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Modeling the Potential for Aviation Liberalization in Central Asia

- Market analysis and implications for the Belt and Road initiative

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Abstract

This study analyzes aviation markets in the five countries in Central Asia. Panel data spanning from 2007 to 2015 are used to estimate airline service patterns in origin-destination markets. Econometric estimates for domestic and international markets are subsequently benchmarked, and route groups are paired by alternative matching algorithms. Counterfactual analysis is conducted based on the service model estimation and matching results. Our investigation suggests that although the Central Asia – China markets are characterized by poor connectivity and high airfares, more liberal aviation policies such as those proposed by the Belt and Road initiative are likely to help overcome the existing high service barriers. In particular, our counterfactual analysis suggests that if the Central Asia–China markets were regulated and operated in a similar way to the routes between Central Asia and other states, the probability of having aviation services between cities in China and Central Asia would increase substantially, with more direct flights to a larger number of Chinese cities such as Xiamen, Shenzhen, Hangzhou, Qingdao, Chengdu, Kunming etc. We recommend further liberalizations between Central Asia and the region's major trade partners.

Keywords: air transport; liberalization; Central Asia; Belt and Road

1. Introduction

Air transportation is of critical importance to a country's economy and consumer wellbeing. For landlocked countries with limited transport options, improving the availability and affordability of aviation services is even more important. Because of the long distances to other major economies, aviation plays a critical role in serving international passenger travel and airfreight shipments for the five countries in Central Asia, namely Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, and Turkmenistan. These countries are all landlocked without convenient access to maritime services. Therefore, aviation plays an important role in connecting these countries to the world. Indeed, a recent study by Campante and Yanagizawa-Drott (2017) found very strong evidence on the positive effect of long-distance flights to increase business and economic activities. However, the region's aviation sector is not achieving its full potential. In most international markets connectivity and airline competition remain low. The restrictive regulations imposed on the international aviation market in Central Asia could be a major constraint on the region's aviation industry. International aviation markets out of Central Asia are generally under restrictive regulation, although liberal policies have been introduced in selected markets. These regulations could have seriously constrained international aviation market growth in the region.

Air liberalization studies have found compelling evidence that the removal of regulation and the promotion of airline competition have led to substantial welfare improvements. Fu et al. (2010) and Adler et al. (2014) reviewed studies of aviation liberalization and concluded that benefits could come from different sources. First, liberalization removes constraints on airline operation, competition and cooperative arrangements, thus leading to improved airline efficiency and increased market competition. As a result, airline service quality increases and airfare levels decrease, jointly stimulating increased traffic volumes. Second, with route entry and capacity regulations removed, airlines can optimize their network configuration and serve more new destinations. As a result, deregulation and liberalization have improved aviation service quality and airline productivity (Oum and Yu 1998, Oum et al. 2005; Vowles and Tierney 2007; Schipper et al. 2007; Homsombat et al. 2010; Wang et al. 2014; Oum 2019). InterVISTAS (2006) conducted extensive reviews of the effects of major liberalization events in the industry and concluded that the results were substantial and positive overall.

The Chinese government proposed the Belt and Road initiative to promote economic, trade and political cooperation in the region. This initiative, first announced in Sep 2013 during Chinese president's visit to Kazakhstan, aimed to promote policy coordination, trade facilitation, financial integration, and transport connectivity across the Asia–Middle East–Europe region. As part of the initiative, aviation connectivity along the region has been identified as one growth area (ICAO 2017). The Civil Aviation Administration of China News (CAAC News 2017) reported that during 2014-2016, China conducted bilateral air service negotiations with 21 countries along the Belt and Road region, and liberalized air freedoms for services from the Chinese cities of Urumqi, Xi'an, Kunming to selected countries in the region. In the summer of 2017, 70 and 34 new international routes between China and Belt and Road states would be offered by airlines in China and foreign countries, respectively.[1] International aviation between Central Asian states to China remains tightly regulated however, which is likely to be one of the major constraints of the market growth. Under the recently proposed Belt and Road initiative, China demonstrated a strong incentive to

[1] http://www.caacnews.com.cn/special/3494/zbzy/201705/t20170516_1214612.html, which is in Chinese.

liberalize and promote air connectivity (Li et al. 2019). Quantifying and predicting the results of aviation liberalization can help governments in the region to evaluate alternative industrial policies and assist stakeholders such as airlines, airports, and freight-forwarders to prepare for future market dynamics, which includes but is not limited to the Belt and Road initiative.

This study focuses on the effects of liberalizing the aviation market between Central Asia and China, which allows us to study a market with substantial potential: China has a large population and high international trade volume and has been the world's second largest aviation market since 2005 (Fu et al. 2015; Wang et al., 2018). The study consists of three parts. The first part provides an overview over the international aviation market in Central Asia. It illustrates that regulations between Central Asia and China are restrictive, which indicates significant potential welfare gains from liberalization. The second part uses a Probit model estimation to empirically analyze the airlines' decision to serve one route. It shows that the intra-Central Asia routes and routes to the other former Soviet Union countries have the lowest service barriers, while Northeast Asian countries, including China, and Southeast Asian countries have high service barriers for airlines. The third part offers counterfactual analysis to predict what the market equilibrium if the Central Asian aviation market had been liberalized. We compile a group of hypothetical routes linking major airports in Central Asia and China (the "treatment group") that are similar to existing international routes from Central Asia to other non-Chinese destinations (the "control group"). Counterfactual analysis is applied to the treatment group using two alternative approaches. The first approach estimates the probability of having aviation services if the service barrier parameter on the treatment group routes has the same values as those of the control groups. The second approach predicts the possibility for the treatment group to have aviation services by matching them to the routes in the control group using propensity score estimation. Both approaches suggest that the treatment group routes linking China and Central Asia have a great growth potential because the probability of having aviation services will increase significantly if regulation is relaxed.

The contribution of this study is two-fold. First, it develops a new method to study the effects of air transport liberalization, *ex ante*, when limited data are available for an aviation network with multiple routes served by multiple airlines. Adler et al. (2014) summarized three general approaches in modeling airline competition and network rivalry that can be used to simulate the effects of liberalization, namely analytical approach, econometric approach and computational network approach. The analytical approach typically models airline competition over a simplified /stylized network with closed form solutions (see, for example, Brueckner et al. 1992; Oum et al. 1995; Zhang 1996; Hendricks et al. 1997, 1999). However, it is difficult to apply these models to realistic aviation networks. The computational network approach can be used to handle large airline networks (see, for example, Hong and Harker 1992; Lederer and Nambimadom 1998; Adler 2001, 2005; Adler et al. 2010; Li et al. 2010). However, such an approach requires detailed cost and market demand information, which are often difficult to obtain for international markets, especially in regulated markets with restrictive data access. The econometric approach can be applied to estimate dynamic models using actual market data, which is the method our paper aims to adopt. However, existing studies using this approach have been mostly carried out for market where there are very detailed data available for a small number of airlines (see, for example, Berry 1990, 1992; Aguirregabiria and Ho 2012). In the market under investigation, there are quite a few airlines serving the international markets in Central Asia, many of which only serve a small number of routes. Therefore, there is insufficient number of observations to estimate a particular airlines' behavior, making it difficult to apply the estimation procedure developed in previous studies. Therefore, we developed an investigation model that requires a relatively small dataset of airline route services and generic control variables. Such a method is feasible for the analysis of many markets in practice.

The second contribution of this study is on the policy side. Our analysis provides rich results for the international markets in Central Asia, which assist decision-making by governments and the airline industry in the region. Specifically, our investigation suggests that although the Central Asia – China markets are characterized by poor connectivity and high airfares currently, more liberal aviation policies such as those proposed by the Belt and Road initiative will likely help overcome the existing high service barriers, especially those imposed by the restrictive air policies. If the Central Asia–China markets were regulated and operated in a similar way to the routes between Central Asia and other states, there might be a substantial potential to increase air connectivity. Our study also identifies specific destinations that are more likely to sustain airline service, for which airlines may put higher priority in introducing direct flights.

In several ways our proposed econometric method can be compared with those used in studies that aimed to identify the negative "border effect" on bilateral trade. McMallum (1995) incorporated the border dummy variable in a gravity model to study how the Canada-US border might hinder bilateral merchandise trade. Many trade papers followed McMallum (1995) to examine the trade hindering effects of bilateral regulation and other trade barriers. Such a border effect is similar to the service barrier parameter estimated in our study, which is a hurdle to airlines in serving international routes from Central Asian countries to a foreign destination. Different from the gravity models used in trade literature, our method is a discrete-choice model based on airlines' profit-maximizing strategy. Airline's decision to serve particular markets has been well studied empirically (Bresnahan and Reiss, 1990; Berry, 1992). Whereas airlines' oligopoly behavior has been considered in the literature, few studies have examined the effects of regulation. Our study extends the airline discrete-choice model to serve particular routes to the international markets, thus that the effects of ASA restrictions on airline route choice and competition can be identified.

The remainder of this paper is organized as follows. Section 2 provides an overview of the international aviation markets in Central Asia. Section 3 describes our data source and variable definitions. Section 4 specifies the airline discrete choice model and estimations of airlines' service barriers between Central Asian and other countries. Section 5 conducts counterfactual analysis to explore the potential of Central Asia-China aviation market. The last section summarizes and concludes this study.

2. The International Aviation Market in Central Asia

All five landlocked countries in Central Asia can be classified as developing countries. Some summary statistics concerning the region's economic and trade activities are available in Appendix. Table A1 summarizes the GDP and GDP per capita for the five countries in year 2006 and 2016 respectively. Table A2 summarizes the export and import values. Overall, these countries have achieved good economic growth over the past decades albeit still at relatively low levels. Figure 1 summarizes the total number of international passengers from Central Asia to the rest of the world between 2006 and 2015. We collect the quarterly airline and route-specific air traffic and average airfare data from PaxIS, a database maintained by IATA (International Air Transportation Association). The data are directional (i.e., one-way from Central Asia to foreign countries), and because passenger traffic volumes are usually symmetric, they present about 50% of the total traffic volumes in the related international markets. In 2015, traffic volume declined slightly for the first time in the sample period. This is probably due to the Russia–Ukraine war that took place in 2014, although more in-depth analysis is needed to identify the true cause behind.[2] Overall, despite the global financial crisis in 2008, the region's aviation market has achieved sustained growth, with one-way passenger volume more than doubled from 1.5 million in 2006 to more than 4 million in 2015.

<Figure 1 about here>

Figure 2 summarizes the number of international routes from Central Asian countries. Strictly, any flights across national border should be classified as international. As will be discussed in Section 3 data source and variable definition, for better econometric identification we will classify routes into different groups. Therefore, for ease of reference an international route is counted if it involves direct flights between an airport in one of the Central Asian countries and an overseas airport, where an overseas airport refers to one in a country outside Central Asia. Flights within a Central Asian country are "domestic", and flights between the five countries are referred as "intra-Central Asia". From 2006 to 2016 the number of international routes in the region grew substantially from 200 in 2006 to close to 300 in 2013, until a reverse in growth in 2015 and 2016, again probably due to the Russia–Ukraine conflict in 2014.

<Figure 2 about here>

As shown in Figure A1 in Appendix 1, the five Central Asian countries have been forming very strong economic and trade ties with China, to the extent that China is becoming the region's most important export or import partners at the time when the Belt and Road initiative is being implemented. Given China's large international trade volume, huge population, and high economic growth, one would expect a high growth in direct routes and air connectivity between Central Asia and China. However, this has not been the case. Table 1(a) summarizes the number of international routes and passenger volumes for Central Asia's top 10 overseas destination countries in 2007, 2010, and 2015, respectively. All five nations in Central Asia were member states of the Soviet Union, and still have strong economic, cultural, and political ties to Russia and other former Soviet states. This probably explains the excellent connectivity between Central Asia and Russia. In comparison, although traffic volumes to China more than doubled between 2007 and 2015, there has been little change in air connectivity. Despite China's enormous economic size and geographic proximity, only a few international routes link Central Asia to China. In 2015, there were only 14 routes between the two regions, with only 3 Chinese destinations (Urumqi, Beijing, and Sanya[3]).

[2] Central Asia had the greatest number of routes and passenger traffic with Russia than with any other overseas country. Russia was sanctioned by Western countries, such that the trade between Central Asia and Russia might have been seriously affected, as well as the bilateral air transport.

[3] Among those, direct flights to Sanya were not available year around. This is probably because Sanya is a tourist destination with tropical weather and supported seasonal operations.

