（Preliminary draft; results may change. Comments are very welcome!）

# Fly to Trade: Effects of International Direct Flights on Chinese Cities' Trade

Linfeng Wang
wanglf@stu.xmu.edu.cn

Shihe Fu
fushihe@xmu.edu.cn

Wang Yanan Institute for Economics Studies (WISE)
Xiamen University
P.R. China

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## Abstract

This paper estimates the causal effect of international direct flights on cities' international trade, using Chinese customs transaction-level trade data and flight route data from 2000 to 2015 and a staggered differences-in-differences approach. On average a Chinese city's exports to a destination country (imports from a source country) increase by 12.8% (10.4%) after a direct flight route is launched between the city and the country. This positive effect is stronger for the industries with high face-to-face communication intensity and high contract intensity, suggesting that international direct flights reduce cost of international trips and promote face-to-face interactions among international business people.

Key words: International direct flight; international trade; face-to-face communication; urban growth

JEL Code: F14, R11, R41

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## 1. Introduction

Even with the rapid development of information and communication technologies over the past few decades, exporting products to a foreign country still requires long-distance face-to-face communications, and therefore, international business travels (Cristea, 2011). International direct flights from a city to another international city can reduce substantially the international travel costs, facilitate face-to-face interactions among international business people, and therefore promote international business transactions. This paper estimates the causal effect of launching international direct flights in Chinese cities on cities' trade with destination countries. Using a staggered differences-in-differences approach with a rich set of fixed effects to control for confounding factors, we find that after a Chinese city connects with a foreign country via direct flight, the city's exports to that country increases by 12.8% relative to the period before; imports from that country increases by 10.4%. We provide suggestive evidence that this is due to international direct flights facilitating cross-border face-to-face communications and therefore international business transactions: exports of industries with high face-to-face communication intensity and high contract intensity increase more due to direct flights. Our study contributes to the literature on the effect of transport infrastructure on urban growth and on the determinants of international trade.

Many empirical studies have identified the important roles of airports and international direct flights in city growth, foreign direct investment (FDI), location choice of firms, but only a few have estimated directly the effects on international trade. Brueckner (2003) finds that airline traffic (total passenger enplanement) in US cities promotes urban employment, with an elasticity of 0.1, but only for service industries, not for manufacturing industries, suggesting that air travel promotes long-distance face-to-face communications. Bel and Fageda (2008) find that European cities that operate international flights are more successful in attracting headquarters of large firms. Campante and Yanagizawa-Drott (2016) find that connecting with other international cities via nonstop international flights generates local economic growth (measured by night light coverage) and facilitates capital flowing from high- to low-income countries. Since capital flow does not directly depend on air travel, they infer that reducing international travel costs promotes face-to-face communications across countries.

International flights can also help reduce trade costs (measured by maximum price differences between traded input prices across cities) for both international and domestic city pairs (Yilmazkuday, 2017). Alderighi and Gaggero (2017) estimate that airport services are positively associated with exports of Italian manufacturing firms to EU. We examine the effect of launching international direct flights in a Chinese city on that city's trade with destination countries and carefully identify the causal link.

The main channel through which international direct flights promote trade is that international direct flights (particularly, nonstop flights) reduce significantly the cost of long-distance travel and face-to-face meeting. Although with rapid development of information and communication technologies, online communications such as emails, online chat, video conference become more prevalent, in-person face-to-face communications are still important. Theoretically, face-to-face and online communications can be complements (Gaspar and Glaeser, 1998). In reality, studies find that high-tech firms that use more online meetings also spend more on air tickets (Van Geenhuizen and Doornbos, 2007)

As more products become knowledge or R&D intensive, international trade increasingly relies on the transmission and exchange of complex information, often realized efficiently via face-to-face communications; this makes international business travel as necessary input to exports (Poole, 2016; Belenkiy and Riker, 2012). Cristea (2011) provide evidence that demand for business-class air travel is directly related to volume and composition of exports in USA. Other studies find that international business trips promote innovation measured by patent applications (Hovhannisyan and Keller, 2015), implying that international travel promotes scientific collaboration across countries. Although we are unable to provide direct evidence that international direct flights promote long-distance face-to-face communications, we provide indirect evidence. We find that industries with high face-to-face communication intensity and high contract intensity increases exports more with the launching of direct flights.

Our study also contributes the literature on trade and urban growth. Cities grow through the export multiplier effect and constantly developing new products and industries. Xu and Zhang (2021) estimate a structural trade model and show that a one million *yuan* increase in gross exports in China creates 5.8 jobs; for every 100 new jobs in the tradable sector, 77 new jobs are created in the non-tradable sector. Assuming this multiplier effect holds for Chinese cities, launching a direct flight to an export destination country can boost a city's exports by 67.6 million yuan (75 million$*7*12.8%) and therefore increase 392 jobs annually in that city. (review more related trade literature, to be done.)

The rest of the paper is organized as follows: Section 2 introduces the data; Section 3 specify the econometric models and discusses the causal identification issues; Section 4 presents the results; Section 5 provides some suggestive evidence to test the channels through which international direct flights promote face-to-face communications and therefore international trade; and Section 6 concludes.

## 2. Data

### 2.1 Direct flight routes

We collect manually the data for international airline routes between Chinese cities and global cities for the period 2000~2015 from various online sources: the news announcement of new international flight routes released by the Civil Aviation

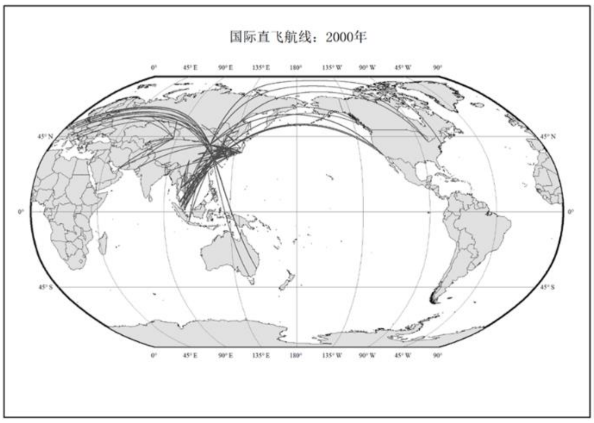
Administration of China (CAAC) (http://www.caac.gov.cn/index.html), the news network of the CAAC (http://www.caacnews.com.cn ), and the Civil Aviation Resource Network of China (http://www.carnoc.com). A direct flight refers to a flight between two cities (airports) with a single flight number. It can be a nonstop flight, or it can involve one or more stops en-route to pick up or offload passengers, or for technical reasons such as refueling. Passengers taking a direct flight do not need to change airplanes although the aircraft may stop on the route.[1] In our research setting, a direct flight route is defined as a pair of a Chinese city (airport) and a foreign city (airport) between which aircrafts fly directly and regularly (excluding chartered planes) between the departure airport and the destination airport without a stop or with only technical stops, regardless of airlines in operation.

