

Research Article

Determinants of Intercity Air-Passenger Flows in the “Belt and Road” Region

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Air-passenger flow, denoting intercity connections, has been a focal point of studies pertaining to urban networks. While most existing studies include only the geoeconomic characteristics of nodes as explanatory variables, this analysis developed a gravity model by incorporating further factors (e.g., cultural disparity and institutional disparity) that might influence air-passenger flows in the “Belt and Road” region. The primary findings are as follows: (1) The cultural and institutional disparities correlate negatively with the air-passenger flows in this region; (2) air-passenger flows are positively related to border, population and economy size, and economic disparity; (3) flows tend to first increase and then subsequently decrease as geographical distance increases; (4) the impact of the factors on the flows varies by subregion. This study could serve as a reference for those interested in gaining a greater insight into air-passenger flows and could also help improve regional strategies for air-transportation development.

1. Introduction

In November 2013, the Chinese government implemented the “Belt and Road” initiative (BRI, hereafter) which aims to improve the connectivity and regional cooperation between the BRI countries. In March 2015, several government departments jointly released detailed plans for the BRI, encompassing the five major priority areas of policy coordination, facilities connectivity, unimpeded trade, financial integration, and people-to-people bonds [1]. Beyond these, a predominant focus has been on facilitating infrastructure connectivity which promotes the transport, energy, and communication infrastructure, forming a network connecting all the subregions within Asia and between the Asian, European, and African countries. Within this infrastructure connectivity, air-transportation infrastructure has linked even remote and inaccessible geographic locations and fostered intercity relations [2–4]. Thus, air transportation could immensely aid developing countries by unlocking the potential of trade and tourism. Air-transport

demand has been of increasing interests to airlines, airports, government institutions, and scholars in recent years. The distribution and evolution law of traffic flow have been the core research objects of transportation geography.

Therefore, in the background of the BRI, what has been unclear is which factors have promoted or blocked the air-passenger flows in the BRI region. In sum, the previous studies have showed that factors influencing the formation of the transportation structure are complex since the cause comes from both internal network itself and external reasons. Internal factors, such as topological effects [5], have been proven to impact network formation. External factors, including social, economic, and geographic elements, impact the formation of the air-transport network structure and determine its functionality. Thus, these external factors are more pivotal to the actual evolution of the aviation network structure. Essentially, these factors are conducted from the node and edge aspects: (1) From the node aspect, population and economic size enormously influence the passenger flows, as a specific number of passengers and the ability of

meeting demands are critical to the aviation network structure [6–9]; (2) from the edge aspect, geographical distance (which can trigger cost increments) and the border (which can cause the boundary effect) between nodes affect the formation of the air-transport network [10, 11]. However, apart from these factors, cultural and institutional factors have been largely ignored in existing literature. Previous studies have noted that cultural differences (e.g., common language) can both stimulate and hinder leisure travel [12, 13]. Regulation by complicated cognitive and normative institutions is a prominent part of the business flows in BRI countries and should hence be incorporated as key factors.

Thus, the aim of our analysis is twofold. First, we examine some emerging potential factors, such as cultural and institutional ones, to determine whether they influence air-passenger flows in the BRI region. Second, besides these potential factors, we reexamine some determinants, such as economic disparity, economic size, population, geographical distance, and border. This paper is divided into five main sections. The analysis commences with a section methodology that provides a rationale on some potential determinants that could influence air-passenger flows. Subsequently, the methodology section introduces the model we have adopted. The results section reports the parameter interpretation and model estimation results. Next, we discuss the primary findings as well as the limitations of this analysis. In the last section, we present the concluding remarks.

2. Literature Review and Hypothesis

In general, air-passenger flows can be broadly classified into two categories: business passengers and leisure passengers. Business passengers typically constitute a small percentage but are the main source of revenue in airlines. In comparison, the number of leisure passengers is higher [14]. Realizing the category by reviewing the literature is helpful to explain how potential determinants influence each passenger category. Previous studies have identified economy, population size, and geographical distance as the most crucial determinants of air-passenger flows [6, 10, 11, 15]. Given the vast expanse of the BRI region and the large disparity, we believe that, in addition to these determinants, cultural, institutional, and economic disparity must also be considered.

2.1. Cultural Disparity and Air Passengers. Although, during its implementation, BRI advocated for the promotion of cultural exchange [16], the manner and extent to which cultural disparity could influence the development of the BRI region remain unexplored. Before reviewing the literature, we propose the following definition for cultural disparity (CD): the cultural similarity between origins and destinations. A small CD indicates a cultural similarity between the two countries, while a large CD represents significantly different cultures. Regarding leisure passengers, several studies have explored the impact of CD on tourist

flows [13, 17]. Mixed results were observed with respect to the relation between CD and passengers' destination selection [18, 19], indicating that CD could positively or negatively affect air-passenger flows. For instance, CD negatively impacts intercity air passengers, because passengers are more likely to visit destinations with cultures similar to their own [13].

In summary, CD affects both leisure and business behaviors and, thus, could be either an inhibitor or a motivator in air-passenger flows between origins and destinations. In reality, BRI countries have considerably different religions and languages (barriers), indicating large communication costs among these countries. Furthermore, most BRI countries are not primary trade partners. Thus, they are unwilling to overcome large communication costs for trade. Thus, we consider CD as a potential inhibitor in this analysis. Therefore, the following hypothesis was established:

Hypothesis 1. CD negatively affects air-passenger flows. A large CD between cities indicates small air-passenger flows.

2.2. Institutional Disparity and Air Passenger. In general, the institutional context varies significantly across countries [20]. Various institutions have invariably posed a special concern for multinational enterprises; their special regulatory environment may influence the foreign market access and entry mode, thereby inhibiting international business [21, 22]. For instance, a multinational enterprise may face legal restrictions on the number of equity shares to be bought in local businesses [23]. Differences in institutional arrangements may challenge the transfer of strategic organizational practices to their overseas subsidiaries and create hurdles in gaining legitimacy [24]. Moreover, the efficiency of the investment rules varies based on the infrastructure charge levied by private operators or the government [11]. Therefore, institutional differences may exacerbate the information asymmetry between the partners, the risk of partner opportunism, and the cost of doing business abroad [25]. While reviewing leisure passengers, multinational tour operators enjoy an advantage in attracting tourists to the countries they invest in due to their reputation [26]. Therefore, we assume that various institutions in the BRI countries could create obstacles to air passengers' exchange.