This is far less than the number of routes to Russia: 176 routes serving 31 airports. Indeed, for Central Asia the relative importance of the Chinese aviation market has declined, and it is now behind major hubs in Turkey and the UAE (Istanbul and Dubai).

<Table 1 (a) and (b) about here>

The airfares to China have been very high. Table 1(b) reports the yields on different routes based on airfare data from PaxIS database. Passengers paid on average US16 cents per kilometer for flights to China, whereas the average in virtually all other markets ranged between US7 and US11 cents. The average yields to Turkey, Ukraine, France and Israel were less than 8 cents, less than 50% of that on Chinese routes. Table 1(a) and (b) jointly suggest that compared with other major destinations, market growth in Central Asia-China routes seems to have lagged behind in recent years. There has been little improvement in air connectivity, and prices have remained remarkably high.

The growth of the aviation markets between Central Asia and China has not matched those to major markets in Russia, Turkey and UAE. This could have been caused by restrictive regulations in the international markets. Table 2 lists the Air Liberalization Index (ALI) calculated by the World Trade Organization (WTO) for Uzbekistan and Kazakhstan, the two largest economies in Central Asia in terms of population and national GDP. The cases for other Central Asian countries are similar so are not reported here to save space. The ALI is calculated based on the air service agreements (ASAs) signed by a country with other international destination countries. A large ALI value indicates liberal regulation, whereas a small ALI value suggests tight regulation on airlines' operation decisions such as route entry, capacity and frequency, airfares, and cooperative arrangements. This indicates that substantial welfare gains could be obtained through liberalization, as the market outcomes observed in previous studies suggest. In the following section, we will first empirically analyze the airlines decision to serve particular routes, so that counterfactual analysis can be carried out to predict the effects of liberalization.

<Table 2 (a) and (b) about here>

3. Data source and variable definition

Our main data source for the empirical investigation is the PaxIS database maintained by IATA. PaxIS database reports the quarterly airline and route specific air traffic volume and average ticket price. We collected the data to construct a sample panel data of 19,129 observations covering origin-destination (OD) routes between 46 Central Asian airports, and from those Central Asian airports to 106 overseas (outside Central Asia) airports during the 2006-2015 sample period. Tables A3 and A4 in Appendix list all the airports included in the sample.

We include an OD route in our sample if this route had (once) been served by airlines during the 2006-2015 period for at least one quarter. By doing this, we avoid confounding scenarios in which airlines are strictly forbidden by ASAs from serving a route, or the route has no chance being served economically. Note even with service permission airlines may choose to exit routes during certain periods, if it is economically infeasible to sustain services on these markets. For example, an OD market A-B that had profitable airline operation in Q1 2010 might lose airline services later in Q4 of 2010, if the demand conditions changed in a way that made operation no longer profitable. The A-B market will be included in our sample, and service variable is 1 for Q1 2010 and 0 for Q4 2010. Another OD C-D will be excluded from our sample if it had never been served by any airline during the sample period.

The data is directional where Central Asian countries are the origin countries. Three types of destination countries or regions are distinguished. The first type of destination country is the own country, which captures the case of Central Asian domestic routes. The second type is a foreign Central Asian country, which captures the case of intra-Central Asian routes. The third type are all other countries and regions, which captures the case of international routes that connect Central Asia with overseas countries and regions outside Central Asia. The sample includes altogether 42 countries and regions: 5 Central Asian Countries (i.e., Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan, Kyrgyzstan), 9 former Soviet Union Countries and 28 other international countries and regions, which are reported in Table 3. Dummy variables are used to represent these types of foreign destinations. A single dummy variable exists for each Central Asian destination country, which takes value one if it is different from the origin Central Asian Country and takes value zero otherwise. Furthermore, we have one dummy variable for every other foreign destination country or region.

<Table 3 about here>

With the above-mentioned sample construction method, there are total 19,129 observations. For the observations from Central Asia to other overseas countries, there are total 412 such routes identified, with the total number of observations as 412*40=16,480 in our study period (40 quarters). It is noted 412 is the total number of routes having ever been served during the study period 2006-2015. This is thus larger than the maximum number of international routes for particular year, because there are some routes previously served by airlines having no airline service in particular following years. For the intra-Central Asia (within Central Asia) sample routes, if it is the routes between any two Central Asian countries, we also followed the approach as the overseas routes, and there are 15 such routes, with observations as 15*40=600 for the study period. The rest 2,049 observations are for the domestic Central Asian route observations. For these routes, as ASA restriction is not a concern, we just included the observations when it had airline services. And there are 79 such domestic routes, with some routes unserved in some quarters, causing the unbalanced panel data.

We regard one route as served at one quarter if at least one airline provides service on this route during the corresponding quarter.[4] A dummy variable is used to indicate that routes were served, taking value 1 if there was aviation service on this route in this quarter, and taking value 0 otherwise. The mean value of this dummy variable is 0.514, which shows that although all routes

[4] To rule out the irregular schedule such as charter flights, we set a minimum requirement of one flight per week to be justified as service availability.

in our sample had aviation services at some point, many did not have continued aviation operations in the sample period. The PaxIS database also includes the route distance information, with which we construct the distance variable. The mean value for route distances is 2,359 kilometres, which is substantial and reflects the huge geographical area covered by Central Asia and long distances to overseas destinations.

Origin and destination airports are characterized by their total scheduled seats. The scheduled seats data is retrieved from the OAG (Official Airline Guide) database, which maintains the airline and airport specific scheduled seats data. The mean size of the origin Central Asian airports in terms of total scheduled seats is 218,108 per quarter while the corresponding value for destination airports is around 2 million quarter, because many destinations are major hub airports in the world (e.g. Dubai International, Istanbul, Beijing etc., as reported in Table A4). Origin and destination airports are further characterized by their airport level HHI indexes, which are calculated with the OAG data as well. The airport HHI is calculated using the share of each airline's scheduled seats in the airport. The mean HHI value for origin airports is 4,344 and higher than the corresponding value of 3,214 for destination airports. Given the substantial differences in airport sizes between Central-Asian origins and destinations outside of Central-Asia, it is not surprising that the smaller Central-Asian airports are more concentrated.

Finally, the GDP for the origin and destination countries collated from the World Bank database is used to control for market potentials. Overall, the GDP of Central Asian countries is much lower than the GDP of destination countries. The summary statistics of our data sample is collated in the following Table 4.

< Table 4 about here>

4. Market Service Barrier Estimation

4.1. Model specification

In this section, we investigate the factors affecting the airlines' ability to serve the Central Asian market. The airline route service decision can be significantly influenced by ASAs and their regulations on air freedoms, capacity and frequency deployment, destinations and cooperation agreements between airlines. This way ASAs can have an impact on the economies of scale, density and scope of airline operations, increase airlines' costs and reduce profit. For example, the 5th freedom is important for airlines to develop hub-and-spoke networks and to aggregate the demand on each flight segment, such that economies of density and operation efficiency can be achieved. On the revenue side, an airline may be forbidden to increase supply even if it is profitable to do so. IITL (2008) noted that Korean Air and Singapore Airlines achieved very high load factors (87% and 90%, respectively) for their services from Korea to Vancouver. Singapore Airlines, however, could not get the approval to increase frequency beyond the grandfather right of 3 flights per week. It is also possible that ASAs act as a market service barrier for rival airlines and, thus, increase airline profit by limiting competition. In this case, the market service barrier parameters may take opposite signs.[5] Other factors beyond managerial control such as historical, cultural, political, and economic ties also affect the airlines' service decisions and service barrier parameter estimates.

Let π_{ikft} be the profit for one airline to serve the route i at time t in Central Asia, where the subscript k represents the origin Central Asian country and f represents the destination country, which can be a Central Asian country or a country outside Central Asia. Let C_f denote the cost/barrier to serve the route to the destination country f. Let Y_{ikft} denote the service status of route i between the Central Asian city and the other foreign country at time t. Given that airline decision to serve one route is conditional on profits exceeding service costs, the probability of airline service can be specified as Prob(Y_{ikft} =1) = Prob(π_{ikft}/C_f >1), where the right-hand side can be rewritten as Prob(lnπ_{ikft} − lnC_f> 0). Letting X_{ikft} denote a vector of control variables and μ_{ikft} denote a stochastic error term, lnπ_{ikft} can be written in the log-linear form,

$$\ln\pi_{ikft} = \ln X'_{ikft}\varphi_r + \mu_{ikft} \tag{1}$$

Using the domestic market in each Central Asian country with cost/barrier parameter denoted by C_d as the benchmark, we can write $C_f = \theta_f C_d$. The parameter θ_f on the right-hand side of the equation measures the barriers imposed by these regulations targeting international routes and, thus, the difficulty to serve a route to the foreign country f relative to the domestic market. Altogether, the probability of airline service can be rewritten as,

$$\text{Prob}\left(Y_{ikft} = 1|X_{ikft}\right) = \text{Prob}\left(\ln X'_{ikft}\varphi_r - \ln C_d - \sum_{\tilde{f}=1}^{F}(\ln\theta_{\tilde{f}} \times D_{\tilde{f}}) + \mu_{ikft} > 0\right), \tag{2}$$

Where D_f are the dummy variables that indicate whether the destination country is a Central Asian country or a specific country outside Central Asia. This equation will be used to estimate the term $\ln\theta_f$ for each country f. The vector of control variables used is

$$X_{ikft} = \begin{pmatrix} Dist_i, AirportsizeOrigin_{ikft}, AirportsizeDest_{ikft}, \\ AirportHHIOrigin_{ikft}, AirportHHIDest_{ifkt}, \\ GDPOrigin_{kt}, GDPDest_{ft}, Quarter_t, Year_t \end{pmatrix}, \tag{3}$$

where the variable $Dist_i$ is the flying distance of the route i. The variables $AirportsizeOrigin_{ikft}$ and $AirportsizeDest_{ikft}$ are the passenger throughputs of the origin airport in the Central Asian country k and the destination airport in the foreign country f, respectively, of the route i at time t. These variables are used as the proxy for the potential market size of the route. The route-level passenger traffic accounts for only a small proportion of the airport's total throughput, so that they can be considered as exogenous. The variables $AirportHHIOrigin_{ikft}$ and $AirportHHIDest_{ikft}$ are the HHI market concentration indexes for the origin and destination airports on route i at time t. These variables help us measure the airlines' hub status in the origin and destination airports. A high airport HHI indicates greater concentration of airports with more monopoly power of particular

[5] We are thankful to an anonymous referee for raising this issue to us.

carriers, affecting airlines' decision to serve the routes involving the airport. The airport HHI is regarded as exogenous because the individual route level passenger throughput accounts for only a small proportion of the airport's total throughput.[6] $GDPOrigin_{kt}$ and $GDPDest_{ft}$ are the GDP values of the origin Central Asia country k and destination foreign country f at times t. As it is difficult to obtain city-level GDP data, national-level GDP data are used. As the quarterly data are used, we also include the quarterly dummies $Quarter_t$ and yearly dummies $Year_t$ to control for the time trends. The error term μ_{ikft} can be assumed to be *iid* and normally distributed ($\mu_{ikft} \sim N(0,1)$), so a standard probit model estimation can be used. To capture differences in the demand characteristics and market competition conditions across routes, we allow random coefficients for the variables capturing airport sizes and airport HHIs. Thus, we allow the parameters φ_r to vary across routes. The logarithm of the cost of domestic route operation, $\ln C_d$, can be estimated as the intercept of the right-hand side of equation 2. And the service barrier parameters, $\ln\theta_f$, can be estimated using country dummies D_f.

4.2. Estimation results

Three models are considered and estimated: Model 1 pools the data of all airlines and all Central Asian countries, which assumes the same values of control variables' coefficients (i.e. endpoint airport size, HHI, endpoint countries' GDP and route distance) for all the sample routes. Model 2, however, distinguishes between two subsamples to allow different coefficients of control variables, because the market demand and airline cost functions vary across the markets. The first subsample covers the domestic routes and the routes between two Central Asian countries, where suffix d is used to indicate this set of routes. The second subsample covers routes between Central Asian countries and other international destinations, and a suffix O is used to indicate this set of routes. Model 3 further assumes that routes to former Soviet Union countries have similar demand characteristics as the domestic and Central Asian routes. This is to capture the close economic, political, and cultural ties between Central Asian countries and countries from the former Soviet Union. The suffix d is applied to domestic, inter-Central Asian routes and the routes to Soviet Union countries in Model 3. The estimated service barriers of the three models will be different because we allow the coefficients of the control variables to vary between countries with suffix d and countries with suffix O in Model 2 and Model 3. Estimating these three models allows us to test the robustness of the model specifications, to identify possible heterogeneity across different routes (by allowing coefficients to be different for those routes to former Soviet Union countries versus to other international destinations, for example), and to increase estimation efficiency if such heterogeneity is significant. Figure 3 illustrates the division of the sample routes for Model 1, 2 and 3.