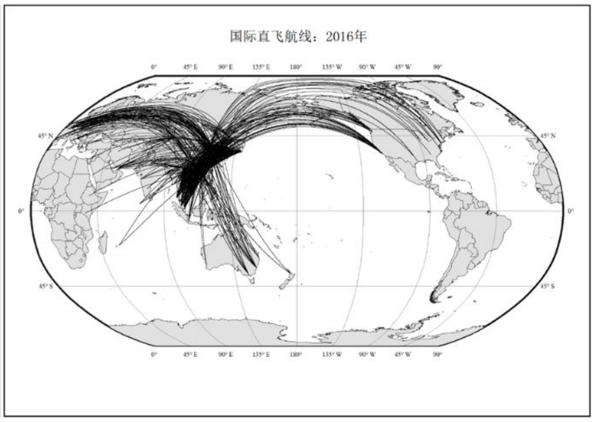
Two examples help illustrate a direct flight route from a Chinese city to a foreign city. United Airline launched the nonstop, direct flight between San Francisco and Chengdu in 2014; China Eastern Airline launched the one-stop, direct flight between Chengdu and Los Angeles via Shanghai in 2005. Both are direct flights between Chengdu and the USA and are counted as two different direct flight routes between Chengdu and the USA because of the two different U.S. destination cities. In 2004, Singapore Airline launched a nonstop, direct flight from Shenzhen to Singapore, and Shandong Airline launched a one-stop, direct flight from Shenzhen to Singapore via Qingdao; both are counted as the same direct flight route in our setting because the city pair is the same. In our sample, most of the direct flights are nonstop; roughly 11% of the direct flights have one stop en-route.

As many airlines use a hub-spoke network to route their airplane traffic, there can be many routes flying from a Chinese city to a foreign city via multiple connecting points or connecting flights with changing flight numbers. However, direct international flights are preferred by international travelers because of time saving and reduced uncertainty and complication. Direct flights do not require waiting time for connecting intermediate flights or going through the customs and immigration at the connecting airports, and the travel distance is shorter than indirect flights. There is no risk of missing connecting flights due to delay of the precedent flights and no complications of luggage transfer (Fuji et al., 1992).

International air travel has been increasing rapidly during the past two decades in China. The number of cities with international direct flights has increased from 20 in 2000 to 58 in 2015; and the number of international direct flight routes increased accumulatively from 101 to 684 during the same period. Figures 1 and 2 show the network of international direct flight routes originated from Chinese cities in 2000 and 2016, respectively.

[1] In some cases, a direct flight can involve a change of aircraft.




(Insert Figure 1, Figure 2 here)

### 2.2 International trade data

Our data for Chinese cities' exports to and imports from other countries are aggregated based on the Chinese customs transaction-level trade data from 2000 to 2015, provided by the China Custom with restricted access. The data contain the nominal dollar value, quantity, and price of exports (imports) at the product level to each destination (from each source) country by Chinese firms. A product is defined at the HS eight-digit code level.[2] This dataset has been widely used in many empirical studies related to China's international trade (for example, Khandelwal et al., 2013; Kee and Tang, 2016; Bai et al., 2016).

For our research purpose, we count the annual total value of exports (imports) of each Chinese city to each destination (from each source) country. For some models, we also count the annual total value of exports (imports) by city, industry, and country. The industry is identified by matching an HS six-digit code with a two-digit China's industrial classification code (GB/T4754-2002). In our sample there are about 8000 products in terms of eight-digit HS code and 36 two-digit manufacturing industries.

### 2.3 Other data sources

To control for the factors that could affect both a city's international trade and the launching of international direct flight route, we construct a set of city and country characteristic variables. The city level variables include total GDP, GDP per capita,

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[2] HS stands for Harmonized System (the full name is Harmonized Commodity Description and Coding System). It is developed by the World Customs Organization (WCO) as a multipurpose international product nomenclature and covers more than 98% of goods in international trade. The HS has six-digit identification code but a country can add more digits after the first six digits. HS is used by more than 200 countries and economies as a basis for their customs duties and international trade statistics. See www.wcoomd.org/en/topics/nomenclature/overview/what-is-the-harmonized-system.aspx.

foreign direct investment, share of industrial GDP in a city. In some model specifications we also include number of international tourists, number of star hotels, and total revenues from international tourists. The data are from the China Urban Statistical Yearbook of each year.

Export destination (import source) country variables include GDP, GDP per capita, ratio of trade account balance to GDP, and trade dependence ratio (ratio of trade volume to GDP); the data are from World Development Indicators database provided by the World Bank.[3]

Our observation is at the city-country-year level and for some models, at the city-country-industry-year level. Appendix Table A1 presents the summary statistics of the key variables used in our estimation.

## 3. Model specification and causal identification issues

To estimate the effect of international direct flights on a Chinese city's exports, we specify the following baseline model:

$$\ln(Export_{ict}) = \beta_0 + \beta_1 DF_{ict} + \beta_2 X_{it} + \beta_3 X_{ct} + \tau_{ic} + \tau_t + \varepsilon_{ict}. \quad (1)$$

The outcome variable $\ln(Export_{ict})$ is the logarithmic of total export value of city *i* to destination country *c* in year *t*. The treatment variable $DF_{ict}$ is a dummy variable set to one if in year *t* city *i* has launched at least one direct flight route to country *c* and zero otherwise. In some models, we use the number of direct flight routes between city *i* and country *c* to measure the treatment intensity. $X_{it}$ is a vector of time-varying city characteristic variables including total GDP, GDP per capita, share of manufacturing industry GDP, and FDI-GDP ratio. Similarly, $X_{ct}$ is time-varying destination country characteristic variables, including total GDP, GDP per capita, ratio of current account trade balance to GDP, trade dependence ratio. $\tau_{ic}$ is city-destination-country pair fixed effect and $\tau_t$ year fixed effect. $\varepsilon_{ict}$ is the error term and is likely not independently and not identically distributed. $\beta_i$'s are the coefficient vectors to be estimated. The key coefficient of interest is $\beta_1$, the effect of launching international direct flights on city exports, conditioning on other controls.

