Exploring connectivity in landlocked developing countries

Modeling the Potential for Aviation Liberalization in Central Asia - Market analysis and implications for the One-Belt-One-Road initiative

ABOUT THIS REPORT

This report comprises one of three interrelated research projects on ***Exploring Connectivity in Landlocked Developing Countries***, undertaken by the University of Sydney and funded by the International Think Tank for Landlocked Developing Countries (ITT LLDC).

The United Nations Convention on the Law of the Sea (1982) defines a "land-locked State" as one that has "no sea-coast". In line with this, early research into landlocked countries mainly focused on the transport infrastructure required by landlocked countries to gain sea access. More recent studies, however, have highlighted the other complexities associated with landlockedness, including vulnerability to neighboring countries' political and regulatory systems, infrastructure, and peace and order. These can serve as impediments to the ability of landlocked developing countries to establish relevant connections required to foster sustainable economic growth and development.

The business and economic context of landlocked countries continues to remain an underexplored area both in the scholarly and policy literature, and the aim of these three exploratory projects is to investigate different aspects of the connectivity challenges faced by landlocked developing countries.

The ***industry and trade connectivity*** component of the project (led by Dr Sandra Seno-Alday and Dr Yayoi Lagerqvist) raises questions on the relationship between industrial development, domestic economic diversification (driven by foreign direct investment in mining), and the international business and trade activities of Laos. The project explores preliminary insights into how significant foreign direct investment in primary industries is correlated with the diversification of economic activity, the growth of international business, and the integration of a landlocked country into the regional economy.

The ***information and communications technology (ICT) connectivity*** component of the project (led by Dr Barney Tan) explores the role of digital connectivity in supporting business activity, and in promoting regional and international business expansion in one of the most digitally connected landlocked countries, Azerbaijan. The project thus offers preliminary insights into best practices in establishing digital connectivity in a landlocked context, which can be used to aid other landlocked countries in developing more robust digital connectivity networks to support regional and international business activity.

The ***transport connectivity*** component of the project (led by Dr Xiaowen Fu) explores the challenges faced by air transport companies operating in landlocked Central Asia, where businesses incur high operating costs due to severe geographic constraints and barriers within small markets. The project offers insights into the business model innovation required by transport companies to operate effectively and profitably within the landlocked business context. The project further provides guidance on how alternative government policies could promote the growth of the aviation industry. This is an important issue that goes beyond the aviation sector as allowing transport companies to operate profitably and efficiently within landlocked contexts gives other businesses access to robust and cost-effective transport services, which supports regional and international business activity.

The three individual projects correspond to the critical challenges for international business development in landlocked countries: that is, (1) the development of a robust digital infrastructure that allows businesses in landlocked countries access to the international online marketplace; (2) the development of a high quality transport infrastructure (operated by profitable private enterprises) that allows businesses physical access to international markets at competitive cost levels; and (3) the development of strong and diversified domestic industry base that allows businesses to engage in the regional and global economy.

These reports represent outputs of the first research collaboration made possible by the Memorandum of Understanding (MOU) between the University of Sydney and the ITT LLDC, signed in 2015.

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The cover page for this report was designed by Audrey Marville, a graphic designer and illustrator who has dedicated time and effort to collaborate with the ITT for LLDCs on this project through the United Nations Volunteer (UNV) Programme.

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Executive summary

This study analyzes aviation markets in land-locked countries in Central Asia, namely Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan, and Kyrgyzstan. In these countries, there is no close substitute for the air travel mode due to the tyranny of distance. Aviation liberalization can therefore be of special importance to these countries, and is an integral part of the one-belt-one-road (OBOR) initiative proposed by the Chinese government. This study uses observed industry panel data spanning from 2007 to 2015 to estimate airline entry patterns in origin-destination markets. Econometric estimates for domestic and international markets are subsequently benchmarked, and route groups are paired by alternative matching algorithms. These investigations allow us to quantify market potential and predict airline route entry in counterfactual scenarios, so that the effects of different liberalization schemes can be simulated. Our empirical results identified substantial market potential in the Central Asia – China aviation market in terms of serviceable routes upon further liberalization. These findings are in sharp contrast to the current market reality that the Central Asia to China market has lagged the developments to other markets such as former Soviet Union states and some European countries. Our investigation suggests the air connectivity from Central Asia to China would have been more than double of the current level if market liberalization had been comparable to those on the routes between Central Asia to other countries in Europe and Asia. Our study finds strong negative effects of the restrictive regulations on the international aviation markets, and calls for further liberalizations between Central Asia and the region's major trade partners.

Keywords: air transport; liberalization; Central Asia; OBOR

1.0 Introduction

Air transportation is of critical importance to a country's economy and consumer wellbeing. It not only directly contributes to local employment, taxation and service export, but also provides essential inputs to logistics services, hotel and tourism, and trade sectors. Numerous studies have identified a positive relationship between aviation services and regional development. Aviation services can serve as a catalyst for regional economic development (Cooper 1990, Sarkis 2000, Green 2007, Button et al. 2010, Bilotkach 2015), whereas improved connectivity and aviation services lead to growth in passenger and cargo volumes, job creation and business outputs (Graham and Guyer 2000, Brueckner 2003, Alkaabi and Debbage 2011, Braathen 2011, Bråthen and Halpern 2012, Button and Yuan 2013, Blonigen and Cristea 2015, Hu, et al., 2015, Tan and Tsui 2016).

Because of the important roles played by air transport in regional development and consumer wellbeing, even countries with the best aviation services and infrastructures are working toward improved connectivity. The UK House of Commons Transport Committee (Transport Committee 2016) urged the UK government to invest a new runway in the London area immediately, as delayed action will threaten London's position as an international hub, reduce UK's connectivity with the world's emerging market that would lead to losses in future trade volumes. For landlocked countries that have limited transport options, improving the availability and affordability of aviation services are even more important. Central Asia is at the cross road between East Asia to Middle East and Europe. 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 land-locked countries. However, as reviewed in the following sections, the region's aviation sector is not achieving its full potential. Although international traffic volumes and directly served destinations have achieved substantial growth over the past decades, in most international markets connectivity and airline competition remain at low levels.

The restrictive regulations imposed on the international aviation market in Central Asia could have been a major constraint of the region's aviation industry. Under the Chicago Convention on international air transportation established in 1944, to serve international routes airlines need to secure commercial rights governed by bilateral air services agreements (ASA) between each pair of countries involved. Having the status of treaties between countries, ASAs can regulate the areas such as international routes that each airline is allowed to serve (i.e. air freedoms), capacity, frequencies and aircraft types that can be deployed in different markets, passenger and cargo tariff levels and approval process, airline ownership and control, the number of airlines that are allowed to enter the markets (i.e. designation), alliance and cooperation among airlines, and the requirements on operational statistics reporting (WTO Secretariat 2006).

Compared to developed economies, international aviation markets out of Central Asia are generally under restrictive regulations, although liberal policies have been introduced in selected markets. These regulations could have seriously constrained the market growth in the international aviation market in the region. Since the world's first open-skies agreement signed between the Netherlands and U.S. in 1992, many international markets have been partially or fully liberalized, so that airlines can initiate services on routes with sufficient demands freely and compete or cooperate with other airlines based on commercial considerations. Studies investigating the effects of those liberalization policies have found compelling evidence that the removal of regulation and the promotion of airline competition have led to substantial welfare improvements:

- The Open Skies agreement signed in 1995 between Canada and the U.S. The number of Canadian cities with air services to U.S. increased from 21 in 1994 to 27 in 2005, and the number of trans-border routes increased from 90 to 171, with scheduled capacity increased by 25% in the first year (Fu and Oum 2014).

- The Single Aviation Market (SAM) between Australia and New Zealand became fully operational in 2000. With three years, the number of passengers in the affected routes increased from 3.3 million to over 4.6 million (Vowles and Tierney 2007). The liberalization provided good growth opportunities for low cost carriers, which further increased aviation services volumes substantially.
- The EU Single Aviation Market was created and the intra-EU market became fully liberalized in 1997, which led to increased airline competition and fast growth of low costs carriers within the European Common Aviation Area (ECAA). During 1992 and 2007, routes served by at least two airlines increased by 385%, and cross-country routes increased by 220%. Increased competition lead to reduced air fares, with traffic volume tripled between 1980 and 2000 (Schipper, Rietveld and Nijkamp 2002).

Fu et al. (2010) and Adler et al. (2014) reviewed the studies on aviation liberalization and concluded that the benefits may come from different sources: First, liberalization removes constraints on airline operation, competition and cooperative arrangements, thus leads to improved airline efficiency and increased market competition. As a result, airline service quality increases whereas air fare levels decrease, which jointly led to increased traffic volume. Second, with route entry and capacity regulations removed, airlines can optimize their network configuration and serve more new destinations. Their views are consistent studies on air connectivity. Arvis and Shepherd (2011) computed air connectivity index for 211 countries and territories for the year 2007, and found a strong positive correlation between connectivity and the degree of air liberalization. They argued that liberalization reduces the cost of moving from one country to another, therefore should lead to more and stronger connections between countries. Morphet and Bottini (2014) concluded that air connectivity leads to economic growth. In addition, there are four main determinants for air connectivity: geography, airport infrastructure, airline models, and a country's regulatory and economic frameworks. In summary, many studies have reached the conclusion that deregulation and liberalization have improved aviation service quality and airlines' productivity (Oum and Yu 1998), Oum et al. 2005), which in turn led to higher economic growth and consumer welfare. InterVISTAS (2006) conducted extensive reviews of the effects of major liberalization events in the industry and concluded that overall results are very substantial and positive.

If the same conclusions on liberalization are applicable to Central Asia, substantial welfare gains and economic benefits may be achieved by removing some of the regulations on the international markets. Quantifying and predicting the results of liberalization will help governments in the region to evaluate alternative industrial policies, and assist stake-holders such as airlines, airports and freight-forwarders to prepare for future market dynamics. This study aims to achieve such an objective by analyzing airlines' route entry behavior, and predict market outcomes when international markets out of Central Asia are further liberalized. Because the Chinese government proposed the "One-Belt-One-Road" initiative which aims to promote the economic, trade and political cooperation along the Belt-and-Road region, this study will focus on the effects of liberalizing the aviation market between Central Asia to China. This also allows us to study a market with substantial potential given the large population and international trade volume of China, which is the world's second largest aviation market since 2005 (Fu et al. 2015).

