capital mobility, portfolio theory, and the "theory of differential international interest rates," where higher interest rates serve as the main incentive for capital movement.

B) Production on an international scale and the rise of multinational corporations (MNEs), emphasizing the importance of uncertainty, investment volatility, and market structure considerations in shaping FDI dynamics.

Until the late 1940s, the dominant theoretical framework was rooted in neoclassical FDI theory, which assumed perfect competition and immobile factors of production across borders. The pioneering contributions of Hymer (1960) marked a turning point in the literature, offering the first comprehensive theory aligned with classical trade models like the Heckscher-Ohlin framework, explaining FDI through the strategic behavior of multinational firms. As the literature on MNEs grew, specific economic rationales for foreign asset placement, including considerations of market imperfections and firm-specific advantages—gained prominence (Hymer, 1960; Vernon, 1992).

Dunning's eclectic paradigm (1988), further developed through Dunning and Narula (2003), provided a comprehensive theoretical framework for FDI, integrating three core components:

• Ownership Advantages (O): Firm-specific intangible assets under exclusive control that can be transferred abroad with minimal costs, resulting in higher revenues or lower costs.

- Location Advantages (L): Benefits derived from host country-specific factors that make a particular location more attractive for FDI.
- Internalization Advantages (I): Gains obtained by internalizing foreign operations—such as avoiding transaction costs associated with licensing or franchising—and engaging directly in foreign production (J. H. Dunning, 1973; 1980).

Over time, additional theories emerged to address the dynamic nature of FDI. Dunning and Lundan (2008) proposed an investment development path model, suggesting that a country's FDI-related advantages evolve with economic development, altering the structure of the OLI framework.

Based on the works of Peng et al. (2008) and Amal et al. (2016), traditional theories typically regard factors such as market size and growth, labor availability and costs, inflation, external debt, and balance of payments as primary determinants of a location's attractiveness for FDI. However, with the increasing influence of institutional quality and emerging economies, contemporary theories have expanded to incorporate political, institutional, and regulatory factors.

Summary of Major Theoretical Frameworks:

- Classical and trade-based theories: FDI driven by higher returns stemming from interest rate differentials.
- Multinational enterprise (MNE) theories: Emphasis on firm-specific competitive advantages, internalization, Vernon's product life cycle, Hymer's resource-based view, and the eclectic paradigm.
- Strategic and behavioral models: Uppsala model emphasizing psychic distance, cultural, linguistic, and political differences affecting FDI decisions.
- Institutional and emerging economy-focused theories: Recognize the critical roles of political stability, institutions, and incremental learning, especially relevant for developing countries.

Most empirical FDI research employs econometric models rooted in these theoretical foundations, analyzing FDI as a dependent variable influenced by

variables such as GDP, inflation, wages, exchange rates, and institutional quality, utilizing time series, panel data, and gravity models. Notable studies by Krishnakumar et al. (2014), Konara & Wei (2019), Matsumoto (2022), Ding et al. (2022), Dankyi et al. (2022), Li & Luo (2023), and Osei & Kim (2023) exemplify this approach. The role of trade agreements as facilitators of FDI has garnered particular interest. Countries join regional agreements to stabilize investment policies, foster investor confidence, and achieve economic integration—though the process entails challenges such as policy coordination and regulatory harmonization (Blomstrom & Kokko, 1997). Worth (1998) posits that regional trade liberalization expands markets, increases GDP, and attracts FDI, especially as countries liberalize trade and integrate previously isolated markets. Empirical research, such as Thangavelu & Findlay (2011), employing gravity models to ASEAN countries, indicates a positive correlation between regional trade agreements and FDI inflows. Similarly, UNCTAD (2013) analyzed developing countries and found mixed effects, sometimes regional agreements inadvertently create barriers, bureaucratic hurdles, or regulatory complexities that impede investment flows. Berger et al. (2013) highlight that the heterogeneity of investment provisions within agreements can influence their effectiveness, emphasizing that supportive institutional frameworks are essential. Given the significance of trade agreements, this study aims to rigorously analyze their impact on FDI by developing enhanced econometric models, incorporating a third dimension within a three-dimensional panel framework. More recently, complex network analysis has gained attention for studying FDI models. Rubinov and Sporns (2010) introduced network approaches to analyze global FDI flows, enabling the visualization of cross-border investment linkages and their structural properties. Foreign FDI network studies fall into three categories:

1. Country Relationship Mapping: Analyzing the geographic and relational positioning of countries within the FDI network (Damgaard & Elkjaer, 2017; Lima et al., 2020).