In estimating the causal effect of international direct flights on city exports using model (1), two identification issues may arise. The first is omitted variables or confounding factors that correlate with both DF and exports. These could include a city's economic growth potential, the destination country's demand for foreign goods, business and cultural connections between a city and a destination country, and global shocks. To control for these confounding factors, we add city and country level time-varying control variables ($X_{it}$ and $X_{ct}$) and a set of fixed effects including city-country pair

[3] The web link is https://databank.worldbank.org/source/world-development-indicators.

fixed effects and year fixed effects, capturing city-country specific time-unvarying factors and year-specific global shocks. These time-varying controls can also capture group-specific trend if the differential trends can be accounted for by a linear model in changes of these controls.

The second is the selection issue: obviously, international direct flights are not assigned randomly to cities. First, an airport must meet some technical standards to qualify for international flights, including quality of airport runways, customs and immigration. Second, whether an international flight route can be approved or not may depend on the diplomatic negotiation on air service agreement between two countries as well as the approval of civil aviation authorities. For example, China and the USA signed the bilateral Air Service Agreement in 1980 and launched two indirect flight routes; the two countries made six amendments in 1982, 1992, 1995, 1999, 2004, and 2007, resulting in phase-in deregulation and liberalization of aviation markets, improved China-US aviation relationship and resulted in substantial passenger and air cargo growth (Lei et al., 2016). Third, the decision to launch an international direct flight by an airline may also depend on other city, city-country characteristics, constant or time-varying. For example, a city with growing international trade or international tourists can generate enough demand for international trips and therefore attract airline to set up new routes. This leads to a "reverse causality" issue in that international flights depend on city economic performance including international trade.

To deal with the selection issue, we use three strategies. First, we exclude the cities that never have had an international direct flight route. They cannot serve as a good control group because they are affected by the nearby cities with direct flight routes, through the spatial spillover or "borrowing size" effects. We keep only cities that have had at least one international direct flight route by 2015. Since all these cities have launched direct flights at some point of time between 2000 and 2015, they are more comparable than those without direct flights. This creates a staggered differences-in-differences (DID) setting with reduced heterogeneity treatment effects (heterogenous treatment effects across groups and time may still exist and we discuss this shortly).

Second, in addition to the city-country pair fixed effects and year dummies, we further add city-, country-, or city-country-specific linear trend to capture unobserved time-varying confounding factors. This is very demanding for the data because the city-country pair-specific trend absorbs part of the variation in the treatment variable. Third, there is no easy way to deal with the reverse causality issue in our setting. We add lagged number of international tourists, revenues from tourism industry, and number of star hotels in a city to attenuate the correlation between DF and past exports.

The specification of model (1) is a DID model with variation in treatment timing or with staggered adoption of treatment. The coefficient $\beta_1$ can be identified as a causal effect only if the treatment effect is constant across groups and over time conditioning on the controls. This is unlikely to hold. The recent econometric literature on DID shows that in the staggered DID setting, the two-way fixed effect estimator is a weighted sum of the average treatment effects in each group and period, where the weights depend on the group size and the variance of their treatment and can be negative (Athey and Imbens, 2021; de Chaisemartin and D'Haultfoeuille, 2020; Goodman-Bacon, 2021). The heterogeneous treatment effects across groups and over time and the negative weights can bias the estimate of $\beta_1$ or even reverse sign. de Chaisemartin and D'Haultfoeuille (2020) provide a formal test to gauge the degree of heterogeneity in average treatment effects across groups and time periods: the ratio of the absolute value of $\beta_1$ to the standard deviation of the weights. [4] We also perform this test for our model specifications.

In estimating model (1), we cluster the standard error at the city-country pair level to allow for serial correlation within a city-country pair.

## 4. Results

### 4.1 Effects on city exports

This subsection reports a set of results of estimating different versions of model (1): the effect of international direct flights on Chinese cities' exports, various robustness checks, and the spatial spillover effects. We summarize briefly the results of the effects on a city's imports and trade dependence in the next two subsections.

#### 4.1.1 Baseline results

Table 1 presents the baseline results from different specifications of model (1). Column (1) is the standard two-way fixed effects model with city-country pair and year fixed effects and without any controls. The coefficient of direct flight dummy variable (the treatment effect) is -0.101 and statistically significant at the 5% level. This does not necessarily mean that the average treatment effect (ATE) is negative. The coefficient of DF can be interpreted as the weighted sum of average treatment effects in each group and period since model (1) is a staggered DID setting. For a city that launched a direct flight route to a country in a certain year, this city and other countries between which no direct flight route has been launched (never treated) serve as the control group; in addition, any other city that launched direct flight to the same destination country in a later year (later treated) also serve as control group. Similarly, for a later-treated city, the earlier-treated city-country pairs also serve as control group. Negative weights are more likely to be assigned to groups treated for many periods or periods when a large share of groups is treated (de Chaisemartin and D'Haultfoeuille, 2020), which may lead to sign reverse of the weighted sum of ATEs. To gauge the degree of heterogeneities of the ATEs across groups and years, we conduct a test proposed by de Chaisemartin and D'Haultfoeuille (2020).

[4] They developed the STATA command "twowayfeweights" to performs this test.

Under the common trends assumption, Column 1 estimates a weighted sum of 3406 average treatment effects of the treated (ATTs), among which 2749 ATTs receive a positive weight and 657 receive a negative weight. The sum of the negative weights is equal to -.0069, although the magnitude is not big, the calculated measures of the robustness of the treatment coefficient to treatment heterogeneity across groups and over time is 0.09, meaning that the estimated coefficient and the ATT can be of opposite signs when the minimal value of the standard deviation of the treatment effect across the treated groups and time periods is as small as 0.09. This suggests the treatment effect heterogeneity is of a concern.