The remainder of this report is organized as follows. Section 2 provides an overview of the international aviation markets in Central Asia. Section 3 describes our modeling approach and analysis results. The last section summarizes and concludes this report.

2.0 The international aviation market in Central Asia.

There are five landlocked countries in Central Asia, which are Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and Kazakhstan. In terms of population, Uzbekistan and Kazakhstan are the two largest nations with 30 and 18 million citizens respectively as of 2016. All nations may be classified as developing countries, although Turkmenistan and Kazakhstan have clearly higher GDP per capita than other countries in the region. Some of the key economic indicators are summarized as in Table 1.

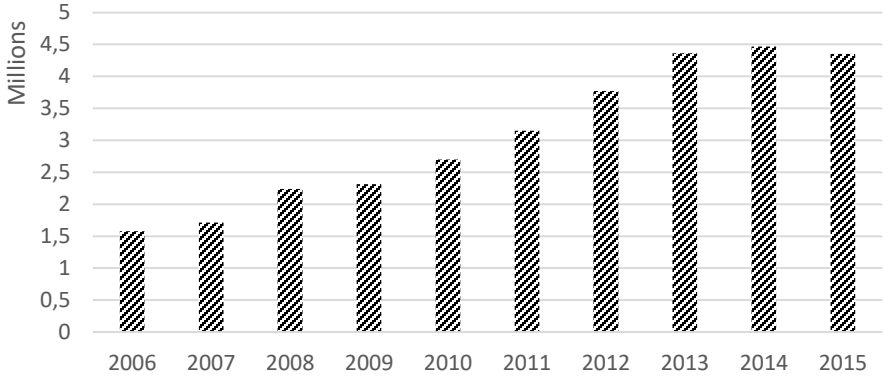
Table 1. Economic indicators for countries in Central

Country	Area (km^2)	Population '000 2016	GDP M USD (2014)	GDP Per Capita in USD (2014)
Kyrgyzstan	199,949	6,034	7,404	1,267.10
Tajikistan	142,600	8,670	9,242	1,114.00
Turkmenistan	488,100	5,439	47,932	9,031.50
Uzbekistan	447,400	30,300	63,030	2,138.80
Kazakhstan	2,724,902	17,855	216,036	12,436.20

Source: United Nations Online Database

Other than Kazakhstan, the sizes of economies in Central Asian countries are relatively small. As a whole, the region has a total population of about 70 million and a total GDP close to 350 billion USD, making it a sizable aviation market by international standard. In addition, as many of these countries are rich in natural resources, they benefited from the commodity boom in the 2000s which has contributed to sustained growth in the international aviation market. Figure 1 summarizes the total number of international passengers from Central Asia to the rest of the world during 2006-2015. The data are directional (i.e. one-way traffic from Central Asia to other foreign countries) and because passenger traffic volumes are usually symmetric, it presents about 50% of the total traffic volumes in the related international markets. The same definition of "directional" traffic volume will be used hereafter. It is clear that despite the global financial crisis in 2008, the region's aviation market had achieved sustained growth, with its one-way passenger volume more than doubled from 1.5 million in 2006 to more than 4 million. Traffic volume declined slightly for the first time in the sample period, likely due to the Russia – Ukrainian war took place in 2014.

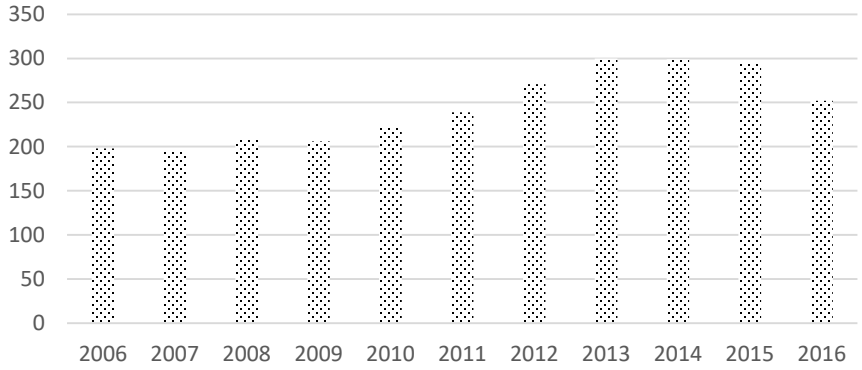
Figure 1. The total number of directional international passengers from Central Asian countries to other foreign nations (year 2006-2015)



Note: the directional passenger is from Central Asian countries to other foreign countries
Source: PaxIS

Figure 2 summarizes the number of international routes from Central Asian countries. A international route is counted if there were direct flights between an airport in one of the Central Asian countries and an overseas airport. Similar growth pattern can be identified. During 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 likely due to the Russia – Ukrainian military actions started in 2014.

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



Source: PaxIS

Because Kazakhstan has a clearly larger economy, it has a few more major international destinations than other Central Asian nations as reported in Table 2. That said, national capitals tend to host a significant proportion of a nation's major businesses, government bureaus and high income residents. Therefore, these cities all ranked high in terms of international passenger volumes in the region. As a proxy of airline

competition, HHI concentration index is calculated for each of the major airports based on each airline's scheduled seats provided at the airport, including both domestic and international services. As shown in Table 2, the market concentration ratios are quite high even for the largest aviation market, another evidence suggesting that there is limited competition in the region's aviation market. Of course, this may be partly due to the relatively small market size, which couldn't support many independent carriers.

Table 2. Top 20 Central Asia Airports in Directional International Passenger Volume for Central Asia International Routes (for year 2015)

Airport Code	Airport Name	Country	Directional Passenger Number	HHI Index
TAS	Tashkent	Uzbekistan	706,085	5,136
ALA	Almaty	Kazakhstan	659,111	4,126
DYU	Dushanbe	Tajikistan	515,473	1,858
FRU	Bishkek	Kyrgyzstan	459,434	1,009
ASB	Ashgabat	Turkmenistan	438,246	5,301
TSE	Astana	Kazakhstan	314,819	4,506
LBD	Khujand	Tajikistan	281,142	1,826
OSS	Osh	Kyrgyzstan	277,435	1,601
SKD	Samarkand	Uzbekistan	94,332	4,671
SCO	Aktau	Kazakhstan	78,582	3,803
TJU	Kulyab	Tajikistan	74,844	5,878
FEG	Fergana	Uzbekistan	61,267	4,339
KGF	Karaganda	Kazakhstan	45,067	2,261
UGC	Urgench	Uzbekistan	43,556	6,781
BHK	Bukhara	Uzbekistan	41,911	7,396
CIT	Shimkent	Kazakhstan	41,137	3,459
AZN	Andizhan	Uzbekistan	32,158	10,000
GUW	Atyrau	Kazakhstan	31,448	6,611
NMA	Namangan	Uzbekistan	29,501	6,712
TMJ	Termez	Uzbekistan	17,603	10,000

Source: The passenger number is from PaxIS database; HHI Index is calculated based on each airlines' scheduled seats provided at the airport including all international and domestic traffic. The HHI is calculated with scheduled airport seats data retrieved from OAG.

All five nations in Central Asia were member states of the Soviet Union. Currently, there are still strong economic, cultural and political ties to Russia and other former Soviet states. Russian serves as common language in the region in addition to its status as one of the official languages in some of the states. This probably explained the relatively high aviation connectivity to Russia. Table 3 reports the top 30 foreign destinations for Central Asia in 2015. Russia is clearly the largest aviation market, followed by destinations in Turkey, UAE, China, Korea, Azerbaijan, Germany, and other international markets. The HHI market concentration is computed as a proxy for airline competition, which suggests somewhat high market concentration ratios, with most routes ranging between 2,000 to 3,000.

Table 3. The Top 30 Foreign Airports in Directional International Passenger Volume for Central Asia International Routes (for year 2015)

Airport Code	Airport Name	Country	Directional Passenger Number	HHI Index
DME	Moscow Domodedovo	Russia	883,277	1,509
IST	Istanbul Ataturk	Turkey	401,744	5,825
LED	St Petersburg Pulkovo	Russia	312,971	2,804
SVO	Moscow Sheremetyevo	Russia	290,915	7,929
VKO	Moscow Vnukovo	Russia	275,948	2,493
OVB	Novosibirsk	Russia	213,669	1,992
DXB	Dubai	United Arab Emirates	173,323	3,933
URC	Urumqi	China	172,759	2,360
SVX	Yekaterinburg	Russia	169,861	2,053
ICN	Seoul Incheon	Korea	114,110	1,644
GYD	Baku Heydar Aliyev	Azerbaijan	82,277	2,871
KJA	Krasnoyarsk	Russia	76,234	1,697
PEK	Beijing Capital	China	74,210	2,017
KZN	Kazan	Russia	69,269	2,080
FRA	Frankfurt International	Germany	64,525	4,301
SHJ	Sharjah	United Arab Emirates	61,877	6,921
BKK	Bangkok Suvarnabhumi	Thailand	59,174	1,323
KRR	Krasnodar	Russia	58,814	2,292
DEL	Delhi	India	57,903	1,502
AYT	Antalya	Turkey	48,406	896
KUF	Samara	Russia	42,353	2,179
SGC	Surgut	Russia	41,688	3,185
KBP	Kiev Borispol	Ukraine	41,246	4,204
ATQ	Amritsar	India	35,424	2,091
REN	Orenburg	Russia	34,859	4,328
CEK	Chelyabinsk	Russia	33,281	3,105
MSQ	Minsk	Belarus	29,828	4,771
TBS	Tbilisi	Georgia	28,790	834
LHR	London Heathrow	United Kingdom	28,333	2,430
IKT	Irkutsk	Russia	25,604	1,561

Source: The passenger number is from PaxIS database; HHI Index is calculated based on each airline's scheduled seats provided at the airport, including all international and domestic traffic. The HHI is calculated with scheduled airport seats data retrieved from OAG.