2. Impact of Exogenous Variables: Examining how institutional or external factors influence network connectivity using econometric models (Garas et al., 2016; Arif et al., 2021; Ouyang et al., 2023).

3. Production Fragmentation and Industry Networks: Investigating global supply chains and FDI flows within industries (De Masi & Ricchiuti, 2018; Schoeneman et al., 2022).

Aligning with the first and second categories, this research will derive degree and ranking indices for key countries within the global FDI network. These indices, along with memberships in trade areas and economic factors, will be integrated into a three-dimensional panel model to enhance the understanding of FDI determinants.

3. Methodology

The nature of panel data reveals the presence of heterogeneities and differences among various groups, sectors, or clusters, such as individuals, groups, countries, firms, industries, banks, etc., which are denoted by indices i and j (Bai, 2009). In two-dimensional panel models with fixed effects, only four types of fixed effects can be examined. As additional dimensions, such as a third dimension, are introduced into the models, the specification of fixed effects gradually increases, taking into account the heterogeneity of the dataset. For instance, the number of possible fixed effects configurations for three dimensions increases to 64 (two to the power of six) (M. & Balazsi, 2011). In regression relations (1) to (7), seven common models of fixed effects in three-dimensional panels are referenced, as proposed by Balazsi et al. (2018) and Balazsi (2011).

$$y_{ijt} = x_{ijt}'\beta + u_{ijt} \tag{1}$$

$$y_{ijt} = x_{ijt}'\beta + \alpha_i + \gamma_j + \lambda_t + u_{ijt} \tag{2}$$

$$y_{ijt} = x_{ijt}'\beta + \gamma_{ij} + u_{ijt} \tag{3}$$

$$y_{ijt} = x'_{ijt}\beta + \gamma_{ij} + \lambda_t + u_{ijt} \tag{4}$$

$$y_{ijt} = x'_{ijt}\beta + \alpha^*_{jt} + u_{ijt} \tag{5}$$

$$y_{ijt} = x'_{ijt}\beta + \alpha_{it} + \alpha^*_{jt} + u_{ijt} \tag{6}$$

$$y_{ijt} = x'_{ijt}\beta + \gamma_{ij} + \alpha_{it} + \alpha^*_{jt} + u_{ijt} \tag{7}$$

Let $i=1,…,N,\ j=1,…,M$, t$=1,…,T$, where y_{ijt} is the dependent variable corresponding to country i in region j during year t. The vector x_{ijt} represents the explanatory variables, which may include lagged variables. The term u_{ijt} denotes the disturbance term, while α_i, γ_j, γ_{ij} , λ_t, α_{it} and $\alpha_{jt}*$ correspond to the fixed effects related to the country, region, the interaction of region with country, time, interaction of time with country, and time effects on region, respectively. The choice criteria for each of the models (1) to (7) depend on the research theory and the investigator's inference. For example, in the gravity models where the effect of countries and their changes over time is significant, α_{it} and $\alpha_{jt}*$ are utilized in models (5), (6), and (7). Additionally, γ_{ij} is employed to assess the effect of group membership on the cross-section (the interaction effect). A specific example is the classification of productivity and the examination of its impact on wages, where this effect is observable through γ_{ij}, with the related models presented in (3), (4), and (7). Overall, it should be noted that the seven mentioned models overlap, and the researcher cannot solely depend on one robust model. Consequently, based on the study by Balazsi et al. (2018), the characteristics of each of these models will be discussed. Model (1) is a group regression model that ignores unobserved differences (fixed effects). Model (2) allows specific effects to be entered into the model collectively. Choosing the model (2) is important for evaluating and inferring the parameter (β). If the selected model is smaller than the actual model, it can create an omitted variable distortion. If a larger template that includes the real template is used, it may cause a significant decrease in performance because many additional virtual variables are generated by the fixed effects. Model (3) contains only a two-

by-two interaction between fixed effects i and j (crossover effect), but the model can be studied as a two-dimensional model with individual fixed effects considering the observation in the dimensions (i, j) are relied upon as a dimension, in other words, when the time dimension changes are not important, this model can be used. Likewise, model (4) can be studied as a two-dimensional model with two-way error components, considering dimensions (i, j) as one dimension and time effects separately in λ_t in such a way that it includes the cross effect and time.