Hypothesis 2. ID negatively affects air-passenger flows. A large ID between cities indicates small air-passenger flows.

2.3. Geographical Distance and Air Passengers. Geographical distance (GD), an important concept in geography, has been identified by the location theory (proposed by Johann Heinrich von Thunen) and industrial location theory (proposed by Alfred Weber) has been identified as a valued variable used to analyze the distribution of agriculture, industry, and other economic activities. From a transportation-cost perspective, long-distance traveling generally leads to lesser demand for air travel, primarily owing to the high travel cost [10]. Leisure passengers are more sensitive to the price than business

passengers [27]. From the viewpoint of cultural geography, residents of geographic locations that are in proximity to each other invariably have a similar language and religion [28], which stimulates air-passenger flows. Thus, we propose the third hypothesis as follows:

Hypothesis 3. GD has a complicated effect on air-passenger flows. The latter might be stimulated or limited by distance.

2.4. Economic Disparity and Air Passengers. Similar to the definition offered for CD, a large economic disparity (ED) indicates a large economic gap between the regions. It has been well acknowledged that income is the most common variable in studies on tourism [15]. Further studies have observed that airlines in developed countries have large capacity and demand [29, 30]. However, there is still a paucity of research on how the economic gap between the origin and destination affects the tourist demand. According to the World Bank statistics, the gap in GDP per capita between the BRI countries was up to 325 times in 2017. In general, the large economic gaps indicate differences in needs, thereby expanding the complementarity and promoting exchanges between the regions. Thus, the following hypothesis is proposed:

Hypothesis 4. A large ED has a positive effect on air-passenger flows.

3. Methodology

3.1. Study Area. A list of 198 cities from 66 BRI countries was compiled as per the following criteria: (1) The study area covered the six subregions in the Eurasian landmass (East Asia, South Asia, Central and Eastern Europe, West Asia, Southeast Asia, and Central Asia; see Figure 1), including 66 countries and 1,718 airports in 2018; (2) cities with airports operating more than 25 airlines were included; (3) the capital cities of all the 66 countries were represented. Data on weekly intercity flights helped map the intercity transport linkages. The dataset was gathered in the first week of August 2018 using Google Flight, with each record containing information on the flights, including schedule and the airline. Ideally, directed and annual data should be used in studies of this nature; however, owing to time constraints, our dataset was much smaller. Our overall goal was to estimate the weight differences in the edges. From the data collected on several weekly flights in August, we observed the following: (a) All binary connections were retrieved, and (b) demand did not show either a peak or a trough. Thus, this effect can be considered to be of minor relevance. Resultantly, data on the 147,970 nonstop flights linking 2,717 city pairs in one week were collected (Figure 2).

3.2. Data Source. The conceptual framework of this analysis is shown in Figure 3. The main aim of this analysis is to examine the influencing factors impacting intercity transport linkages in the BRI region. Since the BRI region

includes six subregions and exhibits obvious subregional features in economic and flight distributions, the interpretation of the factors influencing air-passenger flows is distinguished by subregions.

3.2.1. Cultural Disparity. Two different measurement methods were adopted for calculating CD. In the first method, cultural difference indicators were constructed using databases, e.g., the European Values Survey and World Values Survey [32, 33]. However, the data on developing countries are not invariably available. The second method was modeled on Hofstede's cultural framework [34] which uses multidimensional indicators. In comparison, the second method offers comprehensive coverage and is thus extensively used.

Based on the comparison of the above-mentioned methods, we use Hofstede's cultural dimensions to construct a cultural integration index. The dimensions have considered the six indicators, namely, the power distance index (PDI), individualism versus collectivism (IDV), masculinity versus femininity (MAS), uncertainty avoidance index (UAI), long-term orientation (LTO), and indulgence versus restraint (IVR). The first four cultural indicators are widely applied to denote cultural status. Moreover, data on LTO and IVR are missing for most countries in the region. Thus, we selected the first four cultural indicators listed above to propose cultural blending variables curated for this analysis. The cultural scores of the 29 countries can be retrieved from Hofstede's homepage (<https://www.hofstede-insights.com/>). Missing data on some countries were collected from other studies that had calculated the same by applying the Hofstede method [35–38]. Finally, 59 countries were included in our CD analysis. It is calculated utilizing the following formula:

$$CD_{ij} = \frac{\left(\sum_{m=1}^4 [(C_{im} - C_{jm})^2 / V_m] \right)}{4}, \quad (1)$$

where i and j represent the selected cities; m represents the four indices reflecting the CD, while V_m is the score variance of all involved countries on the m^{th} dimension; CD_{ij} represents the cultural distance between cities i and j ; C_{im} is Hofstede's score of the m^{th} dimension of city i , while C_{jm} is the same dimension's cultural score of city j . It is noteworthy that CD_{ij} equals 0 while cities i and j belong to the same country.

3.2.2. Institutional Disparity. The establishment of ID facilitates the calculation of the similarities and differences in institutions. The Worldwide Governance Indicators (WGI), which we retrieved from the World Bank dataset, are well acknowledged and were applied to calculate the distance [39–41]. The six-dimensional indices include the Control of Corruption (CC), Government Effectiveness (GE), Political Stability (PS), Regulatory Quality (RLQ), Rule of Law (RL), and Voice and Accountability (VA). ID was calculated using the following formula:

