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Entry patterns of low-cost carriers in Hong Kong and implications to the regional market

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NUMBER:	Working Paper ITLS-WP-16-02
TITLE:	**Entry patterns of low-cost carriers in Hong Kong and implications to the regional market**
ABSTRACT:	This study aims to provide a better understanding of Asia's low-cost carriers (LCCs) by empirically analysing their route entry patterns in Hong Kong. Two alternative models have been tested, namely a standard probit model and a generalized least squares estimation. Consistent findings from the two models suggest that LCCs in Asia have a clear preference for high density routes, and the dominance of incumbent full service airlines (FSAs) and the lack of secondary airports are not critical to the growth of LCCs. However, government regulations and airport access are main impediment factors. Despite the adoption of long-distance low-cost models by the region's airlines, geographic distance still plays an important role in LCCs' entry decisions. For the growth of low-cost travel and associated benefits in the tourism industry and overall economy, it is important for governments in the region to liberalize aviation markets, provide sufficient airport capacity, and promote efficient allocation of airport slots.
KEY WORDS:	***Traffic volume changes; Route entry; Low-cost carriers; Hong Kong***
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1. Introduction

Low-cost carriers (LCCs) have been playing a significant role in developing a country's aviation and tourism sectors, and the potential demand for low-cost air travel is huge across Asia (Koldowski and Yoo 2006, Whyte 2008, Chung and Whang 2011, and Duval 2013,). The LCC sector in Asia has achieved substantial growth in recent years, thanks to the growing groups of middle-income travellers, increasing urbanization, ongoing aviation liberalisation and deregulation, and substantial improvements in key aviation infrastructures (Koldowski and Yoo 2006 and Homsombat et al. 2014). The rapid growth of LCCs is also likely to pose serious challenges to the incumbent full service airlines (FSAs). LCCs provide more affordable air travel, which is important in developing countries where the average income per capita is lower than those of developed economies (Connell 2005, Chang and Lee 2008, and Yeung et al. 2012).

Many Asian carriers have emulated the low-cost business model developed in North America and Europe, such as the use of point-to-point networks, one-way fares with few restrictions, direct sale and e-ticketing, single aircraft type, high aircraft utilization, no seat assignments, no-frill services, and simplified airport operations (Windle and Dresner 1995 and 1999, Gillen and Morrison 2002, Gillen and Lall 2003, Mason and Alamdari 2007, Hofer et al. 2008, Mason and Morrison 2009, Fu et al. 2011, Murakami 2011, Zou et al. 2015 and Fageda et al. 2015). Many LCCs in Asia-Pacific have been able to achieve significant cost savings and substantial output growth over the past decade. Although similar development patterns have been observed in mature aviation markets, LCCs in Asia operate in different environments and exhibit some distinctive features in operation and management. Unlike the aviation markets in North America and Europe which are fully deregulated/liberalized, various legacy regulations are still present in both international and domestic routes in Asia (Homsombat et al. 2011, Lei and O'Connell 2011, and Fu et al. 2015b). With low fees and fast turnaround time, secondary airports have been attractive destinations to LCCs. However, only a few cities in Asia are served by multiple airports. A significant proportion of LCC services are provided out of hub airports, where capacities are quickly approaching limits. Moreover, the relatively high charges at hub airport may reduce LCCs' cost advantage over FSAs, because an identical input price increase will have asymmetric effects on LCCs vs. FSAs (Fu et al. 2006, Oum and Fu 2007). Major LCCs in Asia, such as AirAsia, Cebu Pacific, Jetstar Airways, Tiger Airways, have extensive services out of major airports (e.g., Hong Kong, Singapore, and Narita). With significant route overlap and (pending) airport capacity shortage, incumbent FSAs are expected to compete more aggressively to defend their market shares. Although the relatively low income per capita in Asia should make low cost travel attractive to consumers, empirical studies on the Chinese domestic market (e.g., Wang et al. 2014) have found travellers' high value of time and strong preference for flight frequency. Since incumbent FSAs have established networks and controlled most of the slots at major airports, they are likely to be better positioned on routes out of these hubs. In addition, the long-haul LCC business model has been adopted by major LCCs in Asia (including Asia X, Jetstar, and Scoot) to fly travellers across national borders, especially between metropolitan regions (Wensveen and Leick 2009, Daft and Albers 2012).