Model (5) allows the interaction between the specific effects of j and t, and in other words, the cross effect of time on cross-section j can be investigated. Model (6) includes two cross interactions of specific effects of t on i and t on j. Model (7) includes all three two-by-two cross interactions and it can be said that it includes all models (1) to (6) as special cases.

In the article published by Baltagi et al. (2003), model (3) was used to add exporter-importer (bilateral) interaction effects, and model (4) was presented to examine the time effect. On the other hand, Cheng & Wall (2005) investigated the fixed effects in the gravity model to investigate bilateral trade flows, using model (4). Baltagi et al. (2003) used models (5), (6) and (7) to estimate the fixed effects of different models for bilateral trade data. Baier & Bergstrand (2009) considered panel gravity equations with bilateral fixed effects of country and time effects (models (3) and (7)). Berthélemy & Tichit (2004) applied a modified version of model (5) with random effects to estimate the dependent variable, the donation received by i from donor j at time t. Finally, Samaniego & Sun (2016) used model (7) with fixed effects to study the growth of industry j in country i at time t. When N, M, and T are all large, the number of dummy variables added can become very large, and hence the efficiency of the model is greatly reduced. For this reason, choosing a larger model (model (7)) in experimental studies is not always suitable. According to the extent of the model, Lu et al. (2021) examined the appropriateness of each of the models (1) to (7), which is shown in Table 1.

Table 2 shows, in the seven models presented, if the appropriate model or in other words Just-Fitted (zero number), how is the estimation of the other 6 models. If the estimate is Over-fitted, it is shown with a + sign and Under-Fitted with a - sign.

Table 1. Model selection based on Fitted

Model selection	1	2	3	4	5	6	7
1	0	+	+	+	+	+	+
2	-	0	-	+	-	+	+
3	-	-	0	+	-	-	+
4	-	-	-	0	-	-	+
5	-	-	-	-	0	+	+
6	-	-	-	-	-	0	+
7	-	-	-	-	-	-	0

Reference: (Lu et al., 2021)

For example, if model (2) is suitable as a model, the second row indicates that models (1), (3) and (5) are less than the limit and models (4), (6) and (7) are estimated to be more than they create the limit. Considering that the focus of this study is to investigate the effect of region (γ_j) on FDI, in this study, model (2) is used for estimation.

3-1- Model Specification

Considering that one of the objectives of the research is to investigate the effect of the region (γ_j) on FDI, in this research model (2) is used for estimation. This standard model is chosen based on the studies done by Baltagi & Li (1995), Balestra & Krishnakumar (2008) and Balazsi (2011). Also, in terms of the nature of the included variables, it is similar to the study of Arif & Ahmad (2017) and Arif et al. (2021), which was developed for three dimensions *i, j* and *t* (period, region and time) and expressed in (8).

$$FDI_{ijt} = \alpha FDI_{ijt-1} + \beta ECON_{it} + \mu OPEN_{ijt} + \gamma COMP_{it} + \delta GOV_{it} + \gamma_j + \alpha_i + \lambda_t + u_{ijt} \tag{8}$$

Equation 8 is in logarithmic function format and, FDI_{ijt-1} represents the dependent variable and the amount of foreign direct investment entering country i in region j and at time t., $\gamma_j, \alpha_i, \lambda_t$ represent cross-sectional fixed effects for region, country and time, and other explanatory variables are as follows:

A. Economic Variables (*ECON*): This includes three variables: per capita GDP, and inflation rate.

B. Trade Openness Variable (*OPEN*): While this variable is economic in nature, it is defined separately due to its distinct three-dimensional approach. The trade openness is derived from the sum of exports and imports divided by the Gross National Product (*GNP*), indicating the trade openness of country (*i*) in region (*j*) at time (*t*).