In Sep 2013, the Chinese president Xi Jinping first proposed the concept of the Silk Road Economic Belt in Kazakhstan. Given China's large international trade volume, huge population and high economic growth, one would expect high growth for routes connecting to China. However, this has not been the case. Table 4 summarizes the number of international routes from Central Asia to Russia and China as of 2015, whereas Table 5 summarizes the number of international routes and passenger volumes for Central Asia's top 10

overseas destination countries in year 2007, 2010 and 2015 respectively. It is clear that countries in Central Asia maintain very close economic and political ties to Russia, as manifested by the superior air connectivity. In comparison, although the traffic volumes to China more than doubled during 2007 to 2015, there has been little change in terms of air connectivity. Despite China's enormous economy size and close geographic location with the region, only a few of international routes link Central Asia to China. In year 2015, there were only 14 routes between the two regions, with only 3 Chinese destinations reached, namely Urumqi, Beijing and Sanya. This is far more less than the number of routes to Russia as total 176 routes with 31 airports served. Indeed, the relative importance of the Chinese aviation market has declined for Central Asia, now behind major hubs in Turkey and UAE, notably Istanbul and Dubai. Table 6 compares the passenger volume, average yield and stage length for selected international destinations. Average stage length reports the average flying distances for the flights involved. Because the largest Chinese destination is Urumqi which is geographically close to Central Asia, the average stage length to China was only 2,082 kilometers as of 2015, shorter than the distances to other leading destinations such as Russia, Turkey and UAE.

However, the airfare level to China has been extremely high. As shown in Table 6, on average passengers paid 16 US cents to fly one kilometer for flights to China, whereas the average yields in virtually all markets ranged between 7-11 cents. That is, compared to other destinations, market growth between Central Asia and China seemed to lag behind in the past years despite the OBOR initiative – there has been little improvements in air connectivity, whereas prices remained remarkably high.

Table 4. Number of Routes to Russia and China by Central Asian Countries

(Year 2015)

Country	Routes to Russia	Routes to China
Uzbekistan	61	2
Tajikistan	46	2
Kazakhstan	41	6
Kyrgyzstan	26	2
Turkmenistan	2	2

Source: PaxIS

Table 5. 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	United Kingdom	5 (2)	43,590
United Kingdom	5 (2)	47,476	United Kingdom	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. The passenger is directional, originating from the Central Asian countries to the 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.
Source: PaxIS

Table 6. Route Average HHI, Yield and Stage Length of International Routes to Different Countries (for Year 2015)

Country	Total Passenger	HHI	Yield	Stage length (km)
Russian Federation	2,671,742	6,631	0.091	2,605
Turkey	456,494	5,903	0.076	3,149
United Arab Emirates	260,758	7,386	0.087	2,391
China	**247,788**	**6,030**	**0.160**	**2,082**
Korea	114,110	4,244	0.105	4,621
India	93,327	10,000	0.117	1,625
Azerbaijan	82,277	9,203	0.245	1,113
Germany	66,519	9,824	0.096	4,550
Thailand	59,174	10,000	0.091	4,474
United Kingdom	47,476	10,000	0.116	4,949
Ukraine	41,246	6,877	0.067	3,241
Belarus	29,828	8,396	0.080	3,033
Georgia	28,790	10,000	0.178	1,901
Netherlands	23,479	10,000	0.109	4,397
Malaysia	22,240	10,000	0.091	5,220
Iran	21,179	10,000	0.085	1,822
France	18,258	10,000	0.074	4,902
Latvia	8,599	10,000	0.081	3,639
Israel	7,734	10,000	0.077	3,211

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

The sluggish growth for the international aviation markets between Central Asia and China has been, to a great extent, due to the restrictive regulations in the related markets. Table 7 lists the Air Liberalization Index (ALI) calculated by WTO (World Trade Organization) for each Central Asia country based on contents of their bilateral ASAs signed. A large ALI index suggests liberal regulation whereas a small ALI index value suggests tight regulation on airlines' operation decisions such as route entry, capacity and frequency, air fares and cooperative arrangements. The ASAs between Central Asia countries and China are quite restrictive with very low ALI value compared to other ASAs signed between Central Asia countries and other governments. Airlines thus face barriers in designation, price setting, capacity deployment and route choices to fly routes between Central Asia and China.

Table 7(a). WTO Air Liberalization Index for **Kyrgyzstan**

Signatory Country	Date of Signing	ALI ST	Type
United Kingdom	08 Dec 1994	20	o
Germany	13 May 1997	11	o
Turkmenistan	24 Dec 1993	11	o
Malaysia	17 Nov 2000	10	E
Hong Kong China	15 July 1999	8	i
Indonesia	18 July 1995	6	C
Uzbekistan	04 Sept 1996	5	i
Austria	17 Mar 1998	4	B
India	08 Sept 1993	4	B
Georgia	22 April 1997	4	i
China	**04 July 1996**	**0**	**A**
Turkey	14 Oct 1994	0	A
Iran	22 June 1993	0	A
Pakistan	14 Oct 1993	0	A

Note:

1. ALI ST is the standard Air Liberalization Index calculated by WTO using the countries air service agreements (ASA) recorded by ICAO.
2. The "Type" indicates the different categories of the ASA (see the Table A1)

Table 7(b). WTO Air Liberalization Index for **Uzbekistan**

Signatory Country	Date	ALI ST	Type
United States of America	27 Feb 1998	28	G
India	09 July 2007	21	o
Bahrain	11 Dec 1996	16	i
Belarus	22 Dec 1994	13	o
Russia	**02 Mar 1994**	**11**	**o**
Kazakhstan	25 May 1994	11	o
Germany	16 Nov 1995	11	o
Latvia	06 Jun 1995	11	o
Egypt	12 Dec 1992	11	E
Turkey	23 June 1994	10	E
Thailand	17 Dec 1993	10	E
Maldives	06 Nov 1996	10	o
United Kingdom	24 Nov 1993	8	o
Ukraine	20 Feb 1993	7	i
Netherlands	17 Oct 1995	7	i
Switzerland	14 July 1994	6	C
Belgium	14 Nov 1996	6	C
Kyrgyz Republic	04 Sept 1996	5	i
Azerbaijan	27 May 1996	5	B

Moldova	30 Mar 1995	5	B
Turkmenistan	16 Jan 1996	5	i
Georgia	28 May 1996	5	B
Korea	06 June 1994	4	B
China	**19 Apr 1994**	**4**	**B**
Japan	22 Dec 2003	4	B
Iran	17 Aug 2001	4	B
Austria	28 July 2000	4	B
Finland	09 Feb 1996	4	B
Slovak Republic	17 Jan 1997	4	B
Romania	06 Jun 1996	4	B
Pakistan	16 Feb 1992	1	i
Poland	11 Jan 1995	1	A
Israel	04 July 1994	0	A
Greece	26 Nov 1996	0	A
Bulgaria	07 May 1999	0	A
Lithuania	07 Jun 1995	0	A
Indonesia	08 Apr 1995	0	A
Jordan	24 Nov 1996	0	A
Viet Nam	14 July 1995	0	A

Note:
1. ALI ST is the standard Air Liberalization Index calculated by WTO using the countries air service agreements (ASA) recorded by ICAO.
2. The "Type" indicates the different categories of the ASA (see the Table A1)

Table 7 (c). the Air Liberalization Index for **Tajikistan**

Signatory Country	Date	ALI ST	Type
China	**15 Jan 2007**	**4**	**B**

Note:
1. ALI ST is the standard Air Liberalization Index calculated by WTO using the countries air service agreements (ASA) recorded by ICAO.
2. The "Type" indicates the different categories of the ASA (see the Table A1)

Table 7 (d). the Air Liberalization Index for **Turkmenistan**

Signatory Country	Date	ALI ST	Type
United Kingdom	11 Sept 2000	14	o
Latvia	08 Oct 2008	11	o
Kyrgyz Republic	24 Dec 1993	11	o
Germany	28 Aug 1997	11	o
India	14 Sept 1993	10	E
Iran	20 Aug 1998	10	E
Uzbekistan	16 Jan 1996	5	i
China	**31 Aug 1978**	**4**	**B**
Ukraine	25 Feb 1993	0	A

Note:
1. ALI ST is the standard Air Liberalization Index calculated by WTO using the countries air service agreements (ASA) recorded by ICAO.
2. The "Type" indicates the different categories of the ASA (see the Table A1)

Table 7 (e). the Air Liberalization Index for **Kazakhstan**

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

Note:
1. ALI ST is the standard Air Liberalization Index calculated by WTO using the countries air service agreements (ASA) recorded by ICAO.
2. The "Type" indicates the different categories of the ASA (see the Table A1)

As summarized in Table 7 (a) – (e), virtually all countries in Central Asia have imposed tight regulations on international routes to China. This implies that substantial welfare gains may be obtained through liberalization, as suggested by the market outcomes observed in previous studies. In the following section, we will first empirically analyze the airlines' route entry behaviors, airlines' pricing and demand equations, thus that counter-factual analysis can be carried out to predict the effects of liberalization.

3.0 Analyzing the effects of liberalization

3.1 Airlines' entry behavior in international markets

In this section, we investigate the factors affecting the airlines to enter the Central Asian airline markets. The airline route entry decision can be largely influenced by the bilateral regulatory condition on air services which we can be regarded as a "barrier" or implicit/explicit cost to reduce the airlines' *ex-post* entry profit. Of course, other factors beyond managerial control, such as ties in history, cultural, political and economic relationships also affect airlines' entry decisions. To control the effects of these factors, alternative model specifications including the fixed effect" models are also tested.

Let π^*_{ikft} be the profit for one airline to serve the route *i* at time *t* in Central Asia. The subscript *k* stands for the origin Central Asia country *k* (i.e., Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan, Kyrgyzstan). The subscript *f* stands for the destination country *f*. We first model the airline entry for one route, not for one specific airline. Thus one route is regarded to be entered if at least one airline served it, thus that π^*_{ikft} should be interpreted as the lowest profit among all airlines to be profitable to enter the route. The profit function can be specified as,

$$\ln\pi^*_{ikft}=\ln \boldsymbol{X}'_{ikft}\,\boldsymbol{\varphi_r}+\mu_{ikft} \qquad (1)$$

which is a function of a vector of control variables $\boldsymbol{X}'_{ikft}$ and a stochastic error term μ_{ikft}. Let Y_{ikft} denote the entry status of the route i between the Central Asia city and the other foreign country at the time *t*. We can allow the impacts of X_{ikft} to be different for different regions of destinations, recognizing that the demand and airline competition characteristics can vary significantly, so as to affect the airline profit differently.