Common controls strategies are group-specific linear time trends, region-by-year fixed effects, and time-varying group level controls. Column 2 of Table 1 includes city-country-pair specific linear time trend. The treatment effect now becomes positive (0.174) and significant at the 1% level. This confirms that group-specific linear trends help absorb some treatment heterogeneity across groups and periods. Columns 3-5 further adds a few time-varying city level and country level controls and continent-by-year fixed effects, respectively, and the coefficients of DF attenuate somewhat but are still statistically significant at the 1% level. Column 6 replace country-level controls by country-by-year fixed effects and Column 7 replace city-level controls by city-by-year fixed effects, as these fixed effects tend to over control time-varying treatment effects, the coefficient of DF continue to attenuate and lose significance. Column (4) is our preferred specification since the model includes a set of city and country level time-varying controls as well as city-country pair specific time trend. A Chinese city's exports to a destination country on average increases by 12.8% after it launches a direct flight route to that destination country compared with the period before. This is very economically significant. Evaluate at the mean value of city exports in the full sample, $75.4 million, and assume an exchange rate of 7, this amounts to 67.6 million *yuan* boost in exports annually after a direct flight is launched. Using Xu and Zhang (2021)'s estimates that a one million *yuan* increase in gross exports in China creates 5.8 jobs and assuming this multiplier effect holds for Chinese cities, launching a direct flight to an export destination country can create 392 new jobs annually in that city.

(Insert Table 1 here)

Table 1 Baseline results

| | Dependent Variable: Ln(City export) | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| DF | -0.101* | 0.174*** | 0.143*** | 0.128*** | 0.114*** | 0.096** | 0.068† |
| | (0.056) | (0.047) | (0.045) | (0.043) | (0.042) | (0.042) | (0.041) |
| City GDP | | | 0.172 | 0.036 | 0.033 | 0.172* | |
| | | | (0.109) | (0.115) | (0.115) | (0.104) | |
| City GDP per capita | | | -0.007 | 0.079 | 0.081 | 0.019 | |
| | | | (0.083) | (0.086) | (0.086) | (0.079) | |
| Manuf. share | | | 0.010*** | 0.012*** | 0.012*** | 0.010*** | |

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | | | (0.002) | (0.002) | (0.002) | (0.002) | |
| FDI/GDP | | | -0.016*** | -0.014*** | -0.015*** | -0.016*** | |
| | | | (0.003) | (0.003) | (0.003) | (0.003) | |
| Country GDP per capita | | | | 0.604*** | 0.582*** | | 0.603*** |
| | | | | (0.049) | (0.054) | | (0.046) |
| Country GDP | | | | 1.030*** | 1.033*** | | 1.034*** |
| | | | | (0.121) | (0.124) | | (0.111) |
| Current acc. balance | | | | -0.009*** | -0.008*** | | -0.009*** |
| | | | | (0.001) | (0.001) | | (0.001) |
| Trade dependence | | | | 0.003*** | 0.003*** | | 0.004*** |
| | | | | (0.001) | (0.001) | | (0.001) |
| City-Country FE | √ | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ | √ |
| City-Country×Trend | | √ | √ | √ | √ | √ | √ |
| Continent × Year FE | | | | | √ | | |
| Country ×Year FE | | | | | | √ | |
| City × Year FE | | | | | | | √ |
| Adj. $R^2$ | 0.888 | 0.892 | 0.894 | 0.894 | 0.896 | 0.901 | 0.901 |
| Obs. | 135,338 | 128,740 | 122,818 | 122,818 | 121,490 | 110,475 | 106,459 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively. †means p-value equals to 0.101.

Our sample includes cities that have had at least one international direct flight route and all their international trade partners. However, 96.4% of city-destination country pairs are "never treated." The large proportion of "never treated" groups are likely very different than those "eventually treated". We drop the city-country pairs that are never treated and re-estimate the models in Table 1. The results are presented in Table 2. Overall the pattern of the coefficients of DF are very similar to that of Table 1 with slight attenuation in the magnitude except Column (1). The standard two-way fixed effect model for this sample generates a large positive treatment effect, suggesting that dropping "never treated" groups reduces heterogeneity significantly. We also experiment dropping a small number of "always treated" groups (cities that had international direct flights before 2000) and the results are almost identical to those of Table 2. To be conservative, we use the baseline sample for Table 1 models in the rest of the paper.

(insert Table 2 here)

**Table 2** Excluding never-treated city-country pairs

| | Dependent Variable：Ln(City export) | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| DF | 0.268*** | 0.135*** | 0.108** | 0.095** | 0.095** | 0.098** | 0.045 |
| | (0.055) | (0.046) | (0.044) | (0.041) | (0.042) | (0.043) | (0.042) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| City Controls | | | √ | √ | √ | √ | |
| Country Controls | | | | √ | √ | | √ |
| City-Country FE | √ | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ | √ |
| City-Country*Trend | | √ | √ | √ | √ | √ | √ |
| Continent * Year FE | | | | | √ | | |
| Country * Year FE | | | | | | √ | |
| City * Year FE | | | | | | | √ |
| Adj. $R^2$ | 0.910 | 0.947 | 0.952 | 0.954 | 0.954 | 0.958 | 0.958 |
| Obs. | 6,184 | 6,184 | 5,970 | 5,736 | 5,736 | 5,775 | 5,790 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

### 4.1.2: Robustness check

We conduct two robustness checks. First, we replace the binary treatment dummy variable DF by the treatment intensity, the number of international direct flight routes operating in a given year between a city-country pair. Table 3 reports the results where the columns parallel to those in Table 1. Not surprisingly, the pattern of the results is very similar to that of Table 1.[5] Our preferred estimate (Column 4) shows that launching a new international direct flight route to a country increases the city's exports to that country by an additional 11.5% relative to the period before.