C. Governance Quality Index (*GOV*): includes six sub-indices of accountability and responsibility, political stability and absence of violence and terrorism, government effectiveness, supervisory quality, rule of law, and corruption control.

D. Network Variables (*COMP*): The network indicators examine foreign direct investment relationships. Degree centrality is used to assess FDI relationships at the national levels, and PageRank assesses the influence of neighbors on FDI. The general concepts of these two indicators are described as follows:

• Degree Centrality: This measures the importance of a node based on its degree. Thus, the more connections a node has, the more significant it is. In weighted networks, this metric is also referred to as strength. The degree of node i (k_i), is defined in equation (9). Also, *N* represents the total number of nodes and dci measurement in equation (10) (Lima et al., 2020).

$$k_i = \sum_j a_{ij} \tag{9}$$

$$dc_i = k_i/(N-1) \tag{10}$$

- PageRank: This measures the importance of nodes based on the importance of their neighbors. This indicator (x_i) is calculated based on the size of neighboring nodes (x_j) over their out-degree (k_j^{out}). The constants α and β are positive values, as described in equation (11) (Brandes, 2001; Abedighahi et al., 2024).

$$x_i = \alpha \sum_j A_{ij} \frac{x_j}{k_j^{out}} + \beta \tag{11}$$

According to this indicator, if a highly central node connects with a less central node, the centrality of the latter increases (Newman, 2006). The definition of the explanatory variables, along with the data extraction sources, is provided in Table 2.

Table 2. Model variables

Variable	Definition	Database
ECON	It includes three economic variables: GDP per capita, inflation rate and Trade openness.	World Development Indicators (WDI), United Nations Industrial Development Organization (UNIDO) and World Bank (WB)
GOV	It includes six factors (accountability and responsibility, political stability and absence of violence and terrorism, government effectiveness, supervisory quality, rule of law, corruption control).	Global Governance Indicators (WGI)
COMP	It includes two network variables (Degree and PageRank).	Abedighahi et al. (2024)

Source: research finding

3.2. Trade Regions

In this study, the regional dimension (j) includes selected countries that are members of the Shanghai Cooperation Organization, BRICS, D_8 and ECO. The selected countries belonging to these trade agreements are outlined by region in Table3.

Table 3. The average share of FDI inflow of selected countries

Trade Agreement	Shanghai	BRICS	D_8	ECO
	Iran	Brazil	Iran	Iran
	India	Russia	Turkey	Pakistan
	Kazakhstan	China	Pakistan	Afghanistan
	China	South Africa	Bangladesh	Turkey
Country	Kyrgyzstan	India	Indonesia	Tajikistan
	Pakistan	Iran	Malaysia	Azerbaijan
	Russia	Ethiopia	Egypt	Uzbekistan
	Tajikistan	Emirates	Nigeria	Turkmenistan
	Uzbekistan	Egypt		Kazakhstan
				Kyrgyzstan
FDI share of selected countries	99%	84%	83%	98%

Source: International Monetary Fund

Given the data limitations of this study and the possibility of a country being a member of one or more defined regions simultaneously, countries with the highest average inflow of FDI over the thirteen-year period are included as selected countries and are highlighted in gray in Table3. As indicated in Table 3, a total of four trade agreements have been considered for this study. The model employed is a panel data approach, and due to its three-dimensional nature and the large volume of data (11 countries, 15 years, and 4 regions), specific countries have been selected for each trade agreement. The selected countries together account for at least 80% of the average share of incoming foreign direct investment flows from 2009 to

2023 for each agreement. (ECO: 98%, D_8: 83%, BRICS: 84%, and Shanghai Cooperation Organization: 99%). One of the key reasons for selecting the aforementioned regions is Iran's shared membership in these areas and the economic nature of the regions. Additionally, Iran's membership in the Shanghai Cooperation Organization and BRICS is relatively new, while its membership in the other two agreements has a longer historical background.