The entry of LCCs has changed the dynamics in Asia's aviation markets (Kumar 2006). However, due to the distinctive features of regulatory policy, passenger preference, market structure, and airport access as identified above, the operational practice and management strategy of Asian LCCs are yet to be fully understood. It is unclear whether the findings in previous LCC studies that were primarily carried out for North America and Europe can be directly applied to Asia. Other than the Australian domestic market which is fully deregulated, the development status of Asian LCCs has been examined only by a few studies, and their conclusions have been mixed. Zhang et al. (2008) documented substantial price reductions on selected routes with LCC entry. For example, the ticket prices dropped substantially between Kuala Lumpur and Singapore with the entry of AirAsia, Jetstar Asia, and Tiger Airways. Adler et al. (2014) simulated the expansion of LCCs if the aviation market in Northeast Asia is deregulated, and predicted that LCCs would capture a significant market share in a liberalized market. Fu et al. (2014) simulated the effects of a substantial airfare reduction in the Japanese inter-city market based on the parameters estimated prior to the entry of major LCCs. They concluded that the entry of competitive LCCs would significantly increase the air travel volume, but high-speed-rail (HSR) services would continue to dominate the routes among metropolitan regions. Hanaoka et al. (2014) simulated LCC service competition at the major hub airports when the ASEAN Single Aviation Market takes full effect. They predicted that the entry of an LCC in one route may affect the fare, frequency, and profitability of related routes in the entire network. The findings of the above studies are consistent with most of the previous investigations for North America and Europe. However, other than the anecdotal evidences provided by Zhang et al. (2008), most of the studies are based on modelling and simulation instead of systematic empirical analysis. Fu et al. (2015a) investigated the route entry and airfare change patterns associated with Spring Airlines, the largest LCC in China, using the flight schedule and price data in the Chinese domestic market. Their empirical results suggested that in the presence of various regulations, there does not always exist a sharp competition between FSAs and LCCs. An LCC may adopt a “cream-skimming” strategy to achieve high profitability without triggering price wars with incumbent FSAs. Based on descriptive network analysis of the aviation market in Northeast Asia, Fu et al. (2015b) found that international LCC services in Korea and Japan experienced healthy growth, but the market penetration of LCCs in mainland China remains very low. In summary, few empirical studies have systematically examined the performance and business strategies of Asian LCCs, especially in international markets. The key determinants for the growth of this region’s low-cost sector remain to be identified and fully understood.