< Figure 3 about here>

The estimation results of the service model are shown in Table 5. Our main interests are the service barrier parameters $\ln\theta_f$ for different countries benchmarked to the domestic routes of each Central Asian countries (where there is no restriction imposed by bilateral ASA). The estimated service barrier parameters are statistically significant, and Table 6 summarizes and ranks them for Models

[6] Exogeneity of HHI variables may not be guaranteed, especially at small airport. The corresponding estimation results should therefore be considered with caution.

1 to 3. We list the service barrier parameter for the intra-Central Asian countries in the first row, and then rank the other countries' service barriers below it. The intra-Central Asian routes and routes to the other former Soviet Union countries have the lowest service barriers. Northeast Asian countries, including China, and Southeast Asian countries have high service barriers for airlines. This is consistent with the ALI values reported by WTO.

<Table 5 and 6 about here>

The above estimations are based on the pooled data of all the Central Asia routes and airlines (i.e. all airlines in Central Asia and foreign countries). In addition to possible differences across different groups of countries (e.g., as those controlled in Model 2 and Model 3 as reported in Table 5), there could also be significant differences across the five Central Asian countries (e.g. different air travel demand and service barriers), in which case the specifications in Table 5 may not lead to the most efficient estimation. To test the robustness and efficiency of our estimation results, we estimate the service model for each individual Central Asian country respectively as reported in Appendix 3. Because sample size for individual countries are much smaller than the pooled data, many country dummy variables (service barrier parameters) are no longer statistically significant. Nevertheless, there are no radical differences from the results reported in Table 5.

5. Counterfactual Analysis of the Central Asia-China International Market

As suggested by the service barrier parameters estimated in Section 3, air routes to China have higher service barriers than intra-Central Asian routes, and routes to the former Soviet Union and some other countries. In this section, we conduct a counterfactual analysis to study what could possibly be achieved if the aviation market connecting Central Asia and China would be liberalized.

First, we construct a set of hypothetical routes linking major Central Asian and Chinese airports, where aviation services are more likely to be viable than routes linking smaller cities. We select the top 19 largest Chinese airports by scheduled seats in 2011 to generate a sample of potential routes to Central Asian airports with at least 100,000 yearly scheduled seats in 2011. 18 Central Asian airports meet this criterion. The selected Chinese and Central Asian airports are listed in Table 7. With 19 Chinese airports and 18 Central Asian airports, a total of 342 sample routes were generated, which form a set of hypothetic "treatment group" routes for which we will simulate the effects of liberalization. Second, we will use two alternative approaches to conduct such counterfactual analysis. The first uses the barrier parameters estimated in the previous section, while the second applies propensity score matching.

<Table 7 about here>

5.1. Counterfactual analysis using coefficients estimated in service models

We first predict the effects of liberalization by leveraging the coefficients obtained in service model estimations in Section 4. To do so, we first calculate the probabilities of having aviation service using the coefficients estimated in Section 4. The predicted probabilities are calculated using the estimation results of all three Models in Section 4, respectively. It is noted 11 routes of the treatment group (our hypothetical Central Asia to China routes) had airline operation already, and thus excluded in the calculation. The calculations for the remaining 331 treated routes correspond to the probability of having aviation service on individual routes under the current market conditions (i.e. without liberalization). As reported in the first row in Table 8 (a)-(c), the average service probabilities are very low (i.e. 0.15%, 0.03% and 0.24% using estimated service model parameters of Model 1 to 3, respectively). [7] This result is not surprising because we considered a large treatment group routes in order to include all reasonably large OD markets. Under the current market conditions, the aviation connectivity between Central Asia and China is very poor and few routes in the treatment group can secure aviation services. In the last column of Table 8 (a)-(c), we take the average predicted service probabilities for the 11 routes already having services as a robustness check. It is noted these routes on average have much higher predicted service probabilities than other hypothetical routes between China and Central Asia, validating the estimated model.

We then recalculate the probabilities of service by replacing the service barrier parameter values with the average of those estimated for routes to former Soviet Union countries. These calculations allow us to simulate the service probabilities on these routes when they are the under the same market conditions as those between Central Asia and former Soviet Union states, benchmarked to its current status of no service at all on these routes. The second rows of Table 8 (a)-(c) report the average and 95% confidence interval of the predicted service probabilities. The average predicted service probabilities are 15.4%, 19.3% and 35.2% for Model 1, 2 and 3, respectively. The upper limit of the 95% confidence interval of the predicted service probability is 16.7%, 20.81% and 37.09% for Model 1, 2 and 3, respectively. [8] Although these numbers are small, the maximum predicted service probability increased significantly to 54.83%, 70.79% and 85.6%, respectively. We listed those routes with the highest predicted probability, and it can be seen the top candidate routes are TAS(Tashkent)-URC(Urumqi), TAS(Tashkent)-CAN(Guangzhou), TSE(Astana)-PEK(Beijing), TAS(Tashkent)-CTU(Chengdu), TAS(Tashkent)-KMG(Kunming), ALA(Almaty)-KMG(Kunming), TAS(Tashkent)-SZX(Shenzhen), DYU (Dushanbe)-CTU (Chengdu), ALA (Almaty)-SZX (Shenzhen), TAS (Tashkent)- CKG (Chongqing). Therefore, the Tashkent, Astana, Almaty and Dushanbe are top candidate central Asian cities, and Beijing, Urumqi, Guangzhou, Shanghai, Kunming, Chengdu, Shenzhen, Chongqing are the top candidate Chinese cities to open the airline services.

< Table 8 about here>

This suggests that some selected routes may have significantly higher chance of having aviation services if market conditions, including regulation/liberalization, are similar to those on routes from Central Asia to former Soviet Union countries. It should be cautioned that historical, political

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[7] The estimated service barriers of the three models are different because we allow the coefficient of the control variables (i.e. endpoint airport size, HHI, endpoint countries' GDP and route distance) to vary in Model 2 and Model 3. Please refer to the Section 4.3 for more details about the specification of Model 2 and 3.

[8] With 331 treated routes, the upper limit of the 95% confidence interval of the predicted service probabilities implies that about 55, 69 and 122 routes would be entered when China can have similar service barrier parameters to those of former Soviet Union countries.

and cultural factors may be important determinants for aviation services which are not separately identified in our study. Therefore, an implicit assumption for the above simulation is that routes to China will have similar historical, political and cultural conditions as routes to former Soviet Union states. This assumption is likely to be too optimistic and thus overestimate the effects of liberalization. Therefore, we further recalculate the probability of having aviation services by replacing the service barrier parameter with the average of the values estimated for routes from Central Asia to non-former Soviet Union states (i.e. countries listed in "Other International Countries" in Table 4). The results are reported in the third row of Table 8. As the average service barriers with other international countries of Model 1 and 3 are slightly smaller than that with China, overall, this led to very limited changes: the average service probability of all the 331 routes increased from 0.15% to 0.62% using Model 1 estimation, and 0.24% to 3.76% using Model 3 estimation, but slightly decreased from 0.03% to 0.02% using Model 2 estimation. The upper limit of the 95% confidence interval of the predicted probabilities is 0.728%, 0.024% and 4.245% using Model 1, 2 and 3, respectively. [9] And the maximum service probability increases from 1.8% to 6% using Model 1 estimation, and from 4.42% to 29.9% using Model 3 estimation.[10] Such a result is due to several facts: (a) ASAs between Central Asia and non-former Soviet Union states tend to be quite restrictive, and the average of service barrier parameter is 2.96 in Model 1 and 4.678 in Model 3, only marginally lower than the estimate for China; (b) the treatment group included a large number of routes which are unlikely to have aviation services under the current regulations. For Model 2, the estimated average service barriers of the international countries is even slightly larger than that with China, causing the predicted service probabilities to be even lower when replacing the service barriers of China with that of the international countries. Furthermore, in Table 9, we present the top 10 routes between Central and Asia in terms of the predicted service probabilities, by replacing service barrier parameter of China with the average of Soviet Union countries.

<Table 9 about here>

5.2. Counterfactual analysis using propensity score matching (PSM)

The counterfactual analysis in the previous subsection is based on coefficients estimated with the service models as reported in Section 4. Therefore, estimates and interpretations are most reliable for "average routes" that have control variable values close to sample means. The large ranges of predicted service probabilities in Table 8 and 9 suggest, however, that there may be substantial heterogeneity across routes. The previous approach may therefore be particularly problematic for the analysis of routes to China, because during the sample period only 11 routes from Central Asia to 3 Chinese destinations (i.e., Beijing, Urumqi and Sanya) were available for the service model estimation. Chinese airports contained in the treatment group, which currently have no services to

[9] With 331 treated routes, the upper limit of the 95% confidence interval of the predicted service probabilities implies that about 2.4, 0 and 14 routes would be entered when China can have similar service barrier parameters to those of the other non-former Soviet Union countries.

[10] According to Model 1, 2 and 3, the routes with the highest predicted service probabilities are TAS(Tashkent)-URC(Urumqi), ALA(Almaty)-PEK(Beijing), TAS(Tashkent)-CTU(Chengdu), ALA(Almaty)-KMG(Kunming), TSE(Astana)(-CAN(Guangzhou), TAS(Tashkent)-CGO(Chongqing), TAS(Tashkent)-HGH(Hangzhou), DYU(Dushanbe)-URC(Urumqi), TAS(Tashkent)-TAO(Qingdao), TAS(Tashkent)-DLC(Dalian).

Central Asia, may also have very different characteristics from the sample used for service model estimation. To deal with this heterogeneity, we develop an alternative approach based on propensity score matching (PSM) that does not rely on coefficients estimated in Section 4.

We first match the treatment group routes to international routes that had aviation services. Because our sample covered 2006 to 2015, the fourth quarter of 2011 is chosen as the middle point of our sample period. International routes out of Central Asia that had aviation services at this time are used a “control group”. These observed sample routes that had aviation services are matched to routes in the “treatment group”, so that we can identify hypothetical routes resembling existing Central Asian routes. As discussed, routes to former Soviet Union states may be different from the routes to other international destinations. Therefore, they are classified as “Control Group 1” and “Control Group 2” routes, respectively.

PSM allows us to find the most similar counterfactual route in the control group (existing Central Asian routes) for each of our hypothetical Central Asia-China route.[11] The propensity score is calculated by running a probit model to measure the probability of one OD pair to be a hypothetical Central Asia-China route, based on the covariates chosen (see Appendix).

We match the hypothetical routes in the treatment group with Control Group 1 routes to former Soviet Union states and Control Group 2 involving other international destinations, respectively. The “one nearest neighbor matching” method pairs each of our “treated” routes with one “control” route with the closest propensity score. As Table 10 shows, for the matching with Control Group 1, 278 of the 342 “treated” routes (81.3% of the treated routes) are matched with the “control” routes. The average treatment effect on the service status measures the average difference in the service status (with a service variable = 1 with the route served and 0 with the route not served) between the “treated” and matched “control” routes. The “one nearest neighbor matching” approach shows the estimated average treatment effect to be 0.78, which means that, in the counterfactual, there is on average a 78% higher probability that airlines will serve the treated routes. The “two nearest neighbor matching” approach matches each “treated” route with two control routes with the closest propensity score values. It produces very similar results to the “one nearest neighbor matching” approach. The results for Control Group 2 are similar albeit with lower treatment effects, thus, service probabilities.

<Table 10 about here>

However, as Figure 4 shows, the propensity scores of the treated and control routes do not significantly overlap. When one or two nearest neighbor matching is applied, the treated routes on the right tail of the propensity score distribution are forced to be matched with control routes even if they are not very similar as measured by propensity score. We therefore also adopt the caliper matching with bin size set as 0.2 standard deviation of the propensity scores. We plot the distribution of propensity scores of the treated and control routes when they are matched with the caliper matching in Figure 4. This shows that the caliper matching significantly increases the overlap of the treated and control routes in terms of propensity scores, which improves the accuracy of the counterfactual analysis. The matching results and predicted treatment effects are

[11] See Woolridge (2010) for an excellent discussion of the Propensity Score Method.

reported in Table 10 as well. Although the numbers are smaller than nearest neighbor matching, overall the simulation results confirm that the Chinese market has great potential. Even with restrictive caliper matching, our results suggest that the probability of having aviation services will increase by an average of 48% if aviation markets to China are operated under similar circumstances as those to former Soviet Union states or other international destinations.