C_f denotes the cost/barrier to serve the route to the country f. The real profit π^*_{ikft} at route level is not observable by the researcher, but the route entry can be specified as a function of the "latent" profit in Eq (1), such that $Y_{ikft} = 1$ if π^*_{ikft}-C_f>0 and Y_{ikft}=0 if π^*_{ikft}-C_f≤0. The probability of route entry can be thus expressed as in Eq (2). This country specific cost/barrier parameter, C_f can reflect the difficulty to serve the routes to the country f after controlling for the other market characteristics that affecting airlines' profit. When C_f is high, the latent profit must be higher to make the entry economically feasible. The estimations of C_f can thus shed light on the overall difficulty or the "barriers" to serve one country, the effects we would like to identify in this study. The probability of the airline entry can be written as follows,

$$\text{Prob}(Y_{ikft}=1|X_{ikft})=\text{Prob}\left(\frac{\pi^*_{ikft}}{C_f}>1\,|\,X_{ikft}\right)=\text{Prob}\left(\ln\pi^*_{ikft}-\ln C_f>0\,|\,X_{ikft}\right)=\text{Prob}\left(\ln X'_{ikft}\varphi_r-\ln C_f+\mu_{ikft}>0\,|\,X_{ikft}\right) \qquad (2)$$

Using the domestic market in each Central Asian country as the benchmark, we can write $C_f = \theta_f C_d$, where C_d is the cost/barrier parameter for the domestic market, and θ_f measures the degree of relative difficulty to serve a route to the foreign country f compared with the domestic market. Since the most significant difference of the domestic and international markets (after controlling for other demand and cost variables) is the existence of bilateral ASAs and regulations specified by them for international routes, the parameter θ_f indicates the additional barrier imposed by the ASA regulations.

$$\text{Prob}(Y_{ikft}=1|X_{ikft})=\text{Prob}\left(\ln X'_{ikft}\varphi_r-\ln C_f+\mu_{ikft}>0\,|\,X_{ikft}\right)=\text{Prob}\left(\ln X'_{ikft}\varphi_r-\ln C_d-\ln\theta_f+\mu_{ikft}>0\,|\,X_{ikft}\right) \quad (3)$$

From Eq. (3), we can estimate the term, $\ln\theta_f = \ln(\frac{C_f}{C_d})$, for each country f. The economic interpretation of the term $\ln\theta_f$ is the log of the relative additional cost/barrier to enter the route to the foreign country f compared to enter a domestic route. This is somewhat similar the estimation of the border effect of merchandise trade as in McCallum (1995). However, it should be cautioned that $\ln\theta_f$ also contains other confounding heterogeneity of the entry cost for the country f not attributed to the ASA.

We assume the airline profit to be affected by the factors as shown in Eq (4),

$$\text{Prob}(Y_{ikft}=1|\boldsymbol{X_{ikft}})=\text{Prob}\left(-\ln C_d-\ln\theta_f+\ln\pi^*_{ikft}\begin{pmatrix}Dist_{ikf},\ AirportsizeOrigin_{ikft}, AirportsizeDest_{ikft},\\ AirportHHIOrigin_{ikft},\ AirportHHIDest_{ifkt},\\ GDPORIGIN_{ikt}\\ GDPDEST_{ift},\\ Quarter_t\ , Year_t\end{pmatrix}\boldsymbol{\varphi_r}+\mu_{ikft}>0\ |\ \boldsymbol{X_{ikft}}\right) \quad (4)$$

where the variable $Dist_{ikf}$ is the flying distance of the route i. The variable $AirportsizeOrigin_{ikft}$ is the passenger throughput of origin airport in the Central Asia country *k* for the route *i* at the time *t*. The variable $AirportsizeDest_{ikft}$ is the passenger throughput of the destination airport in the foreign country *f* of the route *i* at the time *t*. The variables $AirportsizeOrigin_{ikft}$ and $AirportsizeDest_{ikft}$ are used as the proxy of the potential market size of the route. The route level passenger traffic only accounts for a small proportion of the airport total throughput, thus the variables $AirportsizeOrigin_{ikft}$ and $AirportsizeDest_{ikft}$ can be regarded as exogenous. The variables $AirportHHIOrigin_{ikft}$ and $AirportHHIDest_{ifkt}$ are the HHI market concentration index for the origin and destination airports on the route *i* at the time *t*. The airport HHI are calculated by the share of each airline's scheduled seats in the airport. The airport HHI helps us measure the airlines' hub status in the origin and destination airports. High airport HHI indicates more dominance of the hub carriers, affecting airlines' entry decision on the routes involving this airport. The airport HHI can also be regarded as exogenous because the individual route level passenger throughput only accounts for a small proportion of the airport total throughput. GDP_{ikt} and GDP_{ift} are the GDP of the origin Central Asia country *k* and destination foreign country *f* at time *t*. Since it is difficult to obtain the city level GDP data, the national level GDP data is used. As the quarterly data are used, we also include the quarterly dummies $Quarter_t$ and yearly dummies $Year_t$ to control the time trends.

The error term μ_{ikft} can be assumed to be *iid* and normally distributed (μ_{ikft}~N(0,1)), such that a standard Probit model estimation can be employed. Since the time-series panel data is used. As discussed earlier, because the demand characteristics and market competition conditions can differ for different markets, we allow random coefficients for the variables of $AirportsizeOrigin_{ikft}$, $AirportsizeDest_{ikft}$, $AirportHHIOrigin_{ikft}$, $AirportHHIDest_{ifkt}$, as these variables reflect the market demand and competition. For example, the domestic routes and the routes between two Central Asian countries can have very different market conditions compared to the other international routes. Thus we allow the parameters $\boldsymbol{\varphi_r}$ to vary among the different market segments.

For the sampled routes, they are defined not only by the origin and destination cities but also by time. The controlled Central Asian routes are those once entered by airlines, indicating the permission for airline

entry by ASA, which are thus included in airlines choice set. We first pool the data of all airlines and of all the Central Asian countries. The continuous variables are taken log in the estimation. In Model 1, we impose the same values of parameters $\boldsymbol{\varphi_r}$ for all the routes no matter they are domestic or international. In Model 2, we let the domestic routes and the routes between two Central Asian countries to have the parameters $\boldsymbol{\varphi_r}$ whose values are different to the routes to other international destinations. The variables, *AirportSizeOrigin_d*$_{ikft}$, *AirportSizeDest_d*$_{it}$, *AirportHHIOrigin_d*$_{it}$, and *AirportHHIDest_d*$_{it}$ that have suffix d_{it} are for the domestic and the inter-Central Asia routes, whereas *AirportSizeOrigin_I*$_{it}$, *AirportSizeDest_I*$_{it}$, *AirportHHIOrigin_I*$_{it}$, and *AirportHHIDest_I*$_{it}$ are for the other international routes.

In Model 3, we further assume that routes to the former Soviet Union countries to have similar demand characters as the domestic and Central Asian routes given their closer economic, political, and cultural ties. The variables with the suffix d_{it} thus are for the domestic, inter-Central Asian routes, and the routes to former Soviet Union countries. It is ideal to divide the markets into more specific segments to account for more specific heterogenous impact of the demand and market characteristics. However, this attempt imposes more burden for estimation with too many sub-categories. Besides, the sub-sample size for the routes to particular countries is too small for efficient estimation. The countries that are included in our sample are reported as in Table 8

Table 8. The 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, United Kingdom, 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

The estimation results of the entry model are shown in the Table 9. Our main interests are the entry barrier parameters $\ln\theta_f$ for different countries benchmarked to the domestic routes. The estimated barrier parameters are statistically significant, and Table 10 summarizes and ranks them for each model (Model 1 to Model 3). We list the entry barrier parameter for the intra-Central Asia country in the first row, and then rank the other countries entry barriers below it. It is apparent that the intra-Central Asia routes and the routes to the other former Soviet Union countries have the lowest entry barriers. Northeast Asian countries, including China, and Southeast Asian countries have high barrier for airlines to enter. This is consistent with the ALI index summarized in Table 7(a)-(e).

Table 9. The Estimation Results of the Entry Model

Model 1		Model 2		Model 3	
ln*AirportSizeOrigin*$_{it}$	0.432***	ln*AirportSizeOrigin_d*$_{it}$	0.416***	ln*AirportSizeOrigin_d*$_{it}$	0.541***
	(0.010)		(0.011)		(0.023)
		ln*AirportSizeOrigin_O*$_{it}$	0.582***	ln*AirportSizeOrigin_O*$_{it}$	0.403***
			(0.026)		(0.011)
ln*AirportSizeDest*$_{it}$	0.519***	ln*AirportSizeDest_d*$_{it}$	0.571	ln*AirportSizeDest_d*$_{it}$	0.701***
	(0.010)		(0.012)		(0.030)
		ln*AirportSizeDest_O*$_{it}$	0.294***	ln*AirportSizeDest_O*$_{it}$	0.482***
			(0.023)		(0.011)
ln*AirportHHIOrigin*$_{it}$	0.276***	ln*AirportHHIOrigin_d*$_{it}$	0.155***	ln*AirportHHIOrigin_d*$_{it}$	0.542***
	(0.024)		(0.028)		(0.073)
		ln*AirportHHIOrigin_O*$_{it}$	0.517***	ln*AirportHHIOrigin_O*$_{it}$	0.249***
			(0.052)		(0.026)
ln*AirportHHIDest*$_{it}$	0.131***	ln*AirportHHIDest_d*$_{it}$	0.094	ln*AirportHHIDest_d*$_{it}$	0.070
	(0.026)		(0.030)		(0.077)
		ln*AirportHHIDest_O*$_{it}$	0.405***	ln*AirportHHIDest_O*$_{it}$	0.181***
			(0.057)		(0.028)
ln*GDPOrigin*$_{it}$	-0.169***	ln*GDPOrigin_d*$_{it}$	-0.180	ln*GDPOrigin_d*$_{it}$	-0.051
	(0.011)		(0.013)		(0.044)
		ln*GDPOrigin_O*$_{it}$	-0.180***	ln*GDPOrigin_O*$_{it}$	-0.167***
			(0.021)		(0.011)
ln*GDPDest*$_{it}$	0.332***	ln*GDPDest_d*$_{it}$	0.356***	ln*GDPDest_d*$_{it}$	0.203***
	(0.029)		(0.032)		(0.045)
		ln*GDPDest_O*$_{it}$	0.085	ln*GDPDest_O*$_{it}$	0.593***
			(0.094)		(0.076)
ln*Distance*$_{it}$	-0.474***	ln*Distance*$_{it}$	-0.499***	ln*Distance*$_{it}$	-0.475***
	(0.026)		(0.027)		(0.027)
Central Asia	-0.859***	*Central Asia*	-0.987***	*Central Asia*	-1.284***
	(0.096)		(0.104)		(0.127)