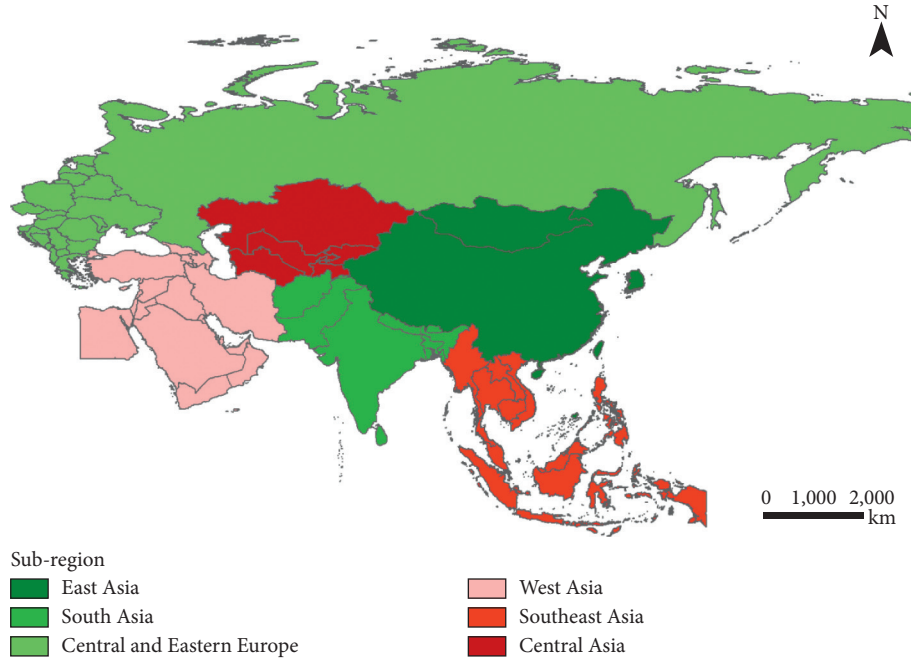


FIGURE 1: Scope of the “Belt and Road.”

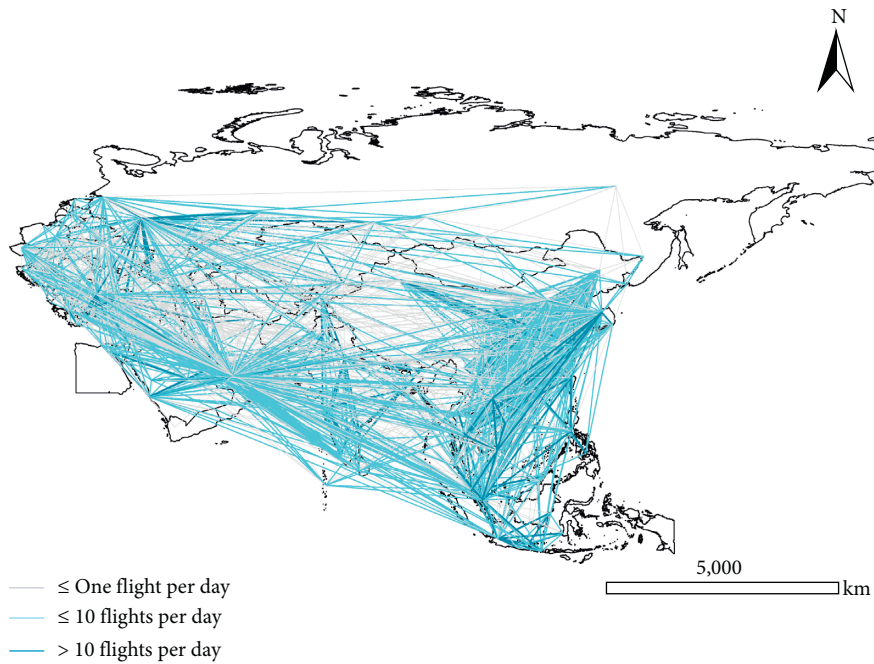


FIGURE 2: Flights in the BRI region [31].

$$ID_{ij} = \frac{\left(\sum_{k=1}^6 \left[\frac{(I_{ik} - I_{jk})^2}{V_k} \right] \right)}{6}, \quad (2)$$

where i and j represent the selected cities; k represents the six dimensions of ID, while V_k represents the score variance of all the involved countries in the k^{th} dimension; ID_{ij} denotes the institutional distance between the two cities; I_{ik}

is the score of the k^{th} dimension of city i , while I_{jk} is the same dimension's score of city j . It is noteworthy that ID_{ij} equals 0 while cities i and j belong to the same country.

3.2.3. Economic Disparity. Economic size is derived from the Visible Infrared Imaging Radiometer Suite imagery nighttime light (NTL) data, and ED was calculated as follows:

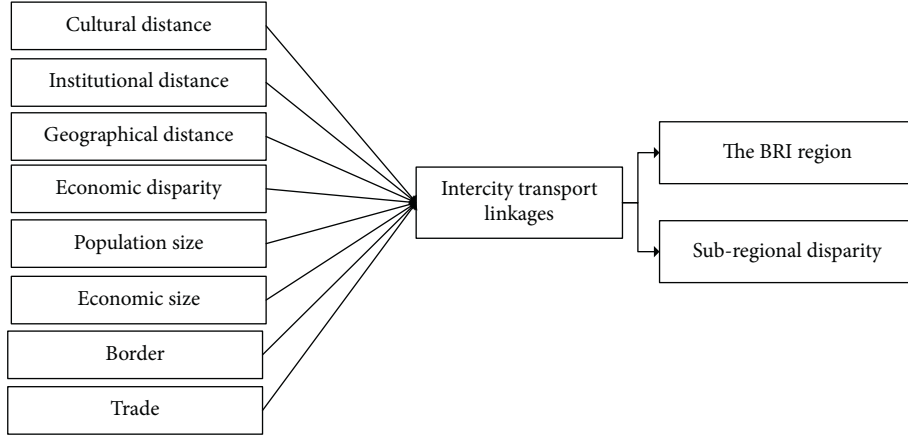


FIGURE 3: Conceptual framework.

$$ED_{ij} = \frac{(L_i - L_j)^2}{L_i * L_j}, \quad (3)$$

where L_i and L_j represent NTL values of cities i and j and ED_{ij} denotes the economic disparity between the two cities.

3.2.4. Other Factors. The geographic distance between the cities is calculated in kilometers by applying the great circle method (Several methods are available to calculate the distance between two points on the surface. Among these, the great circle distance, calculated by the great circle method, is the shortest distance between two points on a sphere.). Both city boundary and population data were obtained from the website <http://population.be/>. The trade data were collected from the World Bank dataset.