(Insert Table 3 here)

**Table 3** Treatment intensity

| | Dependent Variable：Ln(City export) | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Num. of DF Routes | -0.154*** | 0.138*** | 0.120*** | 0.115*** | 0.099*** | 0.068*** | 0.078*** |
| | (0.028) | (0.026) | (0.025) | (0.025) | (0.024) | (0.025) | (0.026) |
| City Controls | | | √ | √ | √ | √ | |
| Country Controls | | | | √ | √ | | √ |
| City-Country FE | √ | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ | √ |
| City-Country*Trend | | √ | √ | √ | √ | √ | √ |
| Continent * Year FE | | | | | √ | | |
| Country * Year FE | | | | | | √ | |
| City * Year FE | | | | | | | √ |
| Adj. $R^2$ | 0.852 | 0.888 | 0.893 | 0.901 | 0.902 | 0.900 | 0.908 |
| Obs. | 135,338 | 135,338 | 129,174 | 106,459 | 106,459 | 129,167 | 111,552 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

[5] The correlation between the DF dummy and the number of routes is 0.78 for the baseline sample and 0.65 if "never treated" groups are excluded.

The second robustness check addresses the potential reverse causality concern that the decision to launch an international direct flight route may depend on the demand for international travel in the previous years in a city. Due to data availability, we collect data for the annual total number of international tourists and the total revenue from international tourists in each city without detailed country of origin. We also collect data for the number of star hotels in each city. We interact lagged one-year value of these three variables with the destination country to add more variations and include each of them in our preferred specification. Columns (1), (3), and (5) of Table 4 report the results. In addition, we experiment interact the initial year (1999) of travel demand proxy with destination country and linear trend and include each of them in the model. Columns (2), (4), and (6) of Table 4 report the results. Overall the estimated coefficients are very similar and stable: the effect of launching international direct flight route on city exports ranges between 10% and 12.5%.

(Insert Table 4 here)

**Table** 4 Control for previous air travel demand

| | Dependent Variable：Ln(City export) | | | | | |
|---|---|---|---|---|---|---|
| | #Tourists | | Tourism revenue($) | | #Starhotels | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| DF | 0.102** | 0.123*** | 0.104** | 0.124*** | 0.109** | 0.125*** |
| | (0.043) | (0.043) | (0.043) | (0.043) | (0.043) | (0.045) |
| Controls | √ | √ | √ | √ | √ | √ |
| City-Country FE | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ |
| City-Country*Trend | √ | √ | √ | √ | √ | √ |
| L.#Tourists*Country | √ | | | | | |
| L.Revenue* Country | | | √ | | | |
| L.#Starhotels* Country | | | | | √ | |
| #Tourists 1999*Country*Trend | | √ | | | | |
| Revenue 1999*Country*Trend | | | | √ | | |
| #Starhotels 1999*Country*Trend | | | | | | √ |
| Adj. $R^2$ | 0.907 | 0.902 | 0.906 | 0.901 | 0.909 | 0.899 |
| Obs. | 99,511 | 103,720 | 99,992 | 106,036 | 93,482 | 99,069 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

### 4.1.3 Dynamic effect

The previous model specification allows for time-varying treatment effect within a group. To better visualize the dynamic effect of launching an international direct flight route, we estimate the following model using a five-year window before and after the inauguration year of direct flight route between a city and a destination country pair:

$$Ln(Export_{ict}) = \beta_0 + \sum_{j=-5}^{5} \delta_j D_{ict}^{j} + \beta_2 X_{it} + \beta_3 X_{ct} + \gamma_{ic} + \tau_t + TR_{ic} + \varepsilon_{ict}, \quad (2)$$

where $D_{ict}^{j}$ equals one for city-destination country pair in $j$th year before (after) the inauguration of first direct flight route if $j < 0$ (if $j > 0$) and 0 otherwise. We exclude the year when the first direct flight route between a city and a country pair is launched, thus the coefficient $\delta_j$ captures the dynamic effect.

Figure 3 visualizes the dynamic effects: relative to the inauguration year, there is no significant trend in the previous five years, implying a parallel pre-treatment trend across city-country pairs; there is a positive treatment effect with an obvious upward trend in the following five years, implying an accumulative effect of international business network expansion due to the launching of international direct flights.

(Insert Figure 3 here)

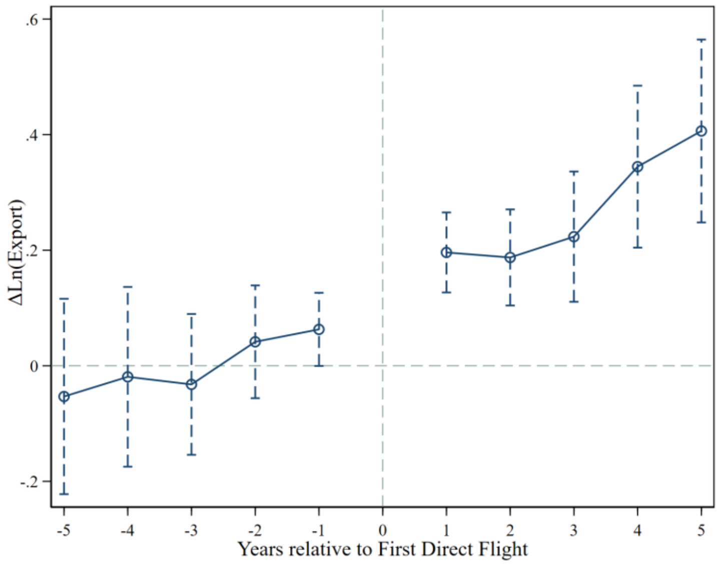


**Figure** 3 Dynamic effect (inauguration year of first direct flight route as base year)

### 4.1.4 Spatial spillover effects

After a city has launched international direct flights to other countries, it attracts international travelers not only from local area but also from surrounding areas, especially from nearby cities that have no international flights. This implies the positive effect of direct flights on exports occurs not only locally but also across city boundary, generating spatial spillover effects. We formally test this. For each city, we count the number of international direct flight routes available within its own area, beyond the city but within a 150km radius, between 150 and 300, 300~450, and 450~600km buffer areas. We add these variables to the baseline model and estimate it for the whole sample, a subsample of city-country pairs that have had direct flights, and a subsample of city-country pairs that have never had direct flights.