Afghanistan	-0.878***	*Afghanistan*	-4.053***	*Afghanistan*	-1.842
	(0.172)		(1.220)		(2.049)
Armenia	-1.138***	*Armenia*	-1.252***	*Armenia*	-1.999
	(0.150)		(0.155)		(2.026)
Austria	-1.820***	*Austria*	-3.693***	*Austria*	-3.569
	(0.245)		(1.453)		(2.272)
Azerbaijan	-1.217***	*Azerbaijan*	-1.405***	*Azerbaijan*	-2.516
	(0.077)		(0.081)		(2.125)
Belarus	-0.891***	*Belarus*	-0.965***	*Belarus*	-2.271
	(0.109)		(0.111)		(2.140)
Bulgaria	-1.251***	*Bulgaria*	-1.300***	*Bulgaria*	-2.525
	(0.216)		(0.222)		(2.136)
China	-3.480***	*China*	-4.607***	*China*	-5.981***
	(0.146)		(1.660)		(2.439)
Czech	-2.601***	*Czech*	-4.711***	*Czech*	-4.143**
	(0.133)		(1.423)		(2.220)
Egypt	-4.006***	*Egypt*	-6.268***	*Egypt*	-5.588***
	(0.200)		(1.462)		(2.239)
France	-4.261***	*France*	-5.493***	*France*	-6.469***
	(0.179)		(1.599)		(2.392)
Georgia	-0.580***	*Georgia*	-0.668***	*Georgia*	-1.470
	(0.138)		(0.147)		(2.037)
Germany	-3.287***	*Germany*	-4.388***	*Germany*	-5.619***
	(0.139)		(1.612)		(2.405)
Greece	-3.513***	*Greece*	-5.700***	*Greece*	-5.161***
	(0.147)		(1.407)		(2.241)
Hong Kong	-3.725***	*Hong Kong*	-5.386***	*Hong Kong*	-5.249***
	(0.204)		(1.388)		(2.236)
India	-2.477***	*India*	-3.848***	*India*	-4.585**
	(0.158)		(1.537)		(2.347)
Iran	-2.460***	*Iran*	-4.408***	*Iran*	-4.283**

	(0.101)		(1.432)		(2.261)
Israel	-0.791*	*Israel*	-2.942**	*Israel*	-2.361
	(0.429)		(1.464)		(2.267)
Italy	-2.654***	*Italy*	-4.021***	*Italy*	-4.776***
	(0.217)		(1.571)		(2.367)
Japan	-3.782***	*Japan*	-4.780***	*Japan*	-6.090***
	(0.190)		(1.638)		(2.427)
Korea	-3.418***	*Korea*	-4.773***	*Korea*	-5.401***
	(0.135)		(1.517)		(2.333)
Latvia	-1.548***	*Latvia*	-1.702***	*Latvia*	-2.663
	(0.131)		(0.136)		(2.098)
Lithuania	-3.037***	*Lithuania*	-3.142***	*Lithuania*	-4.230**
	(0.445)		(0.452)		(2.150)
Malaysia	-2.267***	*Malaysia*	-4.190***	*Malaysia*	-3.839*
	(0.169)		(1.416)		(2.242)
Mongolia	0.366	*Mongolia*	-3.653***	*Mongolia*	-0.597
	(0.243)		(1.177)		(2.057)
Netherlands	-2.245***	*Netherlands*	-3.553**	*Netherlands*	-4.187**
	(0.142)		(1.497)		(2.314)
Pakistan	-3.353***	*Pakistan*	-5.831***	*Pakistan*	-4.982***
	(0.125)		(1.389)		(2.217)
Russia	-2.019***	*Russia*	-2.321***	*Russia*	-4.243**
	(0.094)		(0.106)		(2.348)
Saudi Arabia	-4.943***	*Saudi Arabia*	-6.779***	*Saudi Arabia*	-6.785***
	(0.262)		(1.495)		(2.305)
Singapore	-4.276***	*Singapore*	-6.035***	*Singapore*	-5.802***
	(0.243)		(1.407)		(2.235)
Spain	-4.469***	*Spain*	-5.919***	*Spain*	-6.476***
	(0.240)		(1.562)		(2.360)
Switzerland	-2.876***	*Switzerland*	-4.655***	*Switzerland*	-4.675***
	(0.219)		(1.478)		(2.294)

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

Note: *, **, *** stands for the 10%, 5% and 1% significance level.

Table 10. The Estimated entry 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***	UK	-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	UK	-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***	UK	-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.the countries with a superscript "a" indicates a former Soviet Union member country;
3. *, **, *** stands for the 10%, 5% and 1% significance level.

The above estimations are based on the pooled data of all the Central Asia countries and all airlines, including the Central Asian and foreign airlines. Since some routes are exclusively operated by foreign airlines which might not have the permission to operate other Central Asian routes (for example, a Chinese airline is not allowed to operate a route from Kazakhstan to Russia). The estimations using the pooled data however implicitly assume that all the sampled Central Asian routes are feasible for all airlines to enter, which is not the case. To deal with such potential concern, we only consider the Central Asian carriers, and use the same entry model for each individual Central Asia country. Table 11 lists the major airlines in each Central Asia country.

Table 11. Major airlines in each Central Asia 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

For each Central Asia country, we first estimate a general entry model which is not airline specific. The route is regarded as entered if at least one of the country's carrier operates the route. We then estimate the entry model for the national carrier of each country. We also include the variable, *Foreign_Airline*, the number of foreign airlines present on the route, to control for any competition effect. To control for the different impacts of the 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 the other group. This setup is the same as the Model 3 in previous estimation. Some routes are operated exclusively by foreign airlines and thus treated as not entered for the estimation of Central Asia airlines. In the entry model estimation, the barrier parameters for these countries, however, cannot be identified as there is no variation of the entry variable by the country's own airline. These countries are indicated with a sign of "#".

The model estimation results are summarized in Table 12, with country specific estimation results reported in Annex 2. Overall, the model estimation results seem to be consistent with the estimation results considering all airlines. Therefore, the model estimation results with all airlines will be used for counter-factual analysis because of the larger sample size.

Table 12. The Entry Model Estimations for the Central Asian Carriers Only

	Kazakhstan		Uzbekistan	Tajikistan		Kyrgyzstan		Turkmenistan
	All	*KC*	*HY*	All	*7J*	All	*QH*	*T5*
ln*AirportSizeOrigin_d*$_{it}$	0.652***	1.200***	0.446***	0.357***	0.701***	1.446***	1.449***	-0.662
	(0.023)	(0.034)	(0.021)	(0.056)	(0.082)	(0.253)	(0.269)	(1.031)
ln*AirportSizeOrigin_l*$_{it}$	0.442***	0.563***	0.285***	2.902***	1.959***	0.620*	1.120***	-0.144
	(0.035)	(0.039)	(0.095)	(0.384)	(0.411)	(0.331)	(0.397)	(0.384)
ln*AirportSizeDest_d*$_{it}$	0.568***	1.107***	0.713***	0.435***	0.800***	1.003***	0.776***	1.090***
	(0.026)	(0.035)	(0.024)	(0.034)	(0.048)	(0.070)	(0.065)	(0.245)
ln*AirportSizeDest_l*$_{it}$	0.724***	0.783***	0.928***	0.185*	-0.211**	0.057	0.010	0.004
	(0.046)	(0.047)	(0.094)	(0.108)	(0.103)	(0.079)	(0.091)	(0.091)
ln*AirportHHIOrigin_d*$_{it}$	0.039	0.876***	0.239***	0.079	-0.117	1.041***	1.067***	0.213
	(0.079)	(0.100)	(0.112)	(0.111)	(0.177)	(0.275)	(0.293)	(1.619)
ln*AirportHHIOrigin_l*$_{it}$	-0.643***	1.119***	0.542	-0.623**	-1.273***	0.501	1.100***	0.022
	(0.128)	(0.165)	(0.729)	(0.357)	(0.372)	(0.388)	(0.462)	(0.681)
ln*AirportHHIDest_d*$_{it}$	-0.052	-0.415***	-0.387***	-0.027	-0.470***	-0.098	-0.123	1.877*
	(0.060)	(0.092)	(0.070)	(0.068)	(0.107)	(0.117)	(0.126)	(1.019)
ln*AirportHHIDest_l*$_{it}$	-0.735***	-0.720***	0.949***	-0.038	-0.282	-0.567	1.100***	-0.748*
	(0.082)	(0.084)	(0.165)	(0.289)	(0.282)	(0.307)	(0.462)	(0.467)
ln*GDPOrigin_d*$_{it}$	-0.141	-0.741***	-0.068	0.130**	-0.101	-2.099***	-2.880***	1.480
	(0.096)	(0.127)	(0.218)	(0.069)	(0.103)	(0.205)	(0.961)	(1.118)
ln*GDPOrigin_l*$_{it}$	-0.926***	-1.329***	0.109	-2.307***	-1.360***	-2.732***	-3.127***	3.923***
	(0.226)	(0.261)	(0.308)	(0.490)	(0.560)	(0.657)	(1.150)	(1.332)
ln*GDPDest_d*$_{it}$	-0.084	-0.588***	-0.375***	-0.528*	-0.615*	-0.763***	-0.411***	1.176
	(0.087)	(0.193)	(0.142)	(0.323)	(0.400)	(0.124)	(0.129)	(1.259)
ln*GDPDest_l*$_{it}$	0.814***	1.780***	-0.376	-0.662*	0.256	0.495	0.330	-3.645***
	(0.285)	(0.250)	(0.289)	(0.437)	(0.460)	(0.477)	(0.660)	(0.741)
ln*Distance*$_{it}$	-1.323***	-1.198***	-0.189***	-0.132	-0.028	-1.898***	-2.395***	3.832***
	(0.052)	(0.062)	(0.059)	(0.169)	(0.196)	(0.186)	(0.210)	(0.930)
Foreign_Airline	0.033	-0.121***	0.456***	0.827***	0.673***	0.080	0.301***	0.299