3.3. Model Specification. A regression model will be estimated in this section with these factors as the independent

variables and the air-passenger flows as the dependent variable. The gravity model has been widely used in explaining various interregional and international flows [42, 43]. Although the model has been criticized for its lack of theoretical foundation, several studies have investigated the relationship between economic theory and the gravity model [44, 45]. Thus, we applied the gravity model in this analysis. The ordinary least squares (OLS) method is adopted to perform estimations. Approximately, 183 cities from 56 countries were included, considering the data available in some countries while calculating the CD and ID.

The dependent variable in this analysis is the number of weekly flights between the selected cities. The independent variables include not only the multidistances (CD, ID, GD, and ED) that were initially developed but also some other variables. Specifically, the cities' economic size, population size, trade, and border (determining whether the flight is an intercity or an international one) were included. The gravity function was specified as follows:

$$\text{Flow}_{ij} = f(\text{CD}_{ij}, \text{ID}_{ij}, \text{ED}_{ij}, \text{GD}_{ij}, E_i, E_j, \text{POP}_i, \text{POP}_j, \text{trade}_i, \text{trade}_j, \text{border}_{ij}). \quad (4)$$

To estimate the coefficient elasticities, the regression function was calculated based on

$$\begin{aligned} \text{Flow}_{ij} = & \alpha + \beta \text{CD}_{ij} + \gamma \text{ID}_{ij} + \theta \text{ED}_{ij} + \varepsilon_1 \text{GD}_{ij} \\ & + \varepsilon_2 (\text{GD}_{ij})^2 + \delta (E_i * E_j) + \varepsilon (\text{POP}_i * \text{POP}_j) \\ & + \varphi (\text{trade}_i * \text{trade}_j) + \vartheta \text{border}_{ij}, \end{aligned} \quad (5)$$

where Flow_{ij} is the number of direct flights in one week between cities i and j ; CD_{ij} represents the CD between cities i and j ; ID_{ij} denotes the ID between cities i and j ; ED_{ij} stands for the ED between cities i and j . A quadratic function is applied in estimating GD's impact in which GD_{ij} demonstrates the GD between cities i and j ; POP_i and POP_j

represent the populations of cities i and j , respectively; E_i and E_j represent the economic sizes of cities i and j , respectively; trade_i and trade_j show the trade values in the countries of cities i and j ; border_{ij} determines the city pair of a flight belonging to one country. Moreover, $\text{border}_{ij} = 1$ if the city pair of one flight belongs to one country, while $\text{border}_{ij} = 0$ if cities i and j belong to two different countries.

The above model was built to examine the influence of the distance of four dimensions as well as other determinants on air-passenger flows. Model 2, which was constructed based on the following equation, was to explore how each cultural factor (e.g., PDI, IDV, MAS, and UAI) and each institutional factor (e.g., CC, GE, RL, VA, PS, and RLQ) affect air-passenger flows:

$$\begin{aligned}
\text{Flow}_{ij} = & \alpha + \beta_1 \text{PDI}_{ij} + \beta_2 \text{IDV}_{ij} + \beta_3 \text{MAS}_{ij} \\
& + \beta_4 \text{UAI}_{ij} + \gamma_1 \text{CC}_{ij} + \gamma_2 \text{GE}_{ij} + \gamma_3 \text{RL}_{ij} \\
& + \gamma_4 \text{VA}_{ij} + \gamma_5 \text{PS}_{ij} + \gamma_6 \text{RLQ}_{ij} + \theta \text{ED}_{ij} + \varepsilon_1 \text{GD}_{ij} \\
& + \varepsilon_2 (\text{GD}_{ij})^2 + \delta (E_i * E_j) + \varepsilon (\text{POP}_i * \text{POP}_j) \\
& + \varphi (\text{trade}_i * \text{trade}_j) + \vartheta \text{border}_{ij},
\end{aligned} \tag{6}$$

where CC_{ij} , GE_{ij} , RL_{ij} , VA_{ij} , PS_{ij} , LQ_{ij} represent the disparities of CC, GE, RL, VA, PS, and RLQ between cities i and j , respectively; PDI_{ij} represents the PDI disparity between cities i and j ; IDV_{ij} , MAS_{ij} , and UAI_{ij} show the disparity of IDV, MAS, and UAI between cities i and j , respectively.

All the models were completed using the SPSS software.

4. Results

4.1. Descriptive Statistics, Reliability, and Correlation. Table 1 gives the definition of the variables. Table 2 presents the correlation results between two potential variables and the collinear diagnostic results. As shown, all variance inflation factor (VIF) values are below 4, and tolerance values are larger than 0.657, thereby indicating little cause for concern on the major multicollinearity among these independent variables.

4.2. Regression Results in the BRI Region. In Model 1, CD and ID are examined as determinants, whereas their original indices (e.g., PDI, IDV, and CC) are examined as determinants in Model 2. Here, the model is adopted to (1) test the impacts of CD, ID, and their original indices and (2) determine whether the various factors are stable in the different models. The results from the two models are tabulated (Table 3). Two original observations are drawn from these two models. First, the determination coefficients for the two models are high. The independent variables together account for more than 39.9% of the variations of each model. Second, the air-passenger flows (dependent indicator) significantly correlate with the independent variables, indicating that the regression results in the two models are satisfactory.