Table 5 report the results. Columns (1) and (2) show that city-country pairs that already have had direct flights do not enjoy additional benefit from nearby cities' international direct flights to the same destination country. This is straightforward: in general, if we can fly directly from a local airport, why bothering travel to the nearby city to take flights? The story for cities with no direct flights is very different: Columns (3) and (4) show that for city-country pairs that have no direct flights, those cities' exports can be boosted by 5~6% if direct flights are available within 150km radius. This positive spillover effect persists but attenuate with distance, up to 450~600km with a 2% increase in exports. This suggests that cities without international direct flights can "borrow size" of nearby cities with international airport. Columns (5) and (6) pool all the city-country pairs and the decay pattern of spatial spillovers is very similar. [6]

(Insert Table 5 here)

Table 5 Spillover effects

| | Dependent Variable: Ln(City export) | | | | | |
|---|---|---|---|---|---|---|
| | City-Country pair with Intl. direct flight | | City-Country pair without Intl. direct flight | | Whole sample | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Routes | 0.102*** | 0.063** | | | 0.126*** | 0.081*** |
| | (0.028) | (0.025) | | | (0.028) | (0.026) |
| Routes150km | -0.005 | -0.006 | 0.063*** | 0.046** | 0.058*** | 0.041** |
| | (0.019) | (0.017) | (0.022) | (0.021) | (0.020) | (0.019) |
| Routes150-300km | 0.004 | -0.001 | 0.054*** | 0.054*** | 0.050*** | 0.048*** |
| | (0.018) | (0.017) | (0.016) | (0.016) | (0.015) | (0.014) |
| Routes300-450km | 0.023 | 0.029 | 0.025 | 0.027* | 0.027* | 0.030** |
| | (0.024) | (0.022) | (0.016) | (0.014) | (0.014) | (0.013) |
| Routes450-600km | 0.008 | 0.017 | 0.018 | 0.022* | 0.019* | 0.023** |
| | (0.015) | (0.014) | (0.013) | (0.012) | (0.011) | (0.011) |
| Controls | | √ | | √ | | √ |
| City-Country FE | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ |
| City-Country * Trend | √ | √ | √ | √ | √ | √ |
| Adj. $R^2$ | 0.938 | 0.948 | 0.773 | 0.790 | 0.782 | 0.800 |
| Obs. | 6,189 | 5,740 | 466,679 | 376,164 | 473,661 | 382,615 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

## 4.3 Effects on imports

[6] We also test the spillover effects across destination countries. We hypothesize that if a destination country launched a direct flight to China, neighboring countries without direct flights to China may benefit in terms of increasing exports to China. We did not find such an effect.

We conduct the same set of analysis for city imports, as in Table 1. Not surprisingly, the effect of international direct flights on city imports from the source countries is also both statistically and economically significant: our conservative estimate (column 4 of Table 6) shows that a city's imports from a source country increases by 10.4% after the launching of direct flights between them.

(Insert Table 6 here)

**Table 6** Effects of direct flight on city imports

| | Dependent Variable: Ln(City import) | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| DF | 0.076 | 0.149*** | 0.121*** | 0.104** | 0.090** | 0.083* | 0.044 |
| | (0.078) | (0.048) | (0.046) | (0.043) | (0.042) | (0.043) | (0.039) |
| City Controls | | | √ | √ | √ | √ | |
| Country Controls | | | | √ | √ | | √ |
| City-Country FE | √ | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ | √ |
| City-Country*Trend | | √ | √ | √ | √ | √ | √ |
| Continent * Year FE | | | | | √ | | |
| Country * Year FE | | | | | | √ | |
| City * Year FE | | | | | | | √ |
| Adj. $R^2$ | 0.756 | 0.926 | 0.930 | 0.934 | 0.935 | 0.937 | 0.940 |
| Obs. | 68,377 | 68,377 | 66,160 | 58,160 | 58,160 | 66,013 | 60,137 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

### 4.4 Effects on trade dependence

Can international direct flights between a city and its trade partner also increase the city's trade dependence on that trade partner? To test this, we construct a country-specific trade dependence measure: the sum of a city's annual exports to and imports from a country divided by the city's annual GDP. Column (1) of Table 7 estimates the effect of direct flight route on a city's trade dependence using our preferred model specification; Column (2) replace DF dummy by number of direct flight routes; Columns (3) and (4) replicate the first two columns but dropping "never treated" city-country pairs. Taking together, Table 7 shows some weak evidence that launching direct flights to a trade partner increases a city's trade dependence on that partner.

(Insert Table 7 here)

**Table 7** Effects on trade dependence

| | Dependent Variable: Total trade/City GDP | | | |
|---|---|---|---|---|
| | Full sample | | Exclude never treated | |
| | (1) | (2) | (3) | (4) |
| DF | $0.0028^{\dagger}$ | | 0.0025 | |

| | | | | |
|---|---|---|---|---|
| | (0.0017) | | (0.0017) | |
| Routes | | 0.0025** | | 0.0027** |
| | | (0.0011) | | (0.0011) |
| Controls | √ | √ | √ | √ |
| City-Country FE | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ |
| City-Country*Trend | √ | √ | √ | √ |
| Adj. $R^2$ | 0.902 | 0.902 | 0.891 | 0.891 |
| Obs. | 106,459 | 106,459 | 5,736 | 5,736 |
| Mean of Dep. var | 0.0028 | | 0.0242 | |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

## 5. Suggestive evidence on channels

The increase in cities' international trade due to launching direct flights to destination or source countries is not due to more goods shipped by airlines. Figure 4 shows that the ratio of air to ocean freight shipping is very small in China; most of the traded goods are shipped via ocean.

(Insert Figure 4 here)

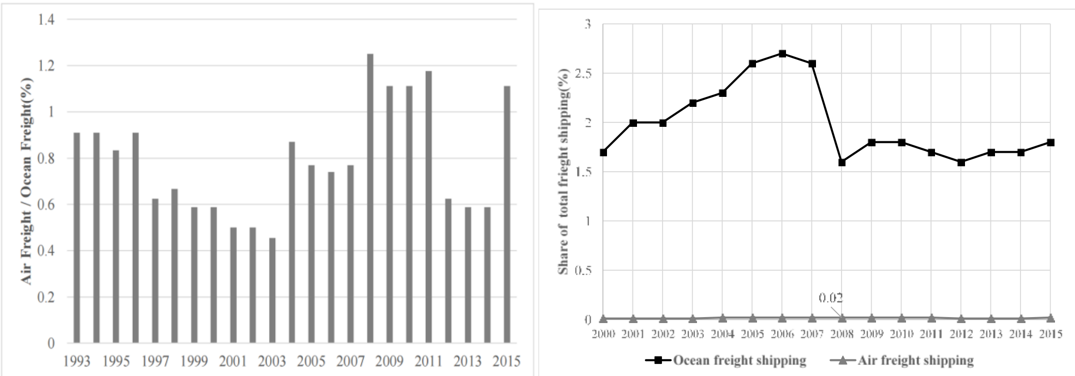


Figure 4 Air freight shipping vs. ocean freight shipping in China

We argue that the main channel is that international direct flights reduce international travel costs substantially, and therefore, promote business travels across countries. This helps generate more social interactions and face-to-face meetings among international business people and therefore create more business opportunities and transactions. Although we have no data for international business trips or international face-to-face communications, we provide three pieces of indirect evidence that industries that require intense face-to-face communications, are more relation specific, or export to the countries with longer linguistic distance or different legal origins are affected more strongly by the international direct flights.