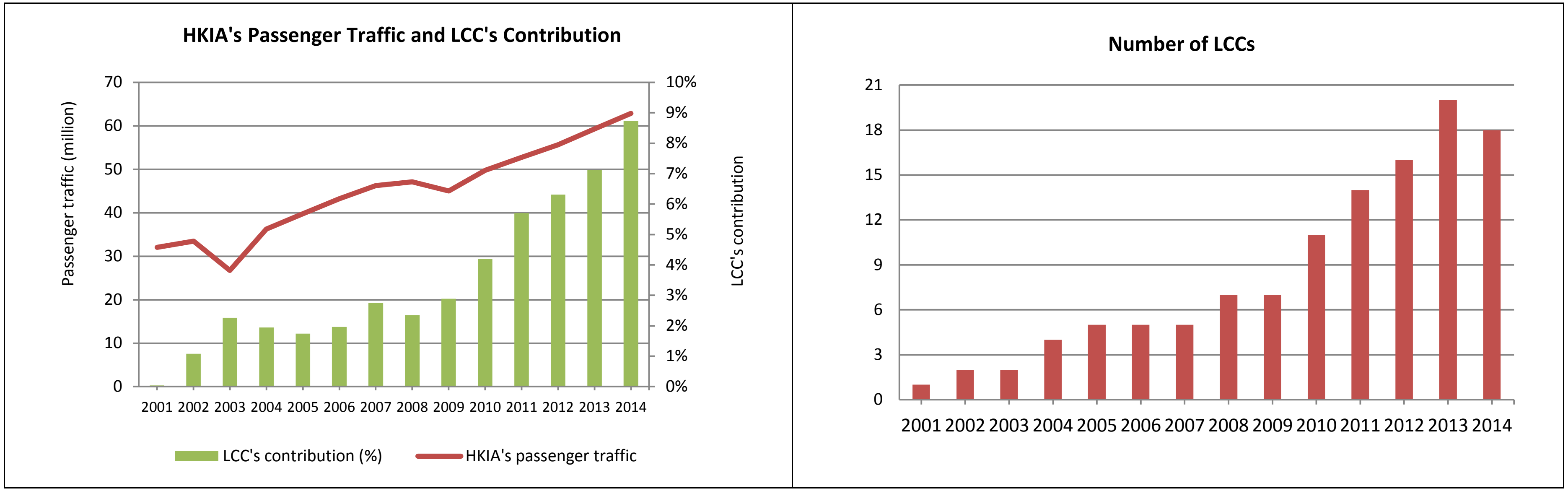
Our study aims to fill this gap in the literature by examining LCC entry pattern in Hong Kong. To the best of our knowledge, this is the first empirical study of Asia’s international LCC markets. Its contribution to the literature are multi-fold: (1) Although the aviation market in Hong Kong is fairly liberalized, regulations on route entry, capacity and airline designation have only been progressively removed on routes to most Asian destinations. Our analysis thus provides valuable insights into the effects of regulation on LCC services. (2) Hong Kong is a hub airport with extensive connections in the region. Our study reveals how airport characteristics affect LCC entry decisions. (3) The empirical results obtained for the Hong Kong aviation market can assist stake-holders in formulating government policies and business strategies. As the aviation and tourism sectors play an important role in Hong Kong’s economy, it is of great practical values to improve the performance in these sectors.

The rest of the paper is organized as follows: Section 2 reviews the development of LCC sector in Hong Kong. Section 3 specifies two econometric models of LCC entry. Section 4 reports our data and estimation results. In Section 5, we summarize and discuss possible improvements in future studies.

2. Growth of the low-cost sector in the Hong Kong aviation market

The aviation industry in Hong Kong has been more liberal than most Asian economies. As of 2015, Hong Kong has signed a total of 64 bilateral air service agreements (ASAs) with foreign sovereignties (Hong Kong Government 2015). Hong Kong’s established reputation of ‘Shopping Paradise’ also attracts millions of tourists every year for shopping and sightseeing (Lew and McKercher 2002). There were a total of 12.85 million of visitor arrivals to Hong Kong by air transport in 2014, for examples, 1.35 million of tourists from North Asia, 2.31million from South and Southeast Asia, 1.23 million from Taiwan, and 4.94 million from mainland China, respectively (Hong Kong Tourism Board 2014). The total tourism expenditure from inbound tourism in Hong Kong was approximately HK$3320.47 billion in 2013 (Hong Kong Tourism Board 2013). The relatively liberal aviation policy and huge tourism demand make Hong Kong an ideal market for LCCs.

Figure 1 presents a summary of the market growth of LCCs at the Hong Kong International Airport (HKIA) during the period of 2001–2014, using various measures such as passenger volume, number of LCCs, number of destinations served, and total flight frequency. It is clear that the overall passenger volume has maintained a stable upward trend throughout the study period, except for temporary setbacks in 2003 and 2008–2009 due to the SARS outbreak and the global financial crisis, respectively (Tsui et al. 2014). HKIA's annual passenger traffic increased from 32.03 million in 2001 to 62.86 million in 2014, equalling an average annual growth rate of 6.88% (HKIA 2001–2014). The first scheduled LCC service was introduced by Cebu Pacific Air on 22 December 2001 between Manila and Hong Kong. Upon entry the airline carried approximately 0.03% of HKIA's annual passenger volume. Since then, LCC traffic outpaced overall market growth, reaching 5.49 million in 2014 or about 9% of the market.