By examining the hypotheses proposed earlier, the following results were obtained:

- (1) The hypothesis that CD has a negative impact on air-passenger flows is well supported. Specifically, the CD coefficient in Model 1 is -0.068 , indicating a negative impact on air-passenger flows and the expected negative signs. While the regression analysis is traced back to the four indices that are used to calculate the CD, not all of them show the same negative impact. The results suggest that IDV and MAS negatively influence air-passenger flows. Specifically, the IDV coefficients in Model 2 amount to -0.055 . The MAS coefficient in Model 2 is -0.033 . The PDI and UAI demonstrate no significant effect.
- (2) Hypothesis 2, in which ID negatively impacts air-passenger flows, is well supported. The ID coefficient in Model 1 measures -0.058 , indicating a consistent and expected effect on air-passenger flows. While the regression analysis is traced back to the six original indices explored in Model 2 (used to calculate the ID), they indicate quite consistent effects. Only CC negatively impacts the air-passenger flows, with a coefficient of -0.172 . In contrast, the RL (0.108) and VA (0.029) coefficients in Model 2 have a positive effect on air-passenger flows. Moreover, GE, PS, and RLQ in Model 3 show no significant impact on air-passenger flows.
- (3) Hypothesis 3, concerning GD having a complicated impact on air-passenger flows, is well supported. The significant results in the quadratic function are observed, indicating an inverted U-shaped relation between GD and air-transport flows. The air-passenger flows in the BRI region are accompanied by a trend of geographical distance increasing first and decreasing afterward. Furthermore, GD has a more significant impact on the flows compared to CD and ID.
- (4) Hypothesis 4, in which ED has a positive impact on air-passenger flows, is well supported. Both models demonstrate positive coefficients, indicating that city pairs with a larger economic disparity are more attractive than those with a small economic disparity. While comparing the effects shown in the two models, considerably similar coefficients (ranging from 0.022 to 0.03) are obtained.

Furthermore, economic and population sizes positively affect air-passenger flows. As indicated by the two models, city pairs with higher economic and population sizes are more attractive than those with lower sizes. Our results also indicate that the border has a significant impact on passenger flows, suggesting that the number of air passengers tends to be higher if a city pair is located in the same country. Moreover, the impact of trade on air passengers tends to be unstable. Specifically, while in Model 1 the impact of trade on air-transport passengers is negative, in Model 2 the impact becomes insignificant.

4.3. Regression Results in the Subregions. The regression in subregions is conducted under Model 1, and the adjusted R-squared is shown in Table 4. Three striking observations can be made here: (1) In general, the R^2 on the diagonal is higher than that on the nondiagonals, indicating that the model is relatively more applicable in explaining the flows within the subregions; (2) in the intrasubregional linkages, the regression model is more applicable in interpreting the flows within Southeast and South Asia, with R^2 being 0.553 and 0.543, respectively. Regarding the flows within East Asia and Central and Eastern Europe, R^2 is 0.387 and 0.356, respectively. The R^2 value in West Asia is the lowest, at 0.326; (3) while interpreting the flows between the subregions, the regression model is more applicable in interpreting those

TABLE 1: Description of variables.

Index	Abbreviations	Description	Maximum values	Minimum values	Means	Standard deviations
Power distance index	PDI	In score	104	13	71.1	20.62
Individualism versus collectivism	IDV	In score	80	14	36.37	15.55
Masculinity versus femininity	MAS	In score	112	9	49.88	22.54
Uncertainty avoidance index	UAI	In score	112	8	66.97	21.37
Control of corruption	CC	In score	2.07	-1.67	-0.23	0.78
Government effectiveness	GE	In score	2.21	-1.82	0.03	0.78
Political stability	PS	In score	1.53	-2.91	-0.31	1.01
Regulatory quality	RLQ	In score	2.18	-2.09	0.00	0.85
Rule of law	RL	In score	1.83	-2.01	-0.11	0.82
Voice and accountability	VA	In score	1.20	-2.13	-0.43	0.91
Geographical distance	GD	In kilometers	11567.28	224	4550.27	2619.27
Population size	Pop	In thousand persons	2449	1.2	254.16	336.26
Economic size	E	In nighttime light volume (10^4 nanowatts/cm ² /sr)	915.59	0.00	9.55	30.78
Trade	Trade	In US dollar thousand	2395400	0	86629.24	285953.09

TABLE 2: Summary of the descriptive statistics and correlation of the variables.

	CD	ID	ED	GD	E	Pop	Trade	Border	VIF	Tolerance
CD	1.00								1.52	0.658
ID	0.04	1.00							1.03	0.967
ED	0.03	0.00	1.00						1.03	0.975
GD	-0.15	0.04	-0.09	1.00					1.42	0.707
E	-0.09	-0.02	-0.09	0.05	1.00				1.20	0.832
Pop	-0.06	0.02	-0.01	-0.03	0.33	1.00			1.30	0.770
Trade	0.13	0.11	0.01	0.04	0.00	-0.06	1.00		2.42	0.414
Border	0.39	0.09	0.03	0.30	0.05	-0.29	0.70	1.00	3.45	0.289

TABLE 3: Estimation results for the OLS model.

Variables	Model 1	Model 2
CD	-0.068 (***)	
PDI		NS
IDV		-0.055 (***)
MAS		-0.033 (***)
UAI		NS
ID	-0.058 (***)	
CC		-0.172 (***)
GE		NS
RL		0.108 (***)
VA		0.029 (***)
PS		NS
RLQ		NS
ED	0.03 (***)	0.022 (***)
GD	0.662 (***)	0.669 (***)
GD ²	-0.907 (***)	-0.912 (***)
Economic size	0.116 (***)	0.09 (***)
Pop	0.187 (***)	0.182 (***)
Border	0.369 (***)	0.385 (***)
Trade	-0.032 (***)	NS
R ²	0.399	0.408
Significance	***	***

***, **, and * indicate that the correlations are significant at 0.01, 0.05, and 0.1 levels, respectively. NS demonstrates that no significance has been found. R² in this analysis refers to adjusted R². The sample size $N=16836$ in Models 1 and 2.

between South Asia and West Asia ($R^2 = 0.381$) and less applicable between Southeast Asia and Central and Eastern Europe ($R^2 = 0.034$). With regard to the flows between East Asia and the other subregions, the R^2 between Central and East Asia is the highest (0.342), while that between West and East Asia is the lowest (0.04). Regarding the flows between Central Asia and Southeast and South Asia, the regression models are insignificant. Taking into account the flows with Southeast Asia, East Asia displays the highest R^2 (0.265), followed by South Asia ($R^2 = 0.161$) and West Asia ($R^2 = 0.118$). Regarding the flows with South Asia, West Asia has the highest R^2 (0.381, as mentioned above), followed by Southeast Asia ($R^2 = 0.161$). The lowest R^2 occurs in flows with East Asia (0.037), while the value is insignificant in flows with Central Asia. With regard to the flows between Central and Eastern Europe and the other subregions, Central Asia has the best fit at 0.268, followed by East and West Asia, with R^2 being 0.102 and 0.074, respectively. In the flows between West Asia and the subregions, South Asia shows the best fit with R^2 equaling 0.381, followed by Central ($R^2 = 0.236$) and Southeast Asia ($R^2 = 0.118$). In comparison, the value of R^2 between West Asia and East Asia is 0.04, indicating the lowest value.