3.3. Empirical Results

In this study, a three-dimensional panel data model comprising eleven countries, four regions, and a time frame from 2009 to 2023 has been developed. Prior to estimating the model, the " Cross section indepency " was examined using second-generation stationary tests, including Crosssectionally Augmented Im, Pesaran, And Shin (CIPS) test, as well as the Hadri and Rao test, along with the Karavias & Tzavalis (2014) test, which are presented in Table 4.

Table 4. Cross-sectional independency tests

Variable / Test	GDP per capita	FDI	Governance	Inflation Rate	Trade openness
Cross section independency	No	No	No	No	No
CIPS	Non stationary	Non stationary	Non stationary	Stationary	Stationary
Karavias & Tzavalis	Stationary	Non stationary	Stationary	Stationary	Stationary
Hadri and Rao	Stationary	Stationary	Stationary	Stationary	Stationary

Source: research findings

Also, for more certainty and the existence of long-term relationship, Westerlund's test was used and to show that the model is a panel, F-test was used, the results of them are presented in Table 5.

Table 5. Westerlund and F-tests

Test	Calculated statistic	p-value	null hypothesis
Westerlund	21.036	0.000	Rejected
F-test	82.14	0.000	Rejected

Source: research findings

4. Estimation Results

As mentioned, parts of the study's variables, which include indices from complex networks, are derived from the FDI inflow network; therefore, their nature is somewhat different from that of other variables. Consequently, in this study, the baseline model is initially estimated using economic variables, after which the indices related to network effects on FDI are separately assessed.

Table 6 provides an overview of the observations and data, accompanied by comprehensive descriptive statistics.

Table 6. Descriptive statistics

Variable	Mean	Min.	Max.	Std. dev.
FDI	0.029	0.0017	1.057	0.109
GDP per capita	0.805	0	1	0.204
Trade openness	0.148	0.21	1.03	0.029
Inflation rate	0.611	0	1	0.179
Quality of gov.	0.771	0.128	1	0.194
Degree	0.541	0	1	0.240
PageRank	0.348	0	1	0.160

Source: research findings

A summary of the results obtained from estimating the three-dimensional panel model, which includes the four trade regions of Shanghai Cooperation Organization, BRICS, D8, and ECO, is presented in Tables 7.

Table 7. The results of the three-dimensional panel model, significance level of 5%

Explanatory variables		Coefficients (P Value)
Economic Variables	FDI (1)	0.117 (0.000)
	GDP per capita	0.076 (0.008)
	Trade openness	0.53 (0.014)
	Inflation rate	-0.058 (0.013)
	Quality of governance	0.054 (0.023)
Network Variables	Degree	0.129 (0.000)
	PageRank	0.233 (0.000)
Selected trade agreements	Shanghai	0.0006 (0.951)
	BRICS	0.0054 (0.547)
	D_8	0.014 (0.181)
	ECO	0.1085 (0.000)
Intercept		0.0187 (0.017)
Wald Statistic		215.42 (0.000)

Source: Research findings using Stata software

Table 7 illustrates the impact of economic variables and governance quality, along with the effect of membership in the identified trade regions on FDI. The results from this table indicate that the effect of lagged FDI, GDP per capita, governance quality (*GOV*), and trade openness (*OPEN*) on FDI is positive and statistically significant. In contrast, the coefficients for inflation rate are negative and significant. Given that the model's functional

form is logarithmic, it can be said that: a one percent increase in the variables FDI (1), GDP per capita, GOV, and OPEN results in increases of approximately 0.117, 0.076, 0.054, and 0.53 percent in FDI, respectively. Therefore, based on the obtained coefficients, it can be concluded that trade openness and previous period's FDI exert greater effects on boosting FDI compared to other variables. Furthermore, the results from Tables 7 indicate a positive and significant effect of ECO membership on the FDI of member countries. In terms of the third dimensions effect involving the region, membership in the ECO leads to an increase in FDI among member countries; however, the effect of membership in other regions on FDI was not statistically significant. The coefficients for the inflation rate reveal that a one percent increase in this variable leads to decrease of approximately 0.058 in FDI, respectively, with the coefficient for the inflation rate being statistically significant.