	(0.055)	(0.063)	(0.065)	(0.068)	(0.088)	(0.106)	(0.117)	(0.445)
DV		-1.227***						
		(0.078)						
SZ					-0.310***			
					(0.147)			
4J					0.325***			
					(0.136)			
EG					-1.497***			
					(0.427)			
YK							0.606***	
							(0.138)	
Central Asian	-3.248***	-5.467**	-1.062***	-0.217	4.148	-1.098***	-0.724*	-8.932***
	(0.232)	(0.310)	(0.243)	(0.304)	(102.023)	(0.370)	(0.373)	(1.814)
Afghanistan	#	#		#	#			
Armenia	-2.221***	#						#
	(0.281)							
Austria	#	#						#
Azerbaijan	-1.969***	-4.436***	#	0.245	4.389	#	#	
	(0.151)	(0.197)		(0.839)	(102.027)			
Belarus	#	#	-3.915***					-8.231***
			(0.383)					(2.355)
Bulgaria	#	#						
China	-9.105***	-10.278***	-5.618	-2.848	-1.472	-5.359	2.105	-0.060
	(3.287)	(3.147)	(8.443)	(6.077)	(102.166)	(13.136)	(16.070)	(20.547)
Czech	#	#	#					
Egypt	#	#	-8.657					
			(7.699)					

France	-9.249***	-9.679***	#					-4.810
	(3.138)	(3.061)						(20.462)
Georgia	-1.941***	-4.961***	#					
	(0.261)	(0.338)						
Germany	-7.593***	-8.035***	-7.382	-2.203	#	-5.035	2.227	2.255
	(3.145)	(3.050)	(8.330)	(6.049)		(12.885)	(15.663)	(20.561)
Greece	#	#	-6.977					
			(7.754)					
Hong Kong	-7.162***	-5.331***						
	(2.603)	(2.629)						
India	-7.226***	-6.951***	-1.554	-3.430	-0.152	-5.666	0.294	1.550
	(3.014)	(2.933)	(8.130)	(5.674)	(102.15)	(12.652)	(15.307)	(20.510)
Iran	#	#	#	-4.743	-0.82	-5.258	#	
				(5.396)	(102.136)	(12.385)		
Israel			-4.479					
			(7.721)					
Italy			-4.850					
			(8.198)					
Japan			-5.073					
			(8.383)					
Korea	-7.307***	-6.865***	#			-3.544	#	
	(2.916)	(2.866)				(12.638)		
Latvia	#	#	#	#	#			
Lithuania	#	#	#					
Malaysia	-5.460***	-3.665***	#					
	(2.608)	(2.647)						
Mongolia	1.175	#				#	#	
	(2.109)							
Netherlands	-6.880***	-6.015***						

	(2.847)	(2.819)						
Pakistan			-6.406	-5.834	-0.893	-5.521	1.423	
			(7.679)	(5.352)	(102.132)	(12.240)	(14.736)	
Russia	-2.375***	-4.606	-1.195***	2.531*	6.641	4.206***	3.483***	-14.534
	(0.229)	(0.309)	(0.535)	(1.866)	(102.049)	(0.840)	(0.896)	(5.075)
Saudi Arabia			-8.815	-5.473	#			
			(7.925)	(5.621)				
Singapore			-8.447					
			(7.722)					
Spain			-7.776					
			(8.118)					
Switzerland			-5.699					
			(7.914)					
Thailand	-6.673***	-5.142**	-5.976	-6.216	#			-10.421
	(2.665)	(2.679)	(7.792)	(5.450)				(20.372)
Turkey	-6.318***	-5.258**	-6.572	-3.547	-0.009	-3.412	#	-4.844
	(2.792)	(2.778)	(7.960)	(5.717)	(102.144)	(12.621)		(20.375)
Ukraine	-2.860***	-5.364***	-2.209***	0.587	#	#	#	#
	(0.152)	(0.232)	(0.255)	(1.118)				
UAE	-6.385***	-4.701**	-6.019	-3.340	0.672	-3.274	4.365	-6.365
	(2.633)	(2.661)	(7.781)	(5.515)	(102.13)	(12.381)	(14.956)	(20.366)
UK	-8.592***	-8.962***	-5.473					-0.042
	(3.098)	(3.000)	(8.252)					(20.530)
Vietnam	-5.760***	-3.342	-9.150					
	(2.478)	(2.555)	(7.596)					
Constant	-1.973*	-12.993***	0.012	-5.758***	-22.548	63.408***	75.868***	-10.019
	(1.237)	(1.553)	(5.670)	(1.002)	(102.033)	(4.659)	(21.466)	(21.023)
No. of Obs	7,347	7,205	5,329	3,405	3,205	2,129	1,889	712

Note: # stands for the destination countries only with foreign airlines' operation. Since the entry of Central Asia airlines are estimated, and there is no variation of entry on these routes, the entry barrier parameters are not identified for these "#" countries.
* represents the 10% significance level; ** represents the 5% significance level; *** represents the 1% significance level.

3.2 Counterfactual analysis of the Central Asia-China international market

Matching technique can help us directly compare our hypothetically constructed Central Asia-China routes (treated group) to our observed sample routes of Central Asia (control group). The control group routes are defined by the origin and destination city as well as the time. The controlled Central Asian routes are those once entered by airlines thus included in airlines choice set. For each constructed route to China, we can search for the most resembling route in the control group, and check if this matched route/ routes has the airline entry or not. This counterfactual analysis can shed light on the potential of the Central Asia – China markets if the bilateral ASA could be liberalized such that the airlines are also allowed to operate these hypothetical Central Asia-China routes. To implement this counterfactual analysis, we employ a "propensity score matching" (PSM) method to match each of the constructed Central-Asia routes with the observed counterfactual routes. The covariates that are used for matching include route distance, airports' throughputs, and airports' HHI.

Specifically, let the vector $\boldsymbol{A}$ to represent our chosen covariates, and $W_i = 0$ to indicate the route i is a control group route, while $W_i = 1$ to indicate the route i is a treated group route. In addition, let Y_i be airline entry outcome, with $Y_i = 1$, indicating that airlines serve this route, and $Y_i = 0$, indicating that airlines do not enter this route.

In the PSM counterfactual analysis, we assume that the treated group routes (our hypothetical Central Asia-routes) to have the same barrier parameters as the control routes. Our target is to measure what would be the difference airline entry outcomes for our treated group routes under the counterfactual, i.e. the treatment effect conditional on the covariate vector $\boldsymbol{A}$: $\mathrm{E}(Y_i(0) - Y_i(1) \mid A_i, W_i = 1)$, where

$$Y_i(W_i) = \begin{cases} Y_i(0), & if\ W_i = 0 \\ Y_i(1), & if\ W_i = 1 \end{cases}$$

We assume "unconfoundedness" (Rubin, 1990), when our treated group routes (the hypothetically constructed Central Asia- China routes) have the same barrier parameter as the control group, in the counterfactual.

$$W_i \perp \big(Y_i(0), Y_i(1)\big) \mid \boldsymbol{A_i}$$

Let the "propensity score" be $0 < e(\mathrm{a}) < 1$,

$$\mathrm{e(a)} = \mathrm{E}[W_i | \boldsymbol{A_i} = \mathrm{a}] = \Pr([W_i = 1 | \boldsymbol{A_i} = \mathrm{a})$$

The combination of the above two assumptions is referred to as strong ignorability by Rosenbaum and Rubin (1983). We thus have,

$$W_i \perp \big(Y_i(0), Y_i(1)\big) \mid \boldsymbol{A_i} \rightarrow W_i \perp \big(Y_i(0), Y_i(1)\big) \mid \mathrm{e(a)}$$

The treatment effect conditional on propensity score can be written as $\mathrm{E}(Y_i(0) - Y_i(1) \mid \mathrm{e(a)}, W_i = 1)$, and the matching based on $\mathrm{e(a)}$ gives us,

$$\begin{aligned} &\mathrm{E}(Y_i(0) | \mathrm{e(a)}, W_i = 0) - \mathrm{E}(Y_i(1) \mid \mathrm{e(a)}, W_i = 1) \\ &\quad = \mathrm{E}(Y_i(0) | A_i, W_i = 0) - \mathrm{E}(Y_i(0) | \mathrm{e(a)}, W_i = 1) + \mathrm{E}(Y_i(0) | \mathrm{e(a)}, W_i = 1) - \mathrm{E}(Y_i(1) \mid \mathrm{e(a)}, W_i \\ &\quad = 1) = \text{treatment effect} + \mathrm{E}(Y_i(0) | \mathrm{e(a)}, W_i = 0) - \mathrm{E}(Y_i(0) \mid \mathrm{e(a)}, W_i = 1) \end{aligned}$$

Because of the strong ignorability, $\mathrm{E}(Y_i(0)|\mathrm{e(a)}, W_i = 0) - \mathrm{E}(Y_i(0)\ |\mathrm{e(a)}, W_i = 1) = \mathrm{E}(Y_i(0)|\mathrm{e(a)}) - \mathrm{E}(Y_i(0)\ |\mathrm{e(a)}) = 0$, such that, treatment effect $= \mathrm{E}(Y_i(0) - Y_i(1)\ |\mathrm{e(a)}, W_i = 1) = \mathrm{E}(Y_i(0)|\mathrm{e(a)}, W_i = 0) - \mathrm{E}(Y_i(1)\ |\mathrm{e(a)}, W_i = 1)$.

Therefore, to calculate the treatment effect with PSM, we first estimate the "propensity score" $\mathrm{e(a)}$ based on the covariate $\boldsymbol{A_i}$. Then we match the route i in our treated group ($W_i = 1$) with one or several routes in the control group ($W_i = 0$) with similar "propensity score" $\mathrm{e(a)}$, and then to compare their airline entry outcomes Y_i.

We select the top 20 largest Chinese airports measured by scheduled seats as of year 2011 to generate a sample of potential routes with the major Central Asian airports. The central Asian airports are chosen with yearly scheduled seats over 100 thousand in year 2011 as well. A total 19 Central Asian airports meet this criteria. The lists of the selected Chinese and Central Asian airports are listed in Table 13.

Table 13. The list of selected Chinese and Central Asian airports to generate the 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		

With 20 Chinese airports and 19 Central Asian airports, a total of 342 sample routes were generated. Since our observations of the route entry are on the quarterly basis, quarterly airport throughput and HHI are used for matching. The 4th quarter of 2011 is chosen, during which only 9 routes among the 342 constructed routes actually had aviation services.