In general, the impact of CD on the air flows varies within the subregions (Table 5). Among them, the flows within South Asia have the largest negative coefficient, which is 0.265, followed by the flows between South and West Asia. The negative influence coefficient of the CD is 0.217. The coefficient of 0.196 has a negative impact on the flows within East Asia. Furthermore, the impact of the CD on the flows between the subregions is not invariably negative. Positive coefficients are generated within West Asia and between West Asia and Central and Eastern Europe, with coefficients of 0.098 and 0.07, respectively.

The impacts of the ID on the flows show immense disparity between and within the subregions (Table 6). Among all negative impacts, the coefficient between South Asia and West Asia is the largest, at 0.269. The negative coefficients between Southeast Asia and South Asia on the one hand and Central and Eastern Europe on the other are 0.149 and 0.101, respectively. Furthermore, the negative coefficient between East and West Asia is 0.096. In contrast, positive effects emerge in the flows within East Asia and between East Asia and Central and Eastern Europe, with R^2 equaling 0.244 and 0.058, respectively.

The impacts of ED on the flows within and between the subregions are primarily positive (Table 7). It is noteworthy that the flows between West Asia and the other subregions are positively affected by the economic disparity. The flows between West Asia and Central Asia have the largest positive impact coefficients, amounting to 0.235. While referring to the flows within South Asia and Central and Eastern Europe, the negative impact of the ID is observed.

The impacts of GD on the flows within and between the subregions adhere to quadratic equations (Tables 8 and 9). Specifically, the coefficients of GD^2 within all subregions, except Central Asia, are below 0 (Table 8). Furthermore, the coefficients of GD^2 between West Asia and South Asia and Central and Eastern Europe are below 0. Moreover, the

coefficients between East Asia and Southeast Asia are also below 0. These negative values indicate that the flows initially increase and subsequently decrease as the distance augments. Contrarily, the coefficients of GD^2 between East Asia and Central Asia and Central and Eastern Europe are above 0, indicating that the flows decrease first and increase afterward as the distance increases.

The impacts of the economic and population size on the flows within and between the subregions are positive. As shown in Tables 10 and 11, all coefficients are above 0. Specifically, economic size has the most significant impact on the flows between East and Central Asia, with a coefficient of 0.325. In contrast, it has the lowest impact on the flows between East Asia and Central and Eastern Europe. In terms of the population size, the flows within Southeast Asia are influenced the most (with a coefficient of 0.526), whereas the flows between South Asia and Central and Eastern Europe (with a coefficient of 0.084) are affected the least.

While observing the impact of trade on the flows within and between the subregions (Table 12), it is noteworthy that the flows within West Asia and between West Asia and other subregions are positively influenced by trade, except the flows between East Asia and West Asia. Further, regarding the flows within and between East Asia and other subregions, trade has negative impacts.

5. Discussion

By constructing multidimensional distances, this analysis hypothesized about the impacts of CD, ID, GD, and ED on the air-passenger flow formation in the BRI region. Applying a gravity model, the test results of the hypotheses were obtained, which are described in Table 13 with several significant findings.

Previous studies have claimed that a large CD may promote complementary trade between countries [46–48]. The positive impact of CD on international trade could be explained from the perspective of firms being more sensitive to the benefits brought about by complementary trade. The comparative advantages offered by complementary trade invariably outweigh the extra cost of the cultural barriers. However, some evidence suggests that companies tend to expand their business to countries that are culturally similar to their existing business branches to reduce the associated uncertainty and risks [49]. Consistent with the conclusions drawn in a previous study [50], our analysis showed that cultural disparity has a significant negative effect on tourist flows. Specifically, IDV and MAS have negative impacts on air-passenger flows. Thus, air passengers in the BRI region tend to be generalized among cities with similar IDV and MAS. First, IDV scores are high in the European countries (e.g., Hungary [80], Latvia [70], and Poland [60]) compared to those in some Asian countries (e.g., China [20], India [48], Indonesia [14], Pakistan [14], South Korea [18], and Thailand [18]) [51, 52]. IDV refers to how people define themselves (in terms of “I” or “we”) and their relationship with others. Thus, a low IDV score denotes more collective traits. IDV is significantly and negatively correlated to air-passenger flows, and the size effect is the largest (0.055 in

TABLE 4: Adjusted R -squared for the gravity model within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	0.387 (***)					
Central Asia	0.342 (***)	—				
Southeast Asia	0.265 (***)	NS	0.553 (***)			
South Asia	0.037 (***)	NS	0.161 (***)	0.543 (***)		
Central and Eastern Europe	0.102 (***)	0.268 (***)	0.034 (***)	NS	0.356 (***)	
West Asia	0.04 (***)	0.236 (***)	0.118 (***)	0.381 (***)	0.074 (***)	0.326 (***)

The number of samples from the five Central Asian countries is small, so there is no value for R^2 between the Central Asian cities; ***, **, and * indicate that the correlations are significant at 0.01, 0.05, and 0.1 levels, respectively. NS demonstrates that no significance has been found (also applied in Tables 5–12).