Based on counterfactual analysis with caliper matching, we further list the top 20 treated routes out of the 342 hypothetical Central Asia-China routes with the highest counterfactual service probabilities in Table 11. This table shows that the average route service probabilities are higher and often even equal to one when the Control Group 1 routes involving former Soviet Union states. As discussed in previous sections, however, this may lead to too optimistic predictions as there are strong historical, political and cultural ties among these states that can hardly be replicated in other markets. Nevertheless, counterfactual analysis using Control Group 2 involving other international countries would still predict a significant increase of 27% in overall service probabilities with restrictive caliper matching as reported in Table 10, and reasonably high service probability greater than 50% in selected routes (Table 11, routes listed in panel b). These results suggest substantial benefits from liberalization. Furthermore, in Table 12, we present the top 20 Central Asian and Chinese airports with the highest average counterfactual route service probability.

<Figure 4 about here>

< Table 11 and 12 about here>

6. Conclusions and Recommendations

International aviation services in Central Asian countries have grown substantially over the past decade, restrictive regulations remain in many markets. These restrictions may prevent stakeholders from enjoying the full benefits of improved air connectivity and aviation services. Our service model estimation results confirm that there are substantial barriers preventing airlines to offer international aviation services. These barriers are a result of restrictive ASAs as reviewed in our Section 2, together with possible political and cultural factors. Our counterfactual analysis suggests that potential substantial benefits could be achieved if more liberal aviation policies such as those proposed by the Belt and Road initiative were introduced. These findings, obtained by both *ex post* estimation and *ex ante* simulations, are complementary to previous studies of air transport liberalization, which have found strong evidence that air liberalization improves airlines' operational efficiency and market competition, generally leading to reduced airfares, increased service quality, and higher traffic volumes (Fu et al. 2010; Oum et al. 2019). This study focuses the bilateral airline service connectivity, which is the subset and premise of the associated benefits of improved airline services.

More specifically, to facilitate the formation of related public policies, this study analyzes the international aviation market in Central Asia to identify market characteristics and predict possible market outcomes for different liberalization scenarios. Our investigation suggests that although the Central Asia-China markets are characterized by poor connectivity and high airfares, potential benefits could be achieved through aviation liberalization. In particular, our counterfactual analysis suggests that if the Central Asia-China markets could be regulated and operated in a similar way to the routes between Central Asia and other non-former Soviet Union states, the probability of having aviation services between cities in China and Central Asia would increase even by conservative estimates. Our study further identifies promising routes and airports, notably those reported in Table 11 and 12, that are most likely to have aviation services upon liberalization. These specific results, obtained *ex ante,* are expected to help both policy-makers and the airline industry to better prepare for a more liberalized world.

Our findings suggest that there could be market potential and welfare gains to be achieved through aviation liberalization. However, we have not analyzed the effects on each individual airline and country. Fu et al. (2010) noted that although liberalization is likely to bring significantly welfare gains overall, such benefits are not always evenly distributed among the airlines, airports, passengers and other stakeholders. Because Central Asian airlines are smaller in size compared to mega foreign carriers such as Air China, British Air and Lufthansa, an immediate and full liberalization may not be optimal. A progressive liberalization would be beneficial. When the US signed the Open Skies Agreement with Canada in 1995, Canadian airlines were given immediate access to any point in the US. However, because US airlines were regarded as stronger and larger, they are subject to a three-year transition period for access to Toronto, and a two-year transition period to Montreal and Vancouver. Similar arrangements may be made for aviation liberalization in Central Asia. Subject to anti-trust approval, carriers in the region can also form alliances with strong foreign carriers during the liberalization process. For example, countries may consider liberalizing the promising destinations identified by our study, and meanwhile selectively allow strategic alliances or code-sharing agreements between Central Asian airlines and overseas carriers.

Although the proposed method has several merits as discussed earlier, it is unable to separate the dramatic changes in ASAs from those caused by economic or political factors. Our model assumed the airline route services in our sample were not led by major ASA liberalization, but by economic and political situation evolutions, such that the service barrier parameter indicates the restrictiveness of ASAs and other country-pair specific factors. If major ASA liberalizations occurred during the study period, it would confound with the political and economic factors which may lead to biased estimations in our model. Thus, future method improvement is called to better disentangle potential ASAs changes from the economic and political factors. Normally, ASA liberalization is irreversible, thus bringing long-run positive impact on bilateral passenger traffic and resultant improved airline services. By contrast, the economic and political factors are much more volatile and exhibit strong variations in relatively short term. One possible statistical method might be to detect the distinct time-series impacts of ASA and economic or political factors on airline services, thus separating their specific impacts. In our study, we tried our best to review relevant literature and market news, and did not notice any major ASA liberalizations between Central Asian countries and other countries included in our sample. We also checked the evolution in the number of routes and destinations to each partner country, and did not identify dramatic or sustained increases. This also suggests the absence of significant ASA liberalizations for Central Asian countries during our study period.

Although our study offers useful and consistent results, it should be noted that factors such as political and cultural ties between countries were not explicitly and separately identified. This is a main reason that we have be cautious using routes to former Soviet Union states as control group in counterfactual analysis. This could lead to overly optimistic predictions because the strong political and cultural ties that exist between Central Asian countries and former Soviet Union states are not easily replicable in the short term by any industrial policies. Designing a framework that can explicitly address these issues would be a meaningful extension in the future.

Last, although our study has clearly suggested considerable potential for Central Asian countries to develop better airline connectivity with China under the Belt and Road initiative, the transport connectivity is only one of the key areas under such initiative, namely policy coordination, facilities connectivity, trade and investment, financial integration and culture exchange (Huang, 2016). The Belt and Road initiative thus goes beyond aviation liberalization, and the associated economic and political influences on the related countries are more enormous, complex and even quite asymmetric. As existing studies on the China-Central Asian economic and transport studies are rare, we try to fill in this research gap with a focus on the aviation sector development in landlocked developing countries. Despite the huge benefits of ASA liberalization on aviation and general economy, the welfare distribution across different countries is yet to be quantified. Future studies on this aspect would be very valuable.

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Table 1(a). Number of routes and yearly directional total passengers for top 10 overseas destination countries

2015			2010			2007		
Country	No. of Routes	Total passengers	Country	No. of Routes	Total passengers	Country	No. of Routes	Total passengers
Russian Federation	176 (31)	2,671,742	Russian Federation	119 (25)	1,503,245	Russian Federation	100 (28)	942,350
Turkey	17 (3)	456,494	United Arab Emirates	12 (3)	132,792	China	11 (2)	111,889
United Arab Emirates	14 (4)	260,758	China	11 (2)	176,640	Ukraine	9 (3)	37,417
China	14 (3)	247,788	Turkey	10 (2)	242,864	Turkey	8 (2)	140,707
India	7 (2)	93,327	Germany	7 (3)	74,604	United Arab Emirates	8 (2)	91,215
Belarus	7 (1)	29,828	Azerbaijan	6 (1)	67,694	India	7 (2)	64,237
Germany	6 (2)	66,519	Ukraine	6 (2)	56,076	Germany	7 (2)	52,752
Azerbaijan	6 (1)	82,277	India	5 (2)	80,603	U.K.	5 (2)	43,590
U.K.	5 (2)	47,476	U.K.	4 (2)	67,408	Iran	5 (2)	13,271
Ukraine	5 (1)	41,246	Iran	4 (2)	22,463	Belarus	4 (1)	6,422

Note:

1. Passenger movement is directional, originating from Central Asian countries to foreign countries.
2. The number in the parenthesis is the number of destination airports served in the corresponding foreign country.
3. For China, the destination airports include Beijing, Urumqi and Sanya.

Data Source: IATA PaxIS

Table 1(b). Total passenger, yield, and stage length of international routes to different countries (for 2015)

Country	Total Passenger	Yield	Stage length (km)
Russian Federation	2,671,742	0.091	2,605
Turkey	456,494	0.076	3,149
United Arab Emirates	260,758	0.087	2,391
China	247,788	0.160	2,082
Korea	114,110	0.105	4,621
India	93,327	0.117	1,625
Azerbaijan	82,277	0.245	1,113
Germany	66,519	0.096	4,550
Thailand	59,174	0.091	4,474
United Kingdom	47,476	0.116	4,949
Ukraine	41,246	0.067	3,241
Belarus	29,828	0.080	3,033
Georgia	28,790	0.178	1,901
Netherlands	23,479	0.109	4,397
Malaysia	22,240	0.091	5,220
Iran	21,179	0.085	1,822
France	18,258	0.074	4,902
Latvia	8,599	0.081	3,639
Israel	7,734	0.077	3,211

Note: For each country, the yield, and stage length are the weighted averages of all of the routes from Central Asian countries to that country. The route passenger number is used as the weight to calculate the average.

Table 2. WTO Air Liberalization Index for Uzbekistan and

(a). Uzbekistan

Signatory Country	Date of ATA	ALI ST
United States of America	27 Feb 1998	28
India	09 July 2007	21
Bahrain	11 Dec 1996	16
Belarus	22 Dec 1994	13
Russia	02 Mar 1994	**11**
Kazakhstan	25 May 1994	11
Germany	16 Nov 1995	11
Latvia	06 Jun 1995	11
Egypt	12 Dec 1992	11
Turkey	23 June 1994	10
Thailand	17 Dec 1993	10
Maldives	06 Nov 1996	10
U.K.	24 Nov 1993	8
Ukraine	20 Feb 1993	7
Netherlands	17 Oct 1995	7
Switzerland	14 July 1994	6
Belgium	14 Nov 1996	6
Kyrgyzstan	04 Sept 1996	5
Azerbaijan	27 May 1996	5
Moldova	30 Mar 1995	5
Turkmenistan	16 Jan 1996	5
Georgia	28 May 1996	5
Korea	06 June 1994	4
China	19 Apr 1994	4
Japan	22 Dec 2003	4
Iran	17 Aug 2001	4
Austria	28 July 2000	4
Finland	09 Feb 1996	4
Slovak	17 Jan 1997	4
Romania	06 Jun 1996	4
Pakistan	16 Feb 1992	1
Poland	11 Jan 1995	1
Israel	04 July 1994	0
Greece	26 Nov 1996	0
Bulgaria	07 May 1999	0
Lithuania	07 Jun 1995	0
Indonesia	08 Apr 1995	0
Jordan	24 Nov 1996	0
Vietnam	14 July 1995	0

(b). Kazakhstan

Signatory Country	Date	ALI ST
Turkey	01 May 1992	10
Uzbekistan	25 May 1994	11
India	10 Sept 1993	4
Austria	26 Apr 1993	4
Finland	07 Feb 1996	0
China	18 Oct 1993	0

Note:
1. ALI ST is the standard Air Liberalization Index calculated by the WTO using the country's air service agreements (ASA) recorded by ICAO.
2. WTO ALI is computed based on the ASAs included in the ICAO World Air Transport Agreements (WATA) database. ICAO relies on member countries to self-report their ASAs. A country may choose not to report all the ASAs and amendments.