PSM allows us to find the most similar counterfactual route in the control group for each of our Central Asia-China routes. The propensity score is calculated by running a Probit model to measure the

probability of one OD pair to be a Central Asia- China route, based on the covariates chosen. Alternative PSM methods are used for matching.

We first use the routes to the former Soviet Union countries as our controlled group. Our entry model estimation shows that the barrier parameters for the Soviet Union countries are lower than other countries. This indicates a less restrictive bilateral ASAs. The "one nearest neighbour matching" pairs each of our "treated" routes with one "control" route with the closet propensity score. As shown in the Table 14, 278 out of the 342 "treated" routes (81.3% of the treated routes) are matched with the "control" routes with the airlines operation. The ATT (average treatment effect) on the entry status measures the average difference in the entry status (with an entry variable = 1 with route entered and =0 with route not entered) between the "treated" and the matched "control" routes. The "one nearest neighbour matching" shows the estimated ATT to be 0.78, which means that in the counterfactual, the "treated" routes on average will have 78% higher probability to be served by airlines. The "Two nearest neighbor matching" matches each "treated" route with two control routes that have the closest propensity score values. It produces very similar results as the "One nearest neighbor matching".

However, as shown in Figure 3, the propensity scores of the "treated" and "control" routes are not well overlapped. 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 thus conduct another "caliper matching" to restrict the matching is done within a narrow bin of nearby propensity score range. Austin (2011) and Lunt (2014) conduct Monte Carlo simulation and suggest that choosing 0.2 standard deviation of caliper produce the estimate with the smallest bias. With this specification, the treated routes that cannot be matched with any control routes within the 0.2 standard deviation of propensity scores will not be included. A total of 149 treated routes are matched. This suggests that the Chinese markets actually have great potential to explore if Central Asia can embrace a similarly liberalized aviation environment as routes to former Soviet Union countries.

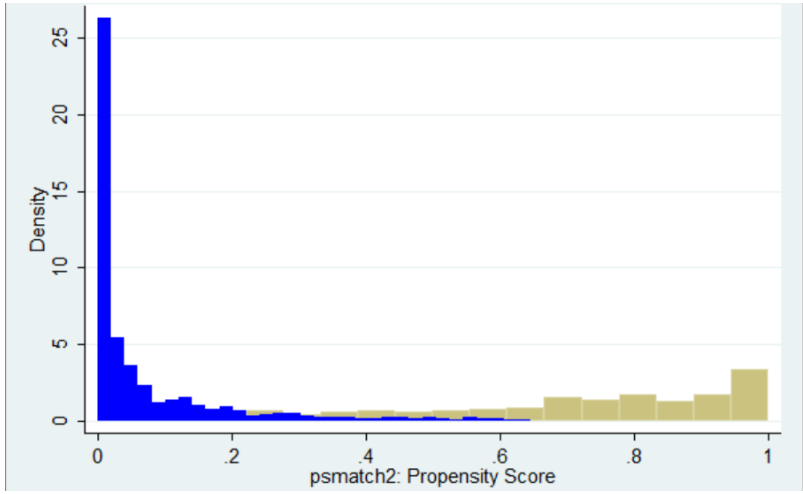
Due to the special economic and political ties among former Soviet Union countries, we also use the international routes other than those to former Soviet Union countries as our "control" group to identify the liberalization potential of Chinese routes. The results also suggest that the Chinese market has great potential. Even with restrictive Caliper matching, our results suggest that the probability of having aviation services will increase by 27% if regulation can be relaxed similar to the routes to countries other than former Soviet Union countries. This would lead to new aviation services to the city of Chengdu, Chongqing, Xi'an, Shanghai, Guangzhou, an increase of 167% compared to the case of three served Chinese cities (Urmuqi , Beijing and Sanya).

Table 14. The propensity score matching between our constructed routes to China and the "control" routes

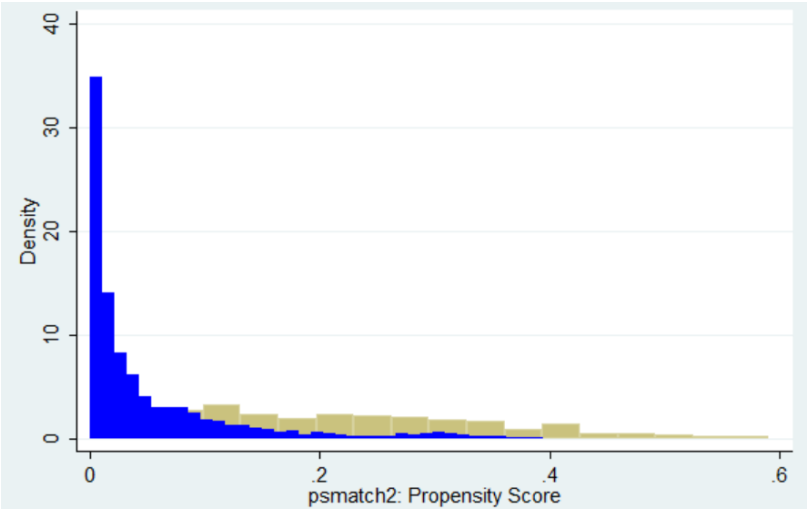
	Alternative matching criteria	# of treated routes matched	# of treated routes matched with controlled routes with airline entry	% of treated routes matched with controlled routes with airline entry	ATT (Average Treatment Effect)
Former Soviet Union Countries	**One nearest neighbour matching**	342	278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

Figure 3. The distribution of the propensity scores of the "treated routes" (in yellow color) and the "control routes" (in Blue color)

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



3(b) With the "control routes" set as the other international routes except the former Soviet Union countries



3.3 The demand and price equation estimations

This section estimates a system of demand and price equations for the Central Asia international routes, so that to reveal the market conditions with minimal econometric assumptions. The demand function is specified as in Eq. (5). $Yield_{ikft}$ is the average ticket price per kilometer on the route i at time t. $Dist_{ikf}$ is the flying distance of the route. $AirportSize_{ikft}$ is the geometric mean of airport passenger throughputs of the endpoint airports of the route i at time t. This airport size variable helps capture the market potential of the route, similar to population of endpoint cities, a control variable routinely used in Gravity models. $GDPCapita_{kft}$ is the geometric mean of GDP per capita of endpoint countries for the route i at time t. This variable measures the income level of the air travelers. $Origincountry_k$, $Destcountry_f$ are the origin and destination country dummy variables. $Quarter_t$ and $Year_t$ are the quarter and year dummies to capture the time trend. The continuous variables are taken logarithm.

$$\begin{aligned}\ln Pax_{ikft} = \vartheta_0 + \delta_1 \ln Yield_{ikft} + \vartheta_1 \ln Dist_{ikf} + \vartheta_2 \ln AirportSize_{ikft} + \vartheta_3 \ln GDPCapita_{kft} \\ + Origincountry_k \phi_1 + Destcountry_f \chi_1 + Quarter_t \Gamma_1 + Year_t \varpi_1 + \xi_{1i} + \eta_{1ikft}\end{aligned} \quad (5)$$

The price equation is specified as Eq. (6). Pax_{ikft} is the route passenger volume. $Dist_{ikf}$, the flying distance. $Fuelprice_{ikf}$, is the fuel price, expected to have a positive effect on airline yield. HHI_route_{ikf} is the route-level HHI index measuring airline competition condition. $HHI\_airport_{ikf}$ is the geometric mean of the HHI for the endpoint airports. The continuous variables are taken logarithm.

$$\begin{aligned}\ln Yield_{ikft} = \kappa_0 + \delta_2 \ln Pax_{ikft} + \kappa_1 \ln Dist_{ikf} + \kappa_2 \ln Fuelprice_{ikf} + \kappa_3 \ln HHI\_route_{ikf} + \kappa_4 \ln HHI\_airport_{ikf} + \boldsymbol{Origincountry_k \varphi_2} \\ + \boldsymbol{Destcountry_f \chi_2} + \boldsymbol{Quarter_t \Gamma_2} + \boldsymbol{Year_t \varpi_2} + \xi_{2i} + \eta_{2ikft}\end{aligned} \quad (6)$$

The error term in both demand and price equations have two components, ξ_i and η_{ikft}. ξ_i is the route specific time-invariant unobservable, and η_{ikft} are white noises. We assume ξ_i to be mean independent to the other control variables, a random effect model can thus be used to improve the estimation efficiency. It is possible that ξ_i is correlated to the other control variables. Thus, a fixed effect model is also tested to demean the equations to eliminate the error term ξ_i.

The demand Pax_{ikft}, and price $Yield_{ikft}$ variables are endogenous given their simultaneity relations. An equation-by-equation two stage least square (2SLS) estimation strategy is thus adopted. To estimate the demand equation, the variables $Fuelprice_{ikf}$, HHI_route_{ikf}, $HHI\_airport_{ikf}$ are used as instrument variables for the endogenous price variable $Yield_{ikft}$, as they are price determinants while excluded in the demand function. Similarly, to estimate the price equation, the variables $AirportSize_{ikft}$ and $GDPCapita_{kft}$ are used as instruments for the endogenous demand variable Pax_{ikft}, as they are demand determinants while not in the price equation.

We estimate the demand and price equations for the domestic and international markets respectively. For the international markets, we further consider the routes to the former Soviet Union countries and other countries, respectively.

PaxIS database of IATA offers us quarterly directional the airline-route specific ticket price and the passenger volume. We aggregate the airline specific data into route-level air ticket price and passenger volume. OAG (Official Airline Guide) also provides us with the airline-route level scheduled seats so that we can calculate the route HHI index to measure the route level airline competition. OAG data also supplements airlines' scheduled seats data in each airport, using which the airport size (total scheduled

seats) and the airport HHI index variables can be constructed. The route flying distance is from OAG whereas the GDP per capita data is retrieved from the World Bank database.
The airline route in our sample is defined as city-pair and directional[1]. For the international routes to a country outside Central Asian region, we are using the directional route originating from the Central Asian city to the foreign city. For the routes between two Central Asian cities, we have the data for both direction. We also rule out some very thin routes as they can be minor regional routes having very distinct demand and competition characters. This is done by excluding routes with quarterly passengers less than 3,600 [2].