TABLE 5: Results of OLS regression analysis of the CD within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	-0.196 (**)					
Central Asia	-0.17 (***)	—				
Southeast Asia	NS	NS	NS			
South Asia	-0.091 (**)	NS	NS	-0.265 (***)		
Central and Eastern Europe	NS	-0.143 (*)	NS	NS	-0.089 (***)	
West Asia	NS	NS	-0.081 (**)	-0.217 (***)	0.07 (***)	0.098 (**)

TABLE 6: Results of OLS regression analysis of the ID within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	0.244 (**)					
Central Asia	NS	—				
Southeast Asia	NS	NS	NS			
South Asia	NS	NS	-0.149 (***)	NS		
Central and Eastern Europe	0.058 (**)	NS	-0.101 (***)	NS	NS	
West Asia	-0.096 (***)	NS	NS	-0.269 (***)	NS	NS

TABLE 7: Results of OLS regression analysis of the ED within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	NS					
Central Asia	NS	—				
Southeast Asia	NS	NS	NS			
South Asia	NS	NS	0.091 (**)	-0.089 (*)		
Central and Eastern Europe	NS	NS	NS	NS	-0.051 (**)	
West Asia	NS	0.235 (**)	0.092 (**)	0.101 (***)	0.067 (***)	NS

TABLE 8: Results of OLS regression analysis of the GD within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	2.178 (***)					
Central Asia	-8.112 (***)	—				
Southeast Asia	NS	NS	1.224 (***)			
South Asia	-0.971 (*)	NS	NS	2.116 (***)		
Central and Eastern Europe	-4.465 (***)	-0.393	NS	NS	NS	
West Asia	NS	NS	NS	2.15 (**)	0.498 (**)	1.65 (***)

Model 2) compared to the other three indices. Second, societies with high MAS scores are driven by achievements, competition, and success, while those with a low score value life quality and happiness. Passengers from a country with a low MAS score have more leisure time, thus leading to a high tourist demand [53]. MAS is significantly and negatively correlated to air-passenger flows, with a coefficient of 0.033.

Thus, air passengers prefer destinations with similar MAS scores.

ID negatively impacts air-passenger flows, as shown in Models 1 and 2. Specifically, CC has a negative influence on air-passenger flows, while RL and VA exhibit a positive influence. However, PS, RLQ, and GE show no significant influence. CC indicates the public's view on the use of public

TABLE 9: Results of OLS regression analysis of the GD² within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	-2.122 (***)					
Central Asia	7.696 (***)	—				
Southeast Asia	-0.946 (*)	NS	-1.443 (***)			
South Asia	NS	NS	NS	-2.374 (***)		
Central and Eastern Europe	4.336 (***)	-0.393	NS	NS	-0.682 (**)	
West Asia	NS	NS	NS	-2.527 (***)	-0.653 (**)	-1.775 (***)

TABLE 10: Results of OLS regression analysis of the economic size within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	NS					
Central Asia	0.325 (***)	—				
Southeast Asia	0.293 (***)	NS	0.257 (***)			
South Asia	0.071 (**)	NS	0.229 (***)	0.106 (**)		
Central and Eastern Europe	0.052 (***)	NS	NS	NS	NS	
West Asia	0.126 (***)	0.306 (***)	0.161 (***)	0.115 (***)	NS	0.289 (***)

TABLE 11: Results of OLS regression analysis of population size within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	0.479 (***)					
Central Asia	0.377 (***)	—				
Southeast Asia	0.500 (***)	NS	0.526 (***)			
South Asia	0.192 (***)	NS	0.308 (***)	0.188 (***)		
Central and Eastern Europe	0.225 (***)	0.231 (**)	0.154 (***)	0.084 (**)	0.341 (***)	
West Asia	0.159 (***)	0.327 (***)	0.162 (***)	NS	0.19 (***)	0.308 (***)

TABLE 12: Results of OLS regression analysis of trade within and between subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	-0.125 (***)					
Central Asia	-0.118 (***)	—				
Southeast Asia	-0.07 (**)	NS	NS			
South Asia	-0.162 (***)	NS	NS	NS		
Central and Eastern Europe	NS	NS	NS	NS	NS	
West Asia	NS	0.263 (**)	0.116 (***)	0.13 (***)	0.096 (***)	0.177 (***)

TABLE 13: Test results of the hypotheses.

	Hypotheses	Estimated results
H1	CD has a negative effect on air-passenger flows.	Supported
H2	ID has a negative effect on air-passenger flows.	Supported
H3	GD has complicated effects on air-passenger flows.	Supported
H4	ED has a negative effect on air-passenger flows.	Supported

power to meet private interests. As shown by Randrianarisoa et al., a country with high corruption hinders airport efficiency [54]. Therefore, countries tend to build more air-transport linkages to countries with similar CC scores. RL captures the perceptions of the extent to which citizens have confidence in and abide by the rules of society. VA indicates the degree to which citizens could participate in governance, expressing freedom. High scores of RL and VA guarantee the development of air infrastructure to some extent, which facilitates cultural exchanges.

Both ED and economy size positively impact air-passenger flows in the BRI region. The results pertaining to economic size suggest that the air-transport demand has a high income elasticity and could be defined as luxury from an economic perspective [27, 55]; this furthermore aligns with the findings of previous studies [56]. Air passengers, especially in international flows, are driven by economic growth to a large extent [15, 57, 58]. Thus, airlines in more developed countries have immense capacity and demand [29, 30]. In 2017, the GDP per capita in the BRI region was

TABLE 14: Regression results among subregions.

	East Asia	Central Asia	Southeast Asia	South Asia	Central and Eastern Europe	West Asia
East Asia	-CD, ID, $-GD^2$, Pop, -trade					
Central Asia	-CD, GD^2 , E, Pop, -trade	—				
Southeast Asia	$-GD^2$, E, Pop, -trade	—	$-GD^2$, E, Pop			
South Asia	-CD, E, Pop, -trade	—	-ID, ED, E, Pop	-CD, -ED, $-GD^2$, E, Pop		
Central and Eastern Europe	ID, GD^2 , E, Pop	-CD, $-GD^2$, Pop	-ID, Pop	Pop	-CD, ED, $-GD^2$, Pop	
West Asia	-ID, E, Pop	ED, E, Pop, trade	-CD, ED, E, Pop, trade	-CD, -ID, ED, $-GD^2$, E, trade	CD, ED, $-GD^2$, Pop, trade	CD, $-GD^2$, E, Pop, trade

5,558 dollars, which increased by 4.39 times that in 2000. A previous study also presented the fact that the given percentage of growth in GDP is matched by an identical growth percentage in annual travel [59]. Regarding ED, cities from a lower level of economic development tend to schedule flights with cities having a higher economic position to achieve development.