Table 3. List of countries in econometric analysis

Central Asian Countries	Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, Turkmenistan
Former Soviet Union Countries	Russia, Azerbaijan, Bulgaria, Armenia, Ukraine, Belarus, Latvia, Georgia, Lithuania
Other International Countries	Netherlands, Germany, U.K., Czech Republic, Greece, France, Italy, Switzerland, Spain, Austria, United Arab Emirates, Turkey, Iran, Saudi Arabia, Israel, Egypt, Korea, Japan, China, Hong Kong, India, Afghanistan, Pakistan, Thailand, Malaysia, Vietnam, Singapore, Mongolia

Table 4. Index descriptions and variables summary statistics

Subscripts	Brief explanation					
i	Route					
K	Origin Central Asia country					
f	Destination country					
t	Quarter					
Variable	Brief explanation	Mean	Std. Dev.	Min	Max	Unit
D_f	Country/region			0	1	Dummy
Y_{ikft}	Route service	0.514	0.499	0	1	Dummy
$Dist_i$	Route distance	2,359	1,230	305	6,040	Kilometre
$AirportsizeOrigin_{ikft}$	Total scheduled seats origin airport	218,108	216,506	1,000	853,203	Seats
$AirportsizeDest_{ikft}$	Total scheduled seats destination airport	2,002,013	3,220,830	1,000	14,700,000	Seats
$AirportHHIOrigin_{ikft}$	HHI index origin airport	4,344	2,176	843	10,000	Index
$AirportHHIDest_{ikft}$	HHI index destination airport	3,214	1,946	436	10,000	Index
$GDPOrigin_{kt}$	GDP origin Central Asia country	81.9	79.4	2.83	244	billion USD
$GDPDest_{ft}$	GDP destination country	1,320	1,500	2.83	10,900	billion USD

Table 5. Estimation results of the service model

	Model 1		**Model 2**	**Model 3**
ln*AirportSizeOrigin*$_{it}$	0.432***	ln*AirportSizeOrigin_d*$_{it}$	0.416***	0.541***
	(0.010)		(0.011)	(0.023)
		ln*AirportSizeOrigin_O*$_{it}$	0.582***	0.403***
			(0.026)	(0.011)
ln*AirportSizeDest*$_{it}$	0.519***	ln*AirportSizeDest_d*$_{it}$	0.571	0.701***
	(0.010)		(0.012)	(0.030)
		ln*AirportSizeDest_O*$_{it}$	0.294***	0.482***
			(0.023)	(0.011)
ln*AirportHHIOrigin*$_{it}$	0.276***	ln*AirportHHIOrigin_d*$_{it}$	0.155***	0.542***
	(0.024)		(0.028)	(0.073)
		ln*AirportHHIOrigin_O*$_{it}$	0.517***	0.249***
			(0.052)	(0.026)
ln*AirportHHIDest*$_{it}$	0.131***	ln*AirportHHIDest_d*$_{it}$	0.094	0.070
	(0.026)		(0.030)	(0.077)
		ln*AirportHHIDest_O*$_{it}$	0.405***	0.181***
			(0.057)	(0.028)
ln*GDPOrigin*$_{it}$	-0.169***	ln*GDPOrigin_d*$_{it}$	-0.180	-0.051
	(0.011)		(0.013)	(0.044)
		ln*GDPOrigin_O*$_{it}$	-0.180***	-0.167***
			(0.021)	(0.011)
ln*GDPDest*$_{it}$	0.332***	ln*GDPDest_d*$_{it}$	0.356***	0.203***
	(0.029)		(0.032)	(0.045)
		ln*GDPDest_O*$_{it}$	0.085	0.593***
			(0.094)	(0.076)
ln*Distance*$_{it}$	-0.474***	ln*Distance*$_{it}$	-0.499***	-0.475***
	(0.026)		(0.027)	(0.027)
Central Asia	0.859***		0.987***	1.284***

	(0.096)	(0.104)	(0.127)
Afghanistan	0.878***	4.053***	1.842
	(0.172)	(1.220)	(2.049)
Armenia	1.138***	1.252***	1.999
	(0.150)	(0.155)	(2.026)
Austria	1.820***	3.693***	3.569
	(0.245)	(1.453)	(2.272)
Azerbaijan	1.217***	1.405***	2.516
	(0.077)	(0.081)	(2.125)
Belarus	0.891***	0.965***	2.271
	(0.109)	(0.111)	(2.140)
Bulgaria	1.251***	1.300***	2.525
	(0.216)	(0.222)	(2.136)
China	3.480***	4.607***	5.981***
	(0.146)	(1.660)	(2.439)
Czech	2.601***	4.711***	4.143**
	(0.133)	(1.423)	(2.220)
Egypt	4.006***	6.268***	5.588***
	(0.200)	(1.462)	(2.239)
France	4.261***	5.493***	6.469***
	(0.179)	(1.599)	(2.392)
Georgia	0.580***	0.668***	1.470
	(0.138)	(0.147)	(2.037)
Germany	3.287***	4.388***	5.619***
	(0.139)	(1.612)	(2.405)
Greece	3.513***	5.700***	5.161***
	(0.147)	(1.407)	(2.241)
Hong Kong	3.725***	5.386***	5.249***
	(0.204)	(1.388)	(2.236)
India	2.477***	3.848***	4.585**
	(0.158)	(1.537)	(2.347)

Iran	2.460***	4.408***	4.283**
	(0.101)	(1.432)	(2.261)
Israel	0.791*	2.942**	2.361
	(0.429)	(1.464)	(2.267)
Italy	2.654***	4.021***	4.776***
	(0.217)	(1.571)	(2.367)
Japan	3.782***	4.780***	6.090***
	(0.190)	(1.638)	(2.427)
Korea	3.418***	4.773***	5.401***
	(0.135)	(1.517)	(2.333)
Latvia	1.548***	1.702***	2.663
	(0.131)	(0.136)	(2.098)
Lithuania	3.037***	3.142***	4.230**
	(0.445)	(0.452)	(2.150)
Malaysia	2.267***	4.190***	3.839*
	(0.169)	(1.416)	(2.242)
Mongolia	-0.366	3.653***	0.597
	(0.243)	(1.177)	(2.057)
Netherlands	2.245***	3.553**	4.187**
	(0.142)	(1.497)	(2.314)
Pakistan	3.353***	5.831***	4.982***
	(0.125)	(1.389)	(2.217)
Russia	2.019***	2.321***	4.243**
	(0.094)	(0.106)	(2.348)
Saudi Arabia	4.943***	6.779***	6.785***
	(0.262)	(1.495)	(2.305)
Singapore	4.276***	6.035***	5.802***
	(0.243)	(1.407)	(2.235)
Spain	4.469***	5.919***	6.476***
	(0.240)	(1.562)	(2.360)

Switzerland	2.876***	4.655***	4.675***
	(0.219)	(1.478)	(2.294)
Thailand	3.127***	4.651***	4.763***
	(0.118)	(1.413)	(2.251)
Turkey	2.887***	4.647***	4.820***
	(0.090)	(1.491)	(2.302)
Ukraine	1.883***	2.122***	3.414
	(0.075)	(0.082)	(2.190)
UAE	2.789***	4.774***	4.519***
	(0.083)	(1.425)	(2.249)
U.K.	3.351***	4.430***	5.559***
	(0.138)	(1.588)	(2.387)
Vietnam	3.878***	6.255***	5.337***
	(0.198)	(1.363)	(2.200)
Constant	2.057***	-0.617	-2.657***
	(0.420)	(0.481)	(0.767)

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Estimated service barrier values ($\ln\theta_f$) and rankings for different countries/regions

Ranking	Model 1 Country /region	Barrier Parameter	Model 2 Country /region	Barrier Parameter	Model 3 Country/ region	Barrier parameter
	Central Asia	0.86***	Central Asia	0.99***	Central Asia	1.28***
1	Mongolia	-0.37	Georgia [a]	0.67***	Mongolia	0.60
2	Georgia [a]	0.58***	Belarus [a]	0.97***	Georgia [a]	1.47
3	Israel	0.79*	Armenia [a]	1.25***	Afghanistan	1.84
4	Afghanistan	0.88***	Bulgaria [a]	1.30***	Armenia [a]	2.00
5	Belarus [a]	0.89***	Azerbaijian [a]	1.41***	Belarus [a]	2.27
6	Armenia [a]	1.14***	Latvia [a]	1.70***	Israel	2.36
7	Azerbaijian [a]	1.22***	Ukraine [a]	2.12***	Azerbaijian [a]	2.52
8	Bulgaria [a]	1.25***	Russia [a]	2.32***	Bulgaria [a]	2.53
9	Latvia [a]	1.55***	Israel	2.94**	Latvia [a]	2.66
10	Austria	1.82***	Lithuania [a]	3.14***	Ukraine [a]	3.41
11	Ukraine [a]	1.88***	Netherlands	3.55**	Austria	3.57
12	Russia [a]	2.02***	Mongolia	3.65***	Malaysia	3.84*
13	Netherlands	2.25***	Austria	3.69***	Czech	4.14***
14	Malaysia	2.27***	India	3.85***	Netherlands	4.19***
15	Iran	2.46***	Italy	4.02***	Lithuania [a]	4.23**
16	India	2.48***	Afghanistan	4.05***	Russia [a]	4.24***
17	Czech	2.60***	Malaysia	4.19***	Iran	4.28***
18	Italy	2.65***	Germany	4.39***	UAE	4.52***
19	UAE	2.79***	Iran	4.41***	India	4.59***
20	Switzerland	2.88***	U.K.	4.43***	Switzerland	4.68***
21	Turkey	2.89***	**China**	**4.61*****	Thailand	4.76***
22	Lithuania [a]	3.04***	Turkey	4.65***	Italy	4.78***
23	Thailand	3.13***	Thailand	4.65***	Turkey	4.82***
24	Germany	3.29***	Switzerland	4.66***	Pakistan	4.98***
25	U.K.	3.35***	Czech	4.71***	Greece	5.16***
26	Pakistan	3.35***	Korea	4.77***	Hong Kong	5.25***
27	Korea	3.42***	UAE	4.77***	Vietnam	5.34***
28	**China**	**3.48*****	Japan	4.78***	Korea	5.40***
29	Greece	3.51***	Hong Kong	5.39***	U.K.	5.56***
30	Hong Kong	3.73***	France	5.70***	Egypt	5.59***
31	Japan	3.78***	Greece	5.70***	Germany	5.62***
32	Vietnam	3.88***	Pakistan	5.83***	Singapore	5.80***
33	Egypt	4.01***	Spain	5.92***	**China**	**5.98*****
34	France	4.26***	Singapore	6.04***	Japan	6.09***
35	Singapore	4.28***	Vietnam	6.26***	France	6.47***
36	Spain	4.47***	Egypt	6.27***	Spain	6.48***
37	Saudi Arabia	4.94***	Saudi Arabia	6.78***	Saudi Arabia	6.79***

Note:
1. China and Russia are in bold for special attention.
2. Countries with a superscript "a" are former Soviet Union member countries.
3. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

Table 7. Selected Chinese and Central Asian airports to form the hypothetical treated routes

Chinese airport code	Chinese airport name	Central Asia airport code	Central Asia airport name
CAN	Guangzhou	AKX	Aktobe (Kazakhstan)
CGO	Zhengzhou	ALA	Almaty (Kazakhstan)
CKG	Chongqing	ASB	Ashgabat (Turkmenistan)
CSX	Changsha	BHK	Bukhara (Uzbekistan)
CTU	Chengdu	CIT	Shymkent (Kazakhstan)
DLC	Dalian	DYU	Dushanbe (Tajikistan)
HGH	Hangzhou	FRU	Manas (Kyrgyzstan)
KMG	Kunming	GUW	Atyrau (Kazakhstan)
NKG	Nanjing	KZO	Kyzylorda (Kazakhstan)
PEK	Beijing	LBD	Khudjand (Tajikistan)
PVG	Shanghai Pudong	OSS	Osh (Kyrgyzstan)
SHA	Shanghai Hongqiao	SCO	Aktau (Kazakhstan)
SHE	Shenyang	SKD	Samarkand (Uzbekistan)
SZX	Shenzhen	TAS	Tashkent (Uzbekistan)
TAO	Qingdao	TSE	Astana (Kazakhstan)
URC	Urmuqi	UGC	Urgench (Uzbekistan)
WUH	Wuhan	UKK	Oskemen (Kazakhstan)
XIY	Xi'an	URA	Oral Ak Zhol (Kazakhstan)
XMN	Xiamen		

Table 8. Counterfactual predicted service probabilities of the hypothetical Central-Asia to China routes

(a). Using estimated service model parameters of Model 1

	Average predicted service probability	95% confidence interval of the Average predicted service probability	Maximum predicted service probability	Minimum predicted service probability	Average predicted service probability for the treated routes with actual service
With current service barrier parameter for China (value: 3.480)	0.15%	[0.119%, 0.180%]	1.80%	0%	8.21%
Replacing service barrier parameter of China with the average of Soviet Union Country (value: 1.280)	15.4%	[14.10%, 16.70%]	54.83%	1%	60.52%
Replacing service barrier parameter of China with that of the other international countries (value: 2.96)	0.62%	[0.512%, 0.728%]	6.0%	0%	16.67%
Zero service barrier parameter	54.4%	[52.37%, 56.43%]	92.00%	15.20%	90.11%

(b). Using estimated service model parameters of Model 2

	Average predicted service probability	95% confidence interval of the Average predicted service probability	Maximum predicted service probability	Minimum predicted service probability	Average predicted service probability for the treated routes with actual service
With current service barrier parameter for China (value: 4.607)	0.03%	[0.023%,0.044%]	0.90%	0%	6.31%
Replacing service barrier parameter of China with the average of Soviet Union Country (value: 1.653)	19.3%	[17.85%, 20.81%]	70.79%	2.27%	72.41%
Replacing service barrier parameter of China with that of the other international countries (value:4.809)	0.02%	[0.012%, 0.024%]	0.525%	0%	4.47%
Zero service barrier parameter	72.31%	[70.83%, 73.78%]	98.52%	35.53%	95.13%