Table 7 also depicts the effects of the network indices described in this study (degree and PageRank) alongside the effect of the third dimension (trade regions) on FDI. The results demonstrate that both degree and PageRank have a direct and significant impact on FDI. Among these two significant variables, the coefficients for the degree and PageRank are 0.129 and 0.233, respectively. Therefore, it can be inferred that the effect of PageRank on FDI is stronger than degree. Moreover, the Wald test statistic indicates the overall significance of the model.

5. Discussion

This study introduces a novel approach by utilizing a three-dimensional panel model to analyze the impact of trade regions and agreements on FDI. In this study, the relevance of the third dimension—specifically, the influence of trade regions and agreements on FDI—was initially presented. The role of trade regions, another innovation of this study, was highlighted, along with the selection of relevant countries participating in each agreement. The analysis utilized data from eleven countries over the period

from 2009 to 2023, examining the effects of four trade agreements: Shanghai Cooperation Organization, BRICS, D_8, and ECO, on the FDI of member countries. The rationale for selecting these regions stems from Iran's participation in significant trade agreements, specifically D_8 and ECO, as well as its recent membership in the Shanghai and BRICS agreements. The results derived from estimating the model, as presented in Tables 6, indicate that membership in the ECO has a significant positive effect on FDI. However, the effect of membership in the other three regions on FDI, while positive, was not found to be statistically significant. The impact of trade regions on countries' FDI flows is a relatively underexplored area in the literature, with empirical findings often showing mixed results regarding the relationship between regional trade agreements and FDI (Carter, 2013). Ahlquist & Prakash (2008) suggested that increased trust in trade agreements and the protection of property rights lead to higher levels of FDI flows in developing countries. Banga (2003) also found that regional agreements significantly impact the overall investment flows in both developed and developing countries. According to UNCTAD (2023), countries that enter into trade agreements tend to attract higher levels of FDI. For instance, the report indicates that countries with existing free trade agreements (FTAs) experienced, on average, a 30% increase in FDI inflows within the first three years of agreement implementation compared to the years prior. Also, A study by Campos & Kinoshita (2010) found that trade liberalization through regional trade agreements leads to significant increases in FDI. They estimated that for each 10% reduction in tariff barriers, FDI inflows could increase by approximately 5%.

Given that developing countries face more substantial financial constraints, they tend to work harder to adhere to agreements and consensus, aiming to enhance their pathways to development through collaboration. This idea is reinforced by the study conducted by Berger & et al. (2013), which argues that the positive impact of agreements on FDI flows, occurs when accompanied by effective investment regulations; otherwise, it may even exert a negative effect on FDI flows.

It appears that trade agreements comprising countries with larger economies show less adherence to their commitments, and the impact of these agreements on FDI is less pronounced compared to those formed by nations with weaker economies. The results presented in Table 7 indicate that the member countries of BRICS and the Shanghai consist of stronger members such as Russia, India, and Brazil, with no significant outcomes indicating the influence of these agreements on FDI. Another factor that may influence the effectiveness of these agreements is their nature and age. The fundamental basis for the establishment of the ECO revolves around economic issues, and this agreement has a longer history compared to the other studied agreements, as it was founded in1962. Additionally, the Shanghai was formed in1996 with the aim of balancing and limiting the influence of the USA and NATO, the D_8 agreement was established in1996 to promote common cultural, financial, and humanitarian activities, and BRICS was formed in 2009, comprising emerging economies with growth potential. Therefore, it can be concluded that the ECO, in addition to having a longer historical backdrop compared to the other agreements studied, emphasizes its economic dimensions more than other aspects such as security, culture, and politics. In Table6, the variable of GDP per capita is identified as one of the economic variables contributing to increase FDI. A higher value of this variable may indicate the attractiveness of the target country's market (Uddin & Boateng, 2011). A higher GDP reflects market improvement and a dynamic economic outlook to attract more FDI, which in turn serves as a precursor to economic growth (Gui-Diby, 2014; Hussain & Haque, 2016). Studies conducted by Fedderke & Romm (2006) and Moosa & Cardak (2006) align with the findings of this study. Another variable examined is the degree of trade openness, defined as the sum of exports and imports relative to GNP. In some studies, the effect of this variable on FDI has been interpreted such that most foreign direct investments are directed toward regions with open economies. This is because more open economies facilitate easier access to international markets through the export of