In previous studies, the impact of GD was found to be positive within a certain distance [60]. After a certain threshold, however, GD starts to negatively impact flows [61]. In our analysis, GD proves to have a similar irregular impact on air-passenger flows. Within a certain distance, air-passenger flow increases in accordance with increasing distance. This is induced by its advantages compared to other traffic modes (e.g., automotive). However, once a specific distance is exceeded, air-passenger flows are unable to break through beyond the distance decay theory and thus decrease along with the increment of the GD. This can be attributed to, among other things, transportation costs rising with increasing GD. Geographical distance is considerably more important than cultural disparity [62]. Moreover, population has an immense impact on air-passenger flows, indicating that a large population produces more potential holiday travelers. Population's positive influence on air-passenger flows could be explained from the perspective of demand, which is supported by the tourist demand and the abilities of satisfying the same [6]. Apart from the factors mentioned above, air-passenger flows are also susceptible to their domestic or international nature. Domestic flow accounts for the majority of the air-passenger flows in the BRI region since visiting friends/relatives and leisure traffic also constitute a large part of domestic travel. It is noteworthy that flows between some subregions (East and Central Asia, East Asia, and Central and Eastern Europe) decrease first and increase subsequently as GD increases. This phenomenon is explained from the perspective of the urban cluster, as economy and population have been concentrated in East China. Resultantly, these cities have introduced more frequent flights to cities in Central Asia and Central and Western Europe compared to cities in Central and West China.

Moreover, the impact of these factors on air-passenger flows varies based on the subregions and is significantly

different from the one in the BRI region as a whole (Table 14). In comparison, the regression model is more applicable in explaining the flows within subregions than between them. Specifically, CD negatively impacts flows in the BRI region within and between most subregions, indicating that cultural ties continue to dominate flight patterns. According to previous studies, international transactions are influenced by not only the costs of overcoming physical distances, such as those of transportation and tariffs, but also the costs associated with the collection and interpretation of the information required to impact such transactions [63]. Thus, CD significantly dissuades firms from investing in foreign countries [64]. Furthermore, it positively impacts the flows within West Asia and between West Asia and Central and Eastern Europe. This can be associated with the tendency of countries with smaller territories to have lower domestic aviation market shares. Therefore, cities tend to arrange flights connecting to foreign cities that display a large cultural disparity. However, negative influences are also observed within South Asia and Central and Eastern Europe. In the context of GD, typically, the flows (e.g., within East Asia, South Asia, and Southeast Asia) increase and then decrease as the distance augments. This is consistent with the findings of previous studies where a distance decay effect was observed [61]. However, in comparison, the flows between East and Central Asia and East Asia and Central and Eastern Europe first decrease and then increase as the distance augments. Furthermore, economic size significantly impacts the flows between East and Central Asia, while population size has a similar effect on the flows between East Asia and other subregions. With the common factor being the East Asian cities, it can be deduced that the growth of population and economy size in these subregions drives outbound tourism and, consequently, increases the number of international flows.

6. Conclusions

The objective of this paper was twofold. First, we estimated the cultural and institutional factors influencing air-passenger flows. We conclude that CD and ID correlate negatively with air-passenger flows in the BRI region. Second, we examined the significance of the most widely used

factors, such as the ED, border, economy, and population size. We conclude that air-passenger flows in the BRI region have positive relations with ED, border, economy, and population size. Third, a complex GD elasticity is confirmed. In general, flows are first positively and then negatively influenced, with a proportionate increase of GD. Fourth, the impact of these factors on air-passenger flows varies by subregion. Specifically, CD has positive impacts on air-passenger flows within West Asia and between Central and Eastern Europe and West Asia. ID has positive impacts on air-passenger flows within East Asia and between East Asia and Central and Eastern Europe. ED has negative impact on flows within South Asia, while GD has a negative impact first and a positive impact subsequently on air-transport flows between East and Central Asia and East Asia and Central and Eastern Europe.

Theoretically, this paper contributes novel insights into understanding air-passenger flows from the perspective of cultural and institutional disparity. Specifically, it contributes to the existing literature by examining how cultural proximity, which can be formidable in terms of its operationalization and interpretation, influences the formation of air-passenger flows. Practically, this paper briefly illustrates that air passengers in the BRI cities target destinations with similar cultural backgrounds and state institutions. However, the results do not intend to eliminate these differences between the BRI countries. Instead, cultural diversity should be respected, and equal communication between different cultures should be advocated. In view of this, enhanced policy communication is necessary to overcome the barriers erected by institutional differences and to foster and enhance mutual trust among the BRI countries. Moreover, an approach to building a successful low-fare airline business model in the BRI region is also significant for the flow since current air passengers in the BRI region continue to be sensitive to transportation costs.

Nevertheless, our study contains some limitations which may offer various scopes for future research. One of the limitations concerns the reliability of the flight data utilized in this analysis. Instead of an accurate passenger flow, weekly flight data have been utilized in this study. Moreover, neither the size of the airplanes nor the origin-destination flow has been taken into account. As a result, the difference in transport passenger caused by seasonal travel is unrecognizable. Thus, even though the actual physical movements can be reflected by the weekly flights to some extent, accurate passenger flow data are more ideal by comparison to comprehend the social and economic processes [14]. A natural progression of this analysis could be to assess more factors since the future of interurban transport will be determined by the interaction of consumer preferences, bilateral aviation policy, technological developments, and the availability of resources to meet mobility needs [65]. Moreover, by considering cultural and institutional differences, this analysis assumes that cities in the same country exhibit no cultural and institutional disparity. On the contrary, there are many autonomous regions within several countries (e.g., Guangxi and Tibet in China). As a result, even cultures and institutions within a country may show

disparities. Additionally, it is acknowledged that the 2019 novel coronavirus (COVID-19) has caused irreparable loss to air-transport [66–68]. Therefore, being sufficiently aware of how to develop efficient strategies under emergency events is instrumental for the air-transport industry.

Data Availability

The data collected during the study are freely available from Google flight search.

Conflicts of Interest

The authors declare no conflicts of interest.

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