(c). Using estimated service model parameters of Model 3

	Average predicted service probability	95% confidence interval of the Average predicted service probability	Maximum predicted service probability	Minimum predicted service probability	Average predicted service probability for the treated routes with actual service
With current service barrier parameter for China (value: 5.981)	0.24%	[0.189%, 0.291%]	4.42%	0%	11.38%
Replacing service barrier parameter of China with average of Soviet Union Country (value: 2.814)	35.2%	[33.32%, 37.09%]	85.6%	6.29%	89.41%
Replacing service barrier parameter of China with that of the other international countries (value: 4.678)	3.76%	[3.290%, 4.245%]	29.9%%	0%	30.42%
Zero service barrier parameter	96.6%	[96.21%, 96.94%]	100%	82.4%	99.87%

Table 9. The top 10 routes with highest predicted service probability
(by replacing service barrier parameter of China with average of Soviet Union countries)

Model 1			Model 2			Model 3		
China	Central Asia	Predicted Probability	China	Central Asia	Predicted Probability	China	Central Asia	Predicted Probability
URC	ALA	0.548	URC	TAS	0.708	URC	TAS	0.856
URC	TSE	0.544	PEK	TAS	0.701	CAN	TAS	0.821
URC	TAS	0.532	URC	TSE	0.698	SZX	TAS	0.811
PEK	ALA	0.512	PEK	ALA	0.692	PEK	ALA	0.799
CAN	TAS	0.499	CAN	TAS	0.681	PEK	TSE	0.763
CTU	TAS	0.484	PEK	TSE	0.652	CTU	TAS	0.761
PEK	TSE	0.482	CTU	TAS	0.650	PEK	TAS	0.744
KMG	TAS	0.453	PVG	TAS	0.644	KMG	TAS	0.741
CTU	DYU	0.449	KMG	TAS	0.641	PVG	TAS	0.721
SXZ	TAS	0.432	CTU	DYU	0.621	URC	TSE	0.712

Table 10. Propensity score matching between our constructed routes to China and "control" routes

	Alternative matching criteria	# of treated routes matched	# of treated routes matched with controlled routes with airline service	% of treated routes matched with controlled routes with airline service	ATT (Average Treatment Effect)
Control Group 1 (Former Soviet Union Countries)	One nearest neighbor matching	342	278	81.3%	0.78
	Two nearest neighbor matching	342	310	90.6%	0.78
	Caliper matching	149	73	49.0%	0.48
Control Group 2 (Other International Countries)	One nearest neighbor matching	342	100	29.2%	0.27
	Two nearest neighbor matching	342	150	43.9%	0.26
	Caliper matching	321	67	20.9%	0.27

Table 11. Top 20 hypothetical routes of average route service probability based on caliper matching

a. Using the former Soviet Union routes as the control routes

Chinese airport	Chinese city	Central Asian airport	Central Asian city	Average route service probability
CTU	Chengdu	URA	Oral Ak Zhol	1.000
NKG	Nanjing	KZO	Kyzylorda	1.000
KMG	Kunming	AKX	Aktobe	1.000
PEK	Beijing	BHK	Bukhara	1.000
TAO	Qingdao	BHK	Bukhara	1.000
XIY	Xi'an	ALA	Almaty	1.000
XMN	Xiamen	OSS	Osh	1.000
KMG	Kunming	ALA	Almaty	1.000
XMN	Xiamen	CIT	Shymkent	1.000
CKG	Chongqing	ALA	Almaty	1.000
HGH	Hangzhou	CIT	Shymkent	1.000
CGO	Zhengzhou	TAS	Tashkent	1.000
SHE	Shenyang	DYU	Dushanbe	1.000
SZX	Shenzhen	CIT	Shymkent	1.000
CTU	Chengdu	TSE	Astana	1.000
TAO	Qingdao	SKD	Samarkand	0.667
SHE	Shenyang	KZO	Kyzylorda	0.613
CGO	Zhengzhou	TSE	Astana	0.600
DLC	Dalian	TSE	Astana	0.600
DLC	Dalina	BHK	Bukhara	0.600

Note: "The average route service probability" is calculated as the share of the matched control routes have airline operations. For example, for CTU-URA route, all the matched control routes have airline operation, and TAO-SKD route, 66.7% of the control routes have airline operation.

b. Using the non-former Soviet Union international routes as the control routes

Chinese airport	Chinese city	Central Asian airport	Central Asian city	Average route service probability
PEK	Beijing	ALA	Almaty	0.543
URC	Urumqi	OSS	Osh	0.540
URC	Urumqi	ALA	Almaty	0.538
CTU	Chengdu	ALA	Almaty	0.533
URC	Urumqi	BHK	Bukhara	0.533
PEK	Beijing	TAS	Tashkent	0.526
XIY	Xi'an	ALA	Almaty	0.523

PEK	Beijing	TSE	Astana	0.520
KMG	Kunming	ALA	Almaty	0.515
CTU	Chengdu	TAS	Tashkent	0.511
CKG	Chongqing	ALA	Almaty	0.509
CAN	Guangzhou	ALA	Almaty	0.509
URC	Urumqi	ASB	Ashgabat	0.505
PEK	Beijing	UKK	Oskemen	0.501
CGO	Zhengzhou	ALA	Almaty	0.497
CTU	Chengdu	TSE	Astana	0.488
CTU	Chengdu	FRU	Manas	0.485
URC	Urumqi	SCO	Aktau	0.480
XIY	Xi'an	TAS	Tashkent	0476
CTU	Chengdu	UKK	Oskemen	0.470

Table 12. Average route service probability for each Chinese and Central Asian sample airports based on caliper matching

a. Using the Soviet Union routes as the control routes

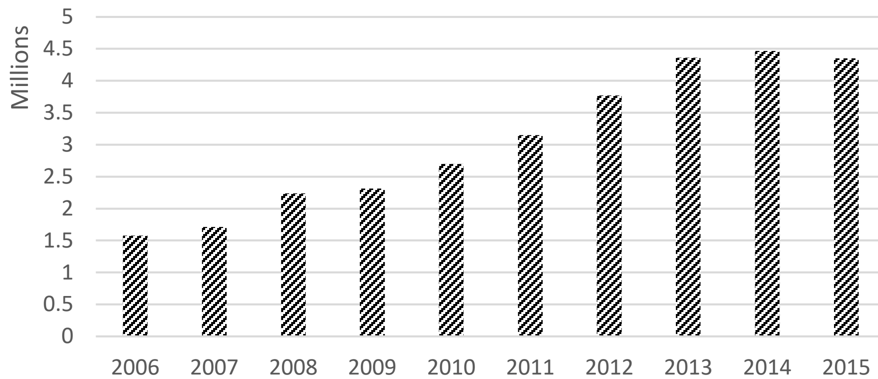
Chinese airport	Chinese city	Average route service probability	Central Asian airport	Central Asian city	Average route service probability
XMN	Xiamen	0.84	ALA	Almaty	0.74
HGH	Hangzhou	0.78	TAS	Tashkent	0.69
SZX	Shenzhen	0.74	URA	Oral Ak Zhol	0.69
PEK	Beijing	0.60	TSE	Astana	0.58
TAO	Qingdao	0.56	DYU	Dushanbe	0.57
CTU	Chengdu	0.56	BHK	Bukhara	0.57
KMG	Kunming	0.55	CIT	Shymkent	0.55
NKG	Nanjing	0.54	AKX	Aktobe	0.54
XIY	Xi'an	0.53	KZO	Kyzylorda	0.53
SHA	Shanghai Hongqiao	0.52	LBD	Khudiand	0.51
CKG	Chongqing	0.52	OSS	Osh	0.50
CGO	Zhengzhou	0.52	FRU	Manas	0.49
SHE	Shenyang	0.50	SKD	Samarkand	0.48
DLC	Dalian	0.49	UGC	Urgench	0.48
CAN	Guangzhou	0.49	ASB	Ashgabat	0.43
CSX	Changsha	0.47	UKK	Oskemen	0.39
WUH	Wuhan	0.47	GUW	Atyrau	0.37
PVG	Shanghai Pudong	0.42	SCO	Aktau	0.37
URC	Urumqi	0.37			

Note: The "airport's average route service probability" is calculated as the average route service probability for the routes out of the airport. For example, for the Chinese airport XMN (Xiamen), the number 0.84 represents the routes linking XMN of the different Central Asian airports have average 84% probability to be matched to a route in the control route with airline operation.

b. Using the non-Soviet Union international routes as the control routes

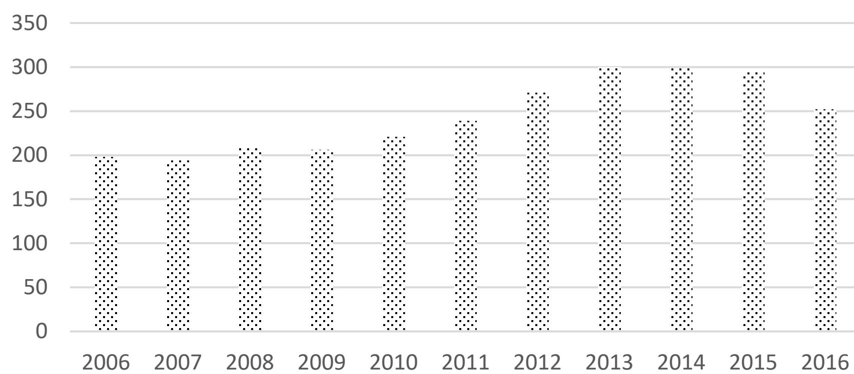
Chinese airport	Chinese city	Average route service probability	Central Asian airport	Central Asian city	Average route service probability
URC	Urumqi	0.523	ALA	Almaty	0.521
CTU	Chengdu	0.475	UKK	Oskemen	0.505
PEK	Beijing	0.461	TAS	Tashkent	0.490
KMG	Kunming	0.459	TSE	Astana	0.482
XIY	Xi'an	0.458	FRU	Manas	0.457
CKG	Chongqing	0.445	OSS	Osh	0.423
CGO	Zhengzhou	0.419	DYU	Dushanbe	0.393
CAN	Guangzhou	0.406	BHK	Bukhara	0.391
WUH	Wuhan	0.400	UGC	Urgench	0.383
SHA	Shanghai Hongqiao	0.385	CIT	Shymkent	0.382
CSX	Changsha	0.369	KZO	Kyzylorda	0.382
NKG	Nanjing	0.367	LBD	Khudiand	0.381
XMN	Xiamen	0.367	SKD	Samarkand	0.379
HGH	Hangzhou	0.366	AKX	Aktobe	0.360
SZX	Shenzhen	0.364	SCO	Aktau	0.348
PVG	Shanghai Pudong	0.361	URA	Oral Ak Zhol	0.325
DLC	Dalian	0.350	GUW	Atyrau	0.271
TAO	Qingdao	0.332	ASB	Ashgabat	0.266
SHE	Shenyang	0.327			

Figure 1. Total number of directional international passengers from Central Asian Countries (2006-2015)



Note: the directional passenger volumes are from Central Asian countries to other foreign countries.
Source: IATA PaxIS

Figure 2. Total number of international routes from Central Asian countries (2006-2016)



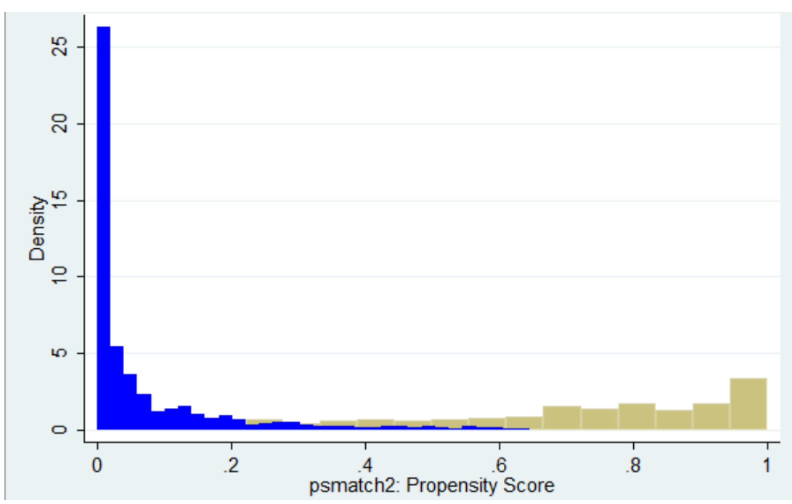
Source: IATA PaxIS

Figure 3. The subsamples and control variables' coefficients for Model 1, 2 and 3 in Section 3