The demand and price estimations are summarized in Table 15 and 16, respectively. The price elasticity of the domestic market is estimated as -1.644 by the fixed effect model, and -1.823 by the random effect model. For the international market, the price elasticity is estimated as -1.891 by the fixed effect model, and -1.407 by the random effect model. Brons et al. (2002) conduct a meta-analysis investigating and summarizing a total of 37 studies in the past decades in which one or more price elasticities for passenger air travel were estimated, the mean elasticity is found to be 1.15. Oum et al. (1992) conduct survey of aviation transport price elasticity, and find the range is between 0.8 to 2.0. Our estimation show that the domestic air travel and travel to foreign countries other than former Soviet Union countries are very elastic. The estimations for other demand characters are also reasonable. However, the estimated price elasticity for routes to former Soviet Union countries is significantly positive. This unexpected result may indicate our demand specifications may not well fit the airline market to the Soviet Union countries, which are probably influenced by factors beyond economic considerations. Caution should be used for the analysis of the markets to the former Soviet Union countries.

Table 15. Demand equation 2SLS estimations for the different market segments

	Domestic		International		Former Soviet Union	
	FE	RE	FE	RE	FE	RE
Yield	-1.644***	-1.823***	-1.891**	-1.407*	1.372***	1.896***
	(0.413)	(0.436)	(0.872)	(0.783)	(0.372)	(0.441)
Distance		-1.053***		-0.975**		1.353***
		(0.296)		(0.461)		(0.436)
Airport Size	1.156***	1.022***	0.632***	0.424**	1.044***	0.981***
	(0.061)	(0.058)	(0.236)	(0.178)	(0.074)	(0.069)
GDP per capita	0.637***	0.638***	0.786**	0.619**	-0.509**	-0.543**
	(0.216)	(0.226)	(0.341)	(0.307)	(0.242)	(0.274)
Constant	-12.030***	-4.175**	-10.455	3.117	1.658	-7.572**
	(2.751)	(1.657)	(7.402)	(2.798)	(2.293)	(3.738)
Quarter and year effects	✓	✓	✓	✓	✓	✓
Country effects	✓	✓	✓	✓	✓	✓
No. of Obs	2,108	2,108	999	999	1,356	1,356

Note: "Domestic" routes include both the domestic routes and the routes between two Central Asian countries. "International" refers to the routes to the foreign countries outside Central Asia, except the

[1] The data for the four international airports in Moscow are combined (Domodedovo International airport, Sheremetyevo International airport, Vnukovo International airport, Zhukovsky International airport).

[2] Suppose that for the route, there are at least three flights per week using a 150 seat aircraft (single-aisle aircraft) with 66% load factor (100 passengers), this requirement is equal to a minimum about 3,600 passenger for one quarter. This criterion can also help eliminate some routes with the unregular charter flights.

former Soviet Union countries. "Former Soviet Union" refers to the routes to the former Soviet Union countries. FE and RE stand for Fixed-effect and Random-effect models. *, **, *** stand for 10%, 5% and 1% significance levels. The same notes apply to other demand and price estimations.

Table 16. Price equation 2SLS estimations for the different market segments

	Domestic		International		Former Soviet Union	
	FE	RE	FE	RE	FE	RE
Passenger volume	0.018	0.049**	0.515	0.505	-0.051	-0.070**
	(0.026)	(0.022)	(0.328)	(0.321)	(0.039)	(0.028)
Distance		-0.589***		-0.392		-0.920***
		(0.021)		(0.378)		(0.044)
Fuel price	0.118***	0.113***	0.116*	0.117**	0.076**	0.080**
	(0.025)	(0.025)	(0.061)	(0.059)	(0.036)	(0.036)
Route HHI	0.043*	0.078***	0.281	0.274	-0.066**	-0.071***
	(0.026)	(0.020)	(0.188)	(0.184)	(0.031)	(0.025)
Airport HHI	-0.153***	-0.166***	-0.055	-0.054	0.185***	0.150***
	(0.026)	(0.023)	(0.064)	(0.063)	(0.030)	(0.025)
Constant	-0.830	2.677***	-8.524*	-4.976	-2.011***	5.674***
	(0.417)	(0.330)	(4.576)	(5.232)	(0.590)	(0.456)
Quarter and year effects	✓	✓	✓	✓	✓	✓
Country effects	✓	✓	✓	✓	✓	✓
No. of Obs	2,108	2,108	999	999	1,356	1,356

4.0 Conclusions and recommendations

Air transportation is of critical importance to a country's economy and consumer wellbeing. This study analyzes aviation markets in land-locked countries in Central Asia, namely Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan, and Kyrgyzstan. In these countries, there is no close substitute for the air travel mode due to the tyranny of distance. Although international aviation services in these countries had achieved substantial growth in the past decade, restrictive regulations remain in many markets, which could have prevented stake-holders to enjoy the full benefits that could have been brought by improved air connectivity and aviation services. Substantial benefits may be achieved if more liberal aviation policies are introduced, such as those proposed by the OBOR initiative.

In order to facilitate the formation of related public policies, this study analyzes the international aviation market in Central Asia so that the market characteristics can be identified and possible market outcomes can be predicted for alternative liberalization scenarios. Our investigation suggests that although the Central Asia – China markets are featured with poor connectivity and high airfares, great benefits can be achieved through aviation liberalization. In particular, our counter-factual analysis suggests that if the Central Asia – China markets can be regulated and operated under similar circumstances as these routes between Central Asia and other non-former Soviet Union states, the probability of having aviation services between cities in China and Central Asia will increase by 27% even with conservative estimates. The

number of destinations in China can increase by more than 150%, with Chengdu, Chongqing, Xi'an, Shanghai and Guangzhou to be added in addition to the three cities that are currently served (i.e., Urmuqi , Beijing and Sanya).[3] Such predictions are further confirmed with our demand and price estimations, which suggest that the aviation demands in Central Asia tend to be quite elastic. That is, traffic volumes are expected to grow substantially if prices were reduced. Such findings are consistent with previous studies on air transport liberalization, which have found strong evidence that air liberalization improves airlines' operational efficiency and market competition, which generally leads to reduced airfares and increased service quality and traffic volumes.

Our results suggest that the OBOR initiative has had limited effects on the international aviation market between Central Asia and China until now, while we found a great potential for liberalization policies promoting air connectivity and airline competition. Stakeholders in the countries involved, including airlines, airports, tourism and hotel industries, freight-forwards, logistics providers should work together to push forward the policy targets set for the aviation industry.

[3] If regulation and operation conditions on the routes to China can be comparable to those routes linking Central Asia to former Soviet Union countries, substantially higher traffic growth and connectivity can be expected by liberalization policy. However, we think such scenarios are over-optimistic because the strong political, cultural and economic ties between Central Asian countries to former Soviet Union states are unlikely to be established in the short term by any industrial policies.

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Annexes

Annex 1. WTO's classification of ASAs.

Table A1. Types of Bilateral Air Services Agreements by WTO

Type	Freedoms	Designation	Withholding/ownership	Tariffs	Capacity	Number of ASAs	Traffic covered
A	3rd and 4th	Single designation	Substantive ownership and effective control	Double approval	Pre-determination	221 (11.2%)	18.4 m (5.3%)
B	3rd and 4th	Multi-designation	Substantive ownership and effective control	Double approval	Pre-determination	182 (9.2%)	19.7 m (5.6%)
C	3rd,4th,5th	Single designation	Substantive ownership and effective control	Double approval	Pre-determination	432 (21.9%)	30.2 m (8.7%)
D	3rd,4th,5th	Single designation	Substantive ownership and effective control	Double approval	Bermuda I	99 (5.0%)	10.4 m (3.0%)
E	3rd,4th,5th	Multi-designation	Substantive ownership and effective control	Double approval	Pre-determination	267 (13.6%)	43 m (12.3%)
F	3rd,4th,5th	Multi-designation	Substantive ownership and effective control	Double approval	Bermuda I	154 (7.8%)	71.1 m (20.4%)
G	3rd,4th,5th	Multi-designation	Substantive ownership and effective control *or* Community of interest *or* Principal place of business	Free pricing *or* Double disapproval	Free determination	69 (3.5%)	58 m (16.6%)
i Incomplete ICAO coding	*If either:*		"n/a"	"n/a"	"other"	302 (15.3%)	56 m (16.0%)
o All other combinations						244 (12.4%)	41.8 m (12%)

Annex 2. Estimation results for Central Asian airlines

Table A2(a). The 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***	UK	-8.962***
Korea	-7.307***	France	-9.679***
Germany	-7.593***	China	-10.278***
UK	-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: # stands for the destination countries only with foreign airlines' operation. Since the entry of Central Asia airlines are estimated, and there is no variation of entry on these routes, the entry barrier parameters are not identified for these "#" countries.
* represents the 10% significance level; ** represents the 5% significance level; *** represents the 1% significance level.

Table A2(b). The 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
UK	-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: # stands for the destination countries only with foreign airlines' operation. Since the entry of Central Asia airlines are estimated, and there is no variation of entry on these routes, the entry barrier parameters are not identified for these "#" countries.
* represents the 10% significance level; ** represents the 5% significance level; *** represents the 1% significance level.

Table A2(c). The Estimated Barrier Parameters for the 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: # stands for the destination countries only with foreign airlines' operation. Since the entry of Central Asia airlines are estimated, and there is no variation of entry on these routes, the entry barrier parameters are not identified for these "#" countries.
* represents the 10% significance level; ** represents the 5% significance level; *** represents the 1% significance level.

Table A2(d). The Estimated Barrier Parameters for the 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: # stands for the destination countries only with foreign airlines' operation. Since the entry of Central Asia airlines are estimated, and there is no variation of entry on these routes, the entry barrier parameters are not identified for these "#" countries.
* represents the 10% significance level; ** represents the 5% significance level; *** represents the 1% significance level.

Table A2(e). The Estimated Barrier Parameters for the Turkmenistan Carriers

Country/Region	Barrier Parameters (T5)
Central Asian	-8.932***
Germany	2.255
India	1.55
UK	-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: # stands for the destination countries only with foreign airlines' operation. Since the entry of Central Asia airlines are estimated, and there is no variation of entry on these routes, the entry barrier parameters are not identified for these "#" countries.
* represents the 10% significance level; ** represents the 5% significance level; *** represents the 1% significance level.