products or the import of raw materials. The implication is that less open economies increase the cost of conducting foreign direct investment activities while reducing their returns. Considering the profit motives of multinational corporations, these entities tend to move towards areas with high levels of openness in order to benefit from greater international interaction. This study finds that the effect of trade openness on FDI is positive and significant, consistent with existing studies by Tahmad & Adow (2018), Asiedu (2002), Donghui et al. (2018), Nketiah et al. (2019), and Wiredu et al. (2020). Another variable examined in this study is the inflation rate. The results indicate a significant negative effect of the inflation rate on foreign direct investment (FDI), consistent with findings from various studies (such as Sekmen & Gökırmak, 2020; Mostafa, 2020; Tsaurai, 2018; Mansoor & Bibi, 2018). Multinational corporations often select investment destinations that are less sensitive to inflation. The transmission of inflation to other factors such as energy prices, wages, food prices, etc., leads to increased costs for foreign investors and reduced profits (Sayek, 2009). Therefore, it can be concluded that rising inflation in countries can lead to a decline in foreign direct investment.

Another variable assessed in this study is the governance quality index. The results presented in Table 7 indicate a significant positive impact of governance quality on FDI. This finding is in alignment with evidence derived from empirical studies, which will be referenced later. Chen & Jiang (2023), Nguyen & Cao (2015), Asiedu (2006), and Gastanaga et al. (1998) have stated that poor institutional performance discourages investors and reduces FDI. Bénassy-Quéré et al. (2007) outline the reasons that poor institutional performance affects FDI negatively as follows:

1) Good governance helps companies enhance their productivity.
2) Weak institutions can increase additional costs.
3) Government inefficiency raises uncertainty among firms and increases their vulnerability.

The results of studies conducted by Wei (1997), Javorcik & Wei (2002),

Knack & Keefer 1995), and Aizenman & Spiegel (2006) also indicate the importance of institutional effectiveness in property rights in attracting FDI. Another topic covered in the study is the effect of network indicators on FDI, with the results presented in Table 7. The effects of degree centrality and PageRank indicators on the inflow of foreign direct investment are positive and significant. The results derived from estimating the three-dimensional panel model suggest that selected countries can increase their FDI by enhancing the degree index (the level of connections and interactions). This aligns with findings from studies by Li et al. (2016), Damgaard & Elkjaer (2017), and Arif et al. (2021). The results obtained from the three-dimensional panel model outlined in Table 7 also shows that the effect of the PageRank index on FDI is positive and significant, corroborating the findings of the study by Arif et al. (2021).

6. Conclusions

In light of the findings on network dynamics and the increasing global integration that diminishes the relevance of geographical borders, countries like Iran aiming to enhance FDI should prioritize establishing a diverse set of international connections. This involves developing a diplomatic strategy focused on expanding diplomatic ties and increasing the network's degree centrality. Specifically, engaging with central, high PageRank countries can elevate Iran's PageRank centrality, thereby attracting greater FDI flows through strengthened connections with influential nations. Among economic factors, GDP per capita exhibits a significant positive impact on FDI, while trade openness and inflation rate are negatively correlated. Additionally, higher governance quality positively influences FDI inflows. Consequently, Iran and similar countries can boost FDI by increasing GDP per capita, strengthening institutional frameworks, and implementing policies to curb inflation. Furthermore, the positive influence of the ECO agreement on member countries' FDI highlights the importance of Iran intensifying its cooperation within the ECO framework to attract more foreign investment.

Due to limited data, it remains difficult to conclusively assess the impacts of recent memberships in the Shanghai Cooperation Organization (SCO) and BRICS on Iran's FDI. Nonetheless, these regional alignments present potential avenues for future growth.

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All authors had contribution in preparing this paper.

Conflicts of interest

The authors declare no conflict of interest

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