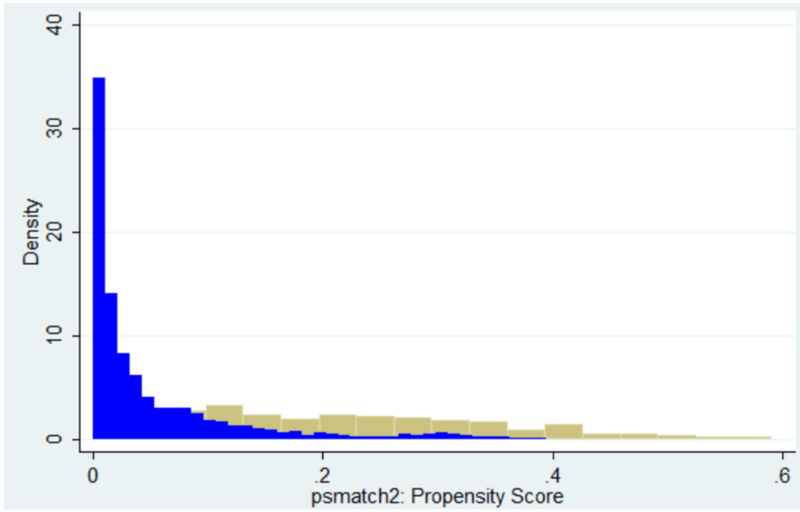
<table>
<tr><th></th><th>Model 1</th><th>Model 2</th><th>Model 3</th></tr>
<tr><td>Domestic Central Asian</td><td rowspan="4">Psi_r</td><td rowspan="2">Psi_r_d</td><td rowspan="3">Psi_r_d</td></tr>
<tr><td>Intra-central Asian</td></tr>
<tr><td>Former Soviet Union countries</td><td rowspan="2">Psi_r_o</td></tr>
<tr><td>Other international countries</td><td>Psi_r_o</td></tr>
</table>

Figure 4. Distribution of propensity scores of the "treated routes" (in yellow) and "control routes" (in blue)

(a) With the "control routes" set as the former Soviet Union countries



(b) With the “control routes” set as the other international routes (not to former Soviet Union countries)



Appendix.

Table A1. GDP of the five Central Asian countries in year 2006 and 2016

Country	2006 (Billion USD)	2016 (Billion USD)	GDP % Growth	2006 GDP Per Capita	2016 GDP Per Capita
Kazakhstan	$81.00	$137.28	69.48 %	$ 5,291.58	$ 7,714.84
Kyrgyzstan	$2.83	$6.81	140.64%	$ 543.11	$ 1,120.67
Tajikistan	$2.83	$6.95	145.58%	$ 404.29	$ 795.96
Turkmenistan	$10.28	$36.18	251.95%	$ 2,136.48	$ 6,389.35
Uzbekistan	$17.33	$67.45	289.21%	$ 654.28	$2,117.74
China	$2,752.13	$11,191.15	306.64%	$ 2,099.23	$ 8,117.26

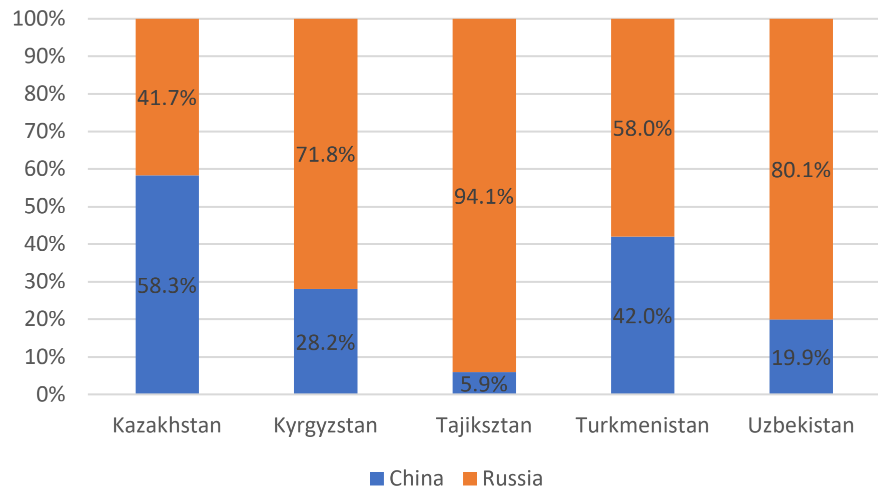
Source: World Bank database**.**

Table A2. The bilateral trade between each Central Asian country and China in year 2006 and 2016

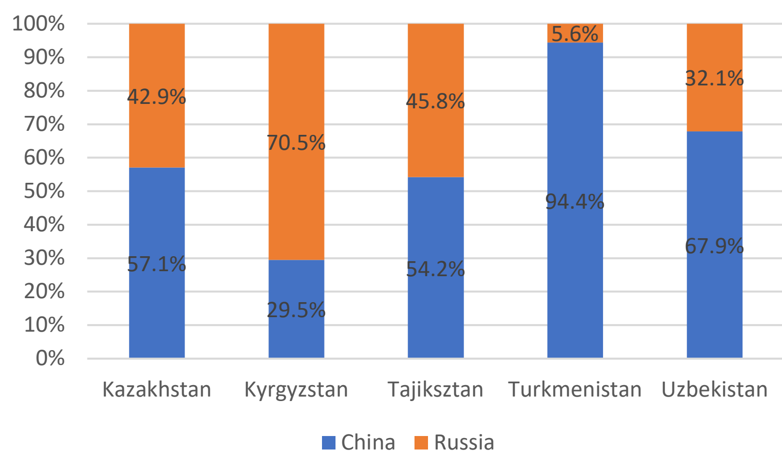
Country	Trade Flow	2006 Trade Value （Billion USD）	2016 Trade Value （Billion USD）	% Value Change
Kazakhstan	Export	$4.75	$8.29	74.53%
	Import	$3.61	$4.81	33.24%
Kyrgyzstan	Export	$2.11	$5.61	165.88%
	Import	$0.11	$0.07	-36.36%
Tajikistan	Export	$0.31	$1.73	458.06%
	Import	$0.02	$0.03	50.00%
Turkmenistan	Export	$0.16	$0.34	112.50%
	Import	$0.02	$5.56	27700.00%
Uzbekistan	Export	$0.41	$2.01	390.24%
	Import	$0.57	$1.61	182.46%

Note: here we refer China as the reporting country. That said, the “export” means China exports to the Central Asian country.

Source: UN trade database (Comtrade)

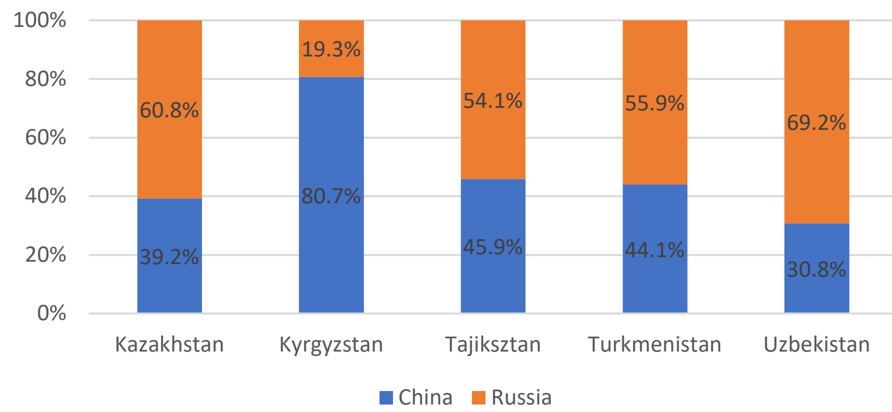


(Year 2007)

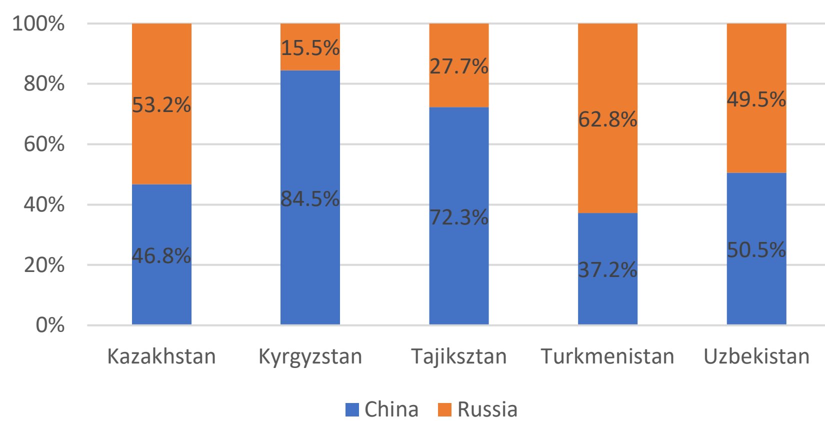


(Year 2016)

(a). Export from each Central Asian country to China and Russia



(Year 2007)



(Year 2016)

(b). Import from China and Russia for each Central Asian Country

Figure A1. The relative share of export and import between each Central Asian country and China or Russia

Source: made by the authors with data retrieved from UN trade database (Comtrade)

Table A3. Sample Central Asian airports

Airport code	Airport Name	Airport code	Airport Name
AFS	Zarafshan	KZO	Kyzylorda
AKX	Aktobe	LBD	Khudzhand
ALA	Almaty	MYP	Mary
ASB	Ashgabat	NCU	Nukus
AZN	Andizhan	NMA	Namangan
BHK	Bukhara	NVI	Navoi
BKN	Balkanabat	OSS	Osh
BXH	Balhash	PLX	Semey
BXJ	Burundai	PPK	Petropavlovsk (KZ)
CIT	Shimkent	PWQ	Pavlodar
CRZ	Turkmenabat	SCO	Aktau
DMB	Taraz	SKD	Samarkand
DYU	Dushanbe	SZI	Zaysan
DZN	Zhezkazgan	TAS	Tashkent
FEG	Fergana	TAZ	Dashoguz
FRU	Bishkek	TDK	Taldykorgan
GUW	Atyrau	TJU	Kulob
KGF	Karaganda	TMJ	Termez
KOV	Kokshetau	TSE	Astana
KQT	Qurghonteppa	UGC	Urgench
KRW	Turkmenbashi	UKK	Ust-Kamenogorsk
KSN	Kostanay	URA	Uralsk
KSQ	Karshi	UZR	Urdzhar

Table A4. Sample international airports

Airport code	Airport name	Airport code	Airport name
ABA	Abakan	KRR	Krasnodar
AER	Sochi	KUF	Samara
AMS	Amsterdam	KUL	Kuala Lumpur
ASF	Astrakhan	KZN	Kazan
ATH	Athens	LED	St Petersburg Pulkovo
ATQ	Amritsar	LGW	London Gatwick
AUH	Abu Dhabi	LHE	Lahore
AYT	Antalya	LHR	London Heathrow
BAX	Barnaul	MAD	Madrid Adolfo Suarez-Barajas
BHX	Birmingham	MCX	Makhachkala