### 5.1 Industries with different face-to-face communication intensity

Cristea (2011) finds that demand for international business-class air travel depends on export or export share of different industries and estimates the industry-specific export elasticity of business trip demand, or face-to-face communication intensity. We borrow his elasticity estimates for US manufacturing industries and manually match (with slight discrepancy) those three-digit NAICS (North American Industrial Classification System) codes with two-digit China's industrial classification codes which can also be matched with two-digit HS codes in our trade data. We interact DF dummy variable with this face-to-face communication intensity measure and estimate the baseline model at the city-country-industry level.

Table 8 shows that the positive, significant effect of international direct flights on exports still exists; furthermore, exports of industries with higher face-to-face communication intensity grow more strongly after the launching of international direct flights. This result is robust to the inclusion of city-country pair by year fixed effects (Column (4)), providing compelling evidence that international direct flights promote international business travel and cross-border business interactions.

(Insert Table 8 here)

Table 8 Industries with different face-to-face communication elasticity

| | Dependent Variable：Ln(City-industry export) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| DF | 0.090** | 0.072* | 0.070* | |
| | (0.041) | (0.038) | (0.038) | |
| DF*industry face-to-face communication intensity | 0.314*** | 0.306*** | 0.298*** | 0.291*** |
| | (0.020) | (0.020) | (0.020) | (0.020) |
| Controls | | √ | √ | √ |
| City-Country FE | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ |
| City-Country * Trend | √ | √ | √ | |
| Industry FE | √ | √ | √ | √ |
| Industry * Year FE | | | √ | √ |
| City-Country * Year FE | | | | √ |
| Adj. $R^2$ | 0.516 | 0.526 | 0.533 | 0.540 |
| Obs. | 1,715,352 | 1,451,413 | 1,451,413 | 1,443,425 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

We also estimate the baseline model for the top five manufacturing industries in terms of face-to-face communication intensity. These are machinery (NAICS 333), computer and electronic products (334), miscellaneous manufactured commodities (339), fabricated metal product (332), and transportation equipment (336). As expected, Table 9 shows that the positive effect of international direct flights on exports of these industries is almost twice larger than those of industries with lower communication intensity.

(Insert Table 9 here)

**Table** 9 Estimation for export of most F2F intensive industries

| | Dependent Variable：Ln(City-industry export) | | | | | | |
|---|---|---|---|---|---|---|---|
| | NAICS: 333 | NAICS: 334 | NAICS: 339 | NAICS: 332 | NAICS: 336 | NAICS Top 5 | Exclude Top 5 |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| DF | 0.145** | 0.167 | 0.124** | 0.108 | 0.220** | 0.205*** | 0.085** |
| | (0.060) | (0.111) | (0.061) | (0.078) | (0.095) | (0.056) | (0.041) |
| Controls | √ | √ | √ | √ | √ | √ | √ |
| City-Country FE | √ | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ | √ |
| City-Country * Trend | √ | √ | √ | √ | √ | √ | √ |
| Adj. $R^2$ | 0.852 | 0.791 | 0.830 | 0.796 | 0.768 | 0.872 | 0.891 |
| Obs. | 79,268 | 51,080 | 81,549 | 76,127 | 60,723 | 94,343 | 103,552 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively. Three-digit NAICS codes are matched with two-digit CIC codes.

### 5.2 Industries with different contract intensity

Nunn (2007) constructed a measure for relation specificity or contract intensity of U.S. industries. If an intermediate input is sold on an organized exchange, then the market is thick and hold-up is not a big issue; if an input is not sold on an exchange, it may be reference priced in trade publications or transacted in a thin market through buy-seller specific investment. Using the U.S. input-output table, Nunn (2007) calculated for each final good the proportion of its intermediate inputs that are relation-specific (not sold on an organized exchange) as contract intensity. Final goods that use relation-specific inputs are more complex, skill intensive, and more dependent on the quality of contract enforcement. The correlation between industry contract intensity and industry face-to-face communication intensity is relatively high with a correlation coefficient about 0.5 (Cristea, 2011). We contemplate that international transactions of contract-intensive products depend more on personal interactions between business partners and therefore are affected more by direct flights. We estimate the baseline model for the top twenty industries in terms of the contract intensity as listed in Nunn (2007) and for the other industries.

Table 10 show that exports of contract-intensive industries increase much more than those of other industries (0.20 versus 0.09) after a city launched a direct flight route to its destination country. This again is consistent with international direct flights reducing international travel costs and facilitating cross-border business interactions.[7]

(Insert Table 10 here)

Table 10 Industries with different contract intensity

| | Dependent Variable: Ln(export) | | | | |
|---|---|---|---|---|---|
| | City-Country level | | City-Country-Industry level | | |
| | Most contract intensive industries | Other industries | Most contract intensive industries | Other industries | All industries |
| | (1) | (2) | (3) | (4) | (5) |
| DF | 0.199*** | 0.089** | 0.121** | 0.093** | 0.039 |
| | (0.062) | (0.040) | (0.054) | (0.038) | (0.040) |
| DF*Most contract intensive dummy | | | | | 0.243*** |
| | | | | | (0.045) |
| Controls | √ | √ | √ | √ | √ |
| City*Country FE | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ |
| City-Country * Trend | √ | √ | √ | √ | √ |
| Adj. $R^2$ | 0.857 | 0.895 | 0.411 | 0.433 | 0.417 |
| Obs. | 88,416 | 104,987 | 355,267 | 1,095,822 | 1,451,413 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