BJV	Bodrum Milas	MHD	Mashhad
BKK	Bangkok	MQF	Magnitogorsk
BOJ	Burgas	MRV	Mineralnye Vody
BUS	Batumi	MSQ	Minsk
BYN	Bayankhongor	MUC	Munich
CAI	Cairo	MXP	Milan Malpensa
CDG	Paris Charles de Gaulle	NBC	Nizhnekamsk
CEK	Chelyabinsk	NCU	Nukus
DEL	Delhi	NRT	Tokyo Narita
DME	Moscow Domodedovo	OMS	Omsk
DNK	Dnipropetrovsk	OVB	Novosibirsk
DUS	Duesseldorf	PEE	Perm
DWC	Dubai Al Maktoum	PEK	Beijing Capital
DXB	Dubai	POX	Paris Pontoise-Cormeilles
EGO	Belgorod	PRG	Prague Ruzyne
ESB	Ankara Esenboga	REN	Orenburg
EVN	Yerevan	RIX	Riga
FCO	Rome Fiumicino	ROV	Rostov
FRA	Frankfurt	SAW	Istanbul Sabiha Gokcen
GME	Gomel	SGC	Surgut
GOJ	Nizhny Novgorod	SGN	Ho Chi Minh City
GRV	Grozny	SHJ	Sharjah
GVA	Geneva	SIN	Singapore Changi
GYD	Baku Heydar Aliyev	SIP	Simferopol
HAJ	Hannover	SKG	Thessaloniki
HAN	Hanoi	SVO	Moscow Sheremetyevo
HKG	Hong Kong	SVX	Yekaterinburg
HMA	Khanty-Mansiysk	SYX	Sanya
ICN	Seoul Incheon	SYZ	Shiraz
IEV	Kiev Zhuliany	TBS	Tbilisi
IKA	Tehran Imam Khomeini	THR	Tehran Mehrabad
IKT	Irkutsk	TJM	Tyumen
ISB	Islamabad	TLV	Tel Aviv-yafo Ben Gurion
IST	Istanbul Ataturk	TOF	Tomsk
JED	Jeddah	UFA	Ufa
KBL	Kabul	ULG	Ulgit
KBP	Kiev Borispol	ULN	Ulaanbaatar
KEJ	Kemerovo	URC	Urumqi
KGD	Kaliningrad	VIE	Vienna
KHG	Kashi	VKO	Moscow Vnukovo
KHV	Khabarovsk	VNO	Vilnius
KIX	Osaka Kansai	VOG	Volgograd

KJA	Krasnoyarsk	VOZ	Voronezh

Barrier parameters estimation results for Central Asian airlines

Some Central Asian overseas routes are exclusively operated by foreign airlines (non-Central Asian airlines), while these airlines might not have permission to operate other international routes from this Central Asian country to a third country (e.g., a Chinese airline exclusively operating a route from Kazakhstan to China is not allowed to operate a route from Kazakhstan to Russia in our sample routes unless it is granted the 5^{th} freedom). Therefore, as the foreign airlines do not have all permission on routes out of one Central Asian country, it could be problematic to pool these routes with other Central Asian overseas routes, as the choice to serve particular routes are restricted by the ASAs for these foreign airlines.

To deal with this issue, when regressing for each individual Central Asian country, we only consider its domestic or flag airlines in the estimation. In this way, we make sure that the Central Asian domestic airlines have free choices of which route to serve in our sample. Routes exclusively served by foreign airlines are treated as if there would be no service. Table A3 lists the major airlines in each Central Asian country, which are used in the estimations reported in this appendix. A route is regarded as entered if at least one of the country's domestic airlines operates the route. We also include a variable *Foreign_Airline* (the number of foreign airlines being present on the route) to control for any competition effect. To control for the effects of different market characteristics, we consider domestic, inter-Central Asia routes, and the routes to former Soviet Union countries as one segment, and the other routes as another segment. This setup is the same as Model 3 as reported in Table 5. For Central Asian Countries with more than one domestic airlines (i.e., Kazakhstan, Tajikistan, Kyrgyzstan), we run two regressions. The one is to include all the domestic airlines in the sample, and the other is to only consider its largest flag airline's route service choices. For the Central Asian countries with only one domestic carrier (i.e., Uzbekistan, Turkmenistan), there is only one regression based on this single domestic carrier.

Some Central Asian overseas routes are exclusively operated by foreign airlines (non-Central Asian airlines), while these airlines might not have permission to operate other international routes from this Central Asian country to a third country (e.g., a Chinese airline exclusively operating a route from Kazakhstan to China is not allowed to operate a route from Kazakhstan to Russia in our sample routes unless it is granted the 5th freedom). Therefore, as the foreign airlines do not have all permission on routes out of one Central Asian country, it could be problematic to pool these routes with other Central Asian overseas routes, as the choice to serve particular routes are restricted by the ASAs for these foreign airlines. "#" is used to denote destination countries in which only foreign airlines operate. Because the entry of Central Asia airlines is estimated and there is no variation of service entry on these routes, the service entry barrier parameters are not identified for these "#" countries. The estimation results are reported in Table A6-A10.

Table A5. Major domestic airlines in each Central Asian country

	Airline code	Airlines name	Hub airport
Kazakhstan	KC	Air Astana	Almaty, Astana
	DV	SCAT Airlines	Shymkent
Uzbekistan	HY	Uzbekistan Airways	Tashkent
Tajikistan	7J	Tajik Air	Dushanbe, Khujand
	EG	East Air	Kulob
	SZ	Somon Air	Dushanbe
Kyrgyzstan	QH	Air Kyrgyzstan	Bishkek
	ZM	Air Manas	Bishkek
	KR	Air Bishkek	Manas
Turkmenistan	T5	Turkmenistan Airlines	Ashgabat

Table A6. Estimated barrier parameters for Kazakhstan carriers

Country/Region	Barrier Parameter (All)	Country/Region	Barrier Parameter (KC)
Central Asian	3.248***	Central Asian	5.467**
Mongolia	1.175	Vietnam	3.342
Georgia[a]	1.941***	Malaysia	3.665***
Azerbaijan[a]	1.969***	Azerbaijan[a]	4.436***
		Russia[a]	4.606
Armenia[a]	2.221***	UAE	4.701**
Russia[a]	2.375***	Georgia	4.961***
Ukraine[a]	2.860***	Thailand	5.142**
Malaysia	5.460***	Turkey	5.258**
Vietnam	5.760***	Hong Kong	5.331***
Turkey	6.318***	Ukraine[a]	5.364***
UAE	6.385***	Netherlands	6.015***
Thailand	6.673***	Korea	6.865***
Netherlands	6.880***	India	6.951***
Hong Kong	7.162***	Germany	8.035***
India	7.226***	U.K.	8.962***
Korea	7.307***	France	9.679***
Germany	7.593***	China	10.278***
U.K.	8.592***	Afghanistan	#
China	9.105***	Armenia[a]	#
France	9.249***	Austria	#
Afghanistan	#	Belarus[a]	#
Austria	#	Bulgaria[a]	#
Belarus[a]	#	Czech	#
Bulgaria	#	Egypt	#
Czech	#	Greece	#

Egypt	#	Iran	#
Greece	#	Latvia [a]	#
Iran	#	Lithuania [a]	#
Latvia [a]	#	Mongolia	#
Lithuania [a]	#		

Note: # denotes destination countries in which only foreign airlines operate. Because the entry of Central Asia airlines is estimated and there is no variation of service on these routes, the service barrier parameters are not identified for these “#” countries.
*, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively.

Table A7. Estimated barrier parameters for Uzbekistan carriers

Country/Region	Barrier (HY)
Central Asian	1.062***
Russia [a]	1.195***
India	1.554
Ukraine [a]	2.209***
Belarus [a]	3.915***
Israel	4.479
Italy	4.85
Japan	5.073
U.K.	5.473
China	5.618
Switzerland	5.699
Thailand	5.976
UAE	6.019
Pakistan	6.406
Turkey	6.572
Greece	6.977
Germany	7.382
Spain	7.776
Singapore	8.447
Egypt	8.657
Saudi Arabia	8.815
Vietnam	9.15
Azerbaijan [a]	#
Czech	#
France	#
Georgia [a]	#
Iran	#
Korea	#
Latvia [a]	#
Lithuania [a]	#
Malaysia	#

Note: # denotes destination countries in which only foreign airlines operate. Because the entry of Central Asia airlines is estimated and there is no variation of service on these routes, the service barrier parameters are not identified for these "#" countries.
*, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively.

Table A8. Estimated barrier parameters for Tajikistan carriers

Country/Region	Barrier Parameters (all)	Country/Region	Barrier Parameters (7J)
Central Asian	0.217	Central Asian	-4.148
Russia [a]	-2.531*	Russia [a]	-6.641
Ukraine [a]	-0.587	Azerbaijan [a]	-4.389
Azerbaijan [a]	-0.245	UAE	-0.672
Germany	2.203	Turkey	0.009
China	2.848	India	0.152
UAE	3.34	Iran	0.82
India	3.43	Pakistan	0.893
Turkey	3.547	China	1.472
Iran	4.743	Afghanistan	#
Saudi Arabia	5.473	Germany	#
Pakistan	5.834	Latvia [a]	#
Thailand	6.216	Saudi Arabia	#
Afghanistan	#	Thailand	#
Latvia [a]	#	Ukraine [a]	#

Note: # denotes destination countries in which only foreign airlines operate. Because the entry of Central Asia airlines is estimated and there is no variation of service on these routes, the service barrier parameters are not identified for these "#" countries.
*, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively.

Table A9. Estimated barrier parameters for Kyrgyzstan carriers

Country/Region	Barrier Parameters (All)	Country/Region	Barrier Parameters (QH)
Central Asian	1.098***	Central Asian	0.724*
Russia [a]	-4.206***	Russia [a]	-3.483***
UAE	3.274	UAE	-4.365
Turkey	3.412	Germany	-2.227
Korea	3.544	China	-2.105
Germany	5.035	Pakistan	-1.423
Iran	5.258	India	-0.294
China	5.359	Iran	#
Pakistan	5.521	Korea	#
India	5.666	Mongolia	#
Azerbaijan [a]	#	Turkey	#
Mongolia	#	Ukraine [a]	#
Ukraine [a]	#	Azerbaijan [a]	#

Note: # denotes destination countries in which only foreign airlines operate. Because the entry of Central Asia airlines is estimated and there is no variation of service on these routes, the service barrier parameters are not identified for these "#" countries.
*, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively.

Table A10. Estimated barrier parameters for Turkmenistan carriers

Country/Region	Barrier Parameters (T5)
Central Asian	8.932***
Germany	-2.255
India	-1.55
U.K.	0.042
China	0.06
France	4.81
Turkey	4.844
UAE	6.365
Belarus [a]	8.231***
Thailand	10.421
Russia [a]	14.534
Armenia [a]	#
Austria	#
Ukraine [a]	#

Note: # denotes destination countries in which only foreign airlines operate. Because the entry of Central Asia airlines is estimated and there is no variation of service on these routes, the service barrier parameters are not identified for these "#" countries.
*, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively.

The Probit model to estimate the propensity score calculation

The covariates we use to match our hypothetical Chinese routes (treated route) and control routes are route distance, $distance_i$, origin and destination airports' passenger volume, $AirportSizeOrigin_{it}$, $AirportSizeDest_{it}$, and the HHI of the origin and destination airports, $AirportHHIOrigin_{it}$, $AirportHHIDest_{it}$. A probit model is run to get propensity score for each treated and control route, so that we can match them based on propensity score which is a scalar, not by the multi-dimensional vector of the covariates.

To calculate the propensity score is specified as follows, a probit model is run on the binary variable, $Treat_i$ which equals 1 if it is hypothetical route (treated route) between the Central Asian airports and the Chinese airports and equals 0 if it is the control route we benchmark. Then with the estimated coefficients of the covariates, we calculate the predicted probability that one route is a treated route based on the values of the covariates of this route, i.e., the propensity score. Propensity score can thus be interpreted as the predicted probability of one route to be in the treated group based on its covariates (Woolridge, 2010). The probit model for the propensity score calculation is specified as follows:

$$Treat_i = \rho_0 + \rho_1 distance_i + \rho_2 AirportSizeOrigin_{it} + \rho_3 AirportSizeDest_{it} + \rho_4 AirportHHIOrigin_{it} + \rho_5 AirportHHIDest_{it} + v_i$$

The probit model estimation for the propensity score calculation is as follows (Table A11). The propensity scores are calculated as the fitted values of the above probit model using the covariate values of the route.

Table A11. Probit model estimation to for the propensity score calculation

	Former-Soviet routes as control	International routes as control
Variable	Coefficient	Coefficient
$distance_i$	0.1124***	0.07275***
	(0.005)	(0.00309)
$AirportSizeOrigin_{it}$	0.012	0.023
	(0.019)	(0.034)
$AirportSizeDest_{it}$	0.186***	-0.532***
	(0.0194)	(0.0574)
$AirportHHIOrigin_{it}$	0.0165	-0.0937
	(0.0282)	(0.0253)
$AirportHHIDest_{it}$	-0.2624***	-0.0535***
	(0.0042)	(0.014)
Constant	-5.083	-3.732***
	(0.270)	(0.135)

Note:
*, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively.

Compared with the former-Soviet Union and other international routes, the hypothetical Central-Asia to China routes are more likely to have longer flying distance, and the airports have lower HHI index. The destination Chinese airports for the hypothetical Central Asia to China routes, on average, have larger size than the former-Soviet Union airports, and smaller size than the other international airports.