### 5.3 Linguistic distance and legal origin

Trading with a country with a different language and legal system involves more complicated search, consulting, negotiation and likely requires more face-to-face communications. Direct flights can facilitate business communications between such countries. We test this by interacting DF dummy with linguistic distance and with legal origin of the destination country. Since Chinese language is mostly spoken in China and English is the dominant foreign language learned and spoken in China, we measure linguistic distance to English, following Chiswick and Miller (2005). If a country's official language is English, we assign a value of "1"; otherwise a value of "2" or "3" is assigned and a larger value indicates that the country's language is more different than English. International direct flights reduce international trip costs, facilitate in-person communications, and help reduce language barrier; therefore, we expect exports to a country with larger linguistic distance to English will increase more after the direct flights are introduced. We also construct a dummy variable "legal origin" set to one if

[7] We do not find the same effects on imports, likely because goods imported in China are very different from exports goods and also many observations are missing (to be done)

the export destination country's legal origin is the same as China and zero otherwise.[8] We expect exports to the countries with different legal origin than China will increase more after direct flights are launched. We find such consistent evidence only when we use the sample excluding "never treated" city-country pairs and use the baseline model without city-country specific linear trend, possibly because large share of never treated groups and pair-specific trend over control variations in country characteristics.

(Insert Table 11 here)

Table 11 Linguistic Distance and Legal Origin

| | Dependent Variable: Ln(export) | | | | | |
|---|---|---|---|---|---|---|
| | Full sample | | Exclude never-treated | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| DF | 0.234* | 0.103** | 0.179 | 0.075 | -0.094 | 0.201*** |
| | (0.128) | (0.050) | (0.120) | (0.049) | (0.141) | (0.054) |
| DF* Linguistic Distance | -0.066 | | -0.052 | | 0.140* | |
| | (0.073) | | (0.067) | | (0.082) | |
| DF* Legal Origin | | 0.070 | | 0.067 | | -0.255*** |
| | | (0.099) | | (0.093) | | (0.093) |
| Controls | √ | √ | √ | √ | √ | √ |
| City*Country FE | √ | √ | √ | √ | √ | √ |
| Year FE | √ | √ | √ | √ | √ | √ |
| City-Country * Trend | √ | √ | √ | √ | | |
| Adj. $R^2$ | 0.904 | 0.909 | 0.956 | 0.957 | 0.930 | 0.930 |
| Obs. | 96,002 | 84,757 | 5,474 | 5,435 | 5,474 | 5,435 |

Note: Robust standard errors in the parentheses, clustered at city-destiny country pair level. ***, ** and * stand for statistical significance level of 1%, 5% and 10%, respectively.

## 6. **Conclusion**

Connecting with global cities via direct flight promotes Chinese cities' international trade, both exports to destination countries and imports from source countries. We provide the causal evidence for this. Specifically, on average a Chinese city's export to a destination country (imports from a source country) increases by 12.8% (10.4%) after a direct flight route is launched between the city and the country. International trade of cities without international airports can also benefit from nearby cities with international direct flights. We also find that exports of industries with high face-to-face communication intensity and high contract intensity benefit more from international direct flights, suggesting that international direct flights reduce cost of cross-country, long-distance travel and promote face-to-face social interactions among international business people.

[8] Legal origins of countries are listed on this webpage: https://www.nationmaster.com/country-info/stats/Government/Legal-origin.

Our findings have important policy implications. Since international direct flights are important for trade, it is important to keep international travel industry operating smoothly. Interrupting international travel due to political reasons or public health issues (such as the current pandemics) will have detrimental effects not only on the international travel industry itself but also on international trade. In addition, international direct flights generate external economies in terms of boosting trade in both local and neighboring areas and local employment. City government may consider subsidizing (new) international direct flight routes.

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## Appendix

### Table A1 Summary statistics

| | | No. obs | Mean | Std. Dev |
|---|---|---|---|---|
| **Panel A** – Variables in Baseline Model | | | | |
| **Key variables** | | | | |
| Export(log) | Export from city to destiny country, | 135,699 | 14.498 | 2.986 |
| Export, current $ (million) | full sample | 135,699 | 75.406 | 630.229 |
| Export(log) | Export from city to destiny country, | 6,184 | 18.570 | 2.304 |
| Export, current $ (million) | exclude never treated sample | 6,184 | 742,357 | 2304.096 |
| Import(log) | Import from city to destiny country | 69,274 | 14.202 | 3.794 |
| Import, current $ (million) | | 69,274 | 146.158 | 1011.134 |
| DF | First direct flight dummy | 135,699 | 0.025 | 0.156 |
| Routes | # of Direct flight routes | 135,699 | 0.041 | 0.328 |
| **City level control variables** | | | | |
| City GDP(log) | City gross domestic product | 912 | 25.731 | 1.258 |
| City PGDP(log) | City GDP per capita | 868 | 10.330 | 0.762 |
| Manufacture share(%) | $2^{nd}$ industry / $3^{rd}$ industry | 900 | 44.717 | 9.474 |
| FDI(%) | Foreign direct investment / City GDP | 879 | 3.653 | 3.956 |
| **Country level control variables** | | | | |
| Country GDP(log) | Country gross domestic product | 2,904 | 23.817 | 2.373 |
| Country PGDP(log) | Country GDP per capita | 2,954 | 8.484 | 1.512 |
| CAB(%) | Current account balance | 2,610 | -2.962 | 11.603 |
| TrDdep(%) | Total Trade / Country GDP | 2,781 | 88.563 | 49.084 |
| **Panel B** – Additional variables for sensitivity and other analyses | | | | |
| Inbound tour(log, L1) | No. of inbound tour., lag 1 year | 891 | 12.443 | 1.571 |
| Inc. of foreign tour.(log, L1) | Foreign exchange inc. of tour., lag 1 year | 898 | 4.804 | 1.698 |
| Star hotel(log, L1) | No. of star hotels, lag 1 year | 831 | 4.215 | 0.809 |
| Inbound tour.(log, 1999) | No. of inbound tourists in 1999 | 53 | 11.534 | 1.536 |
| Inc. of foreign tour.(log,1999) | Foreign exchange inc. of tour. in 1999 | 56 | 3.825 | 1.524 |
| Star hotel(log,1999) | No. of star hotels in 1999 | 52 | 3.687 | 0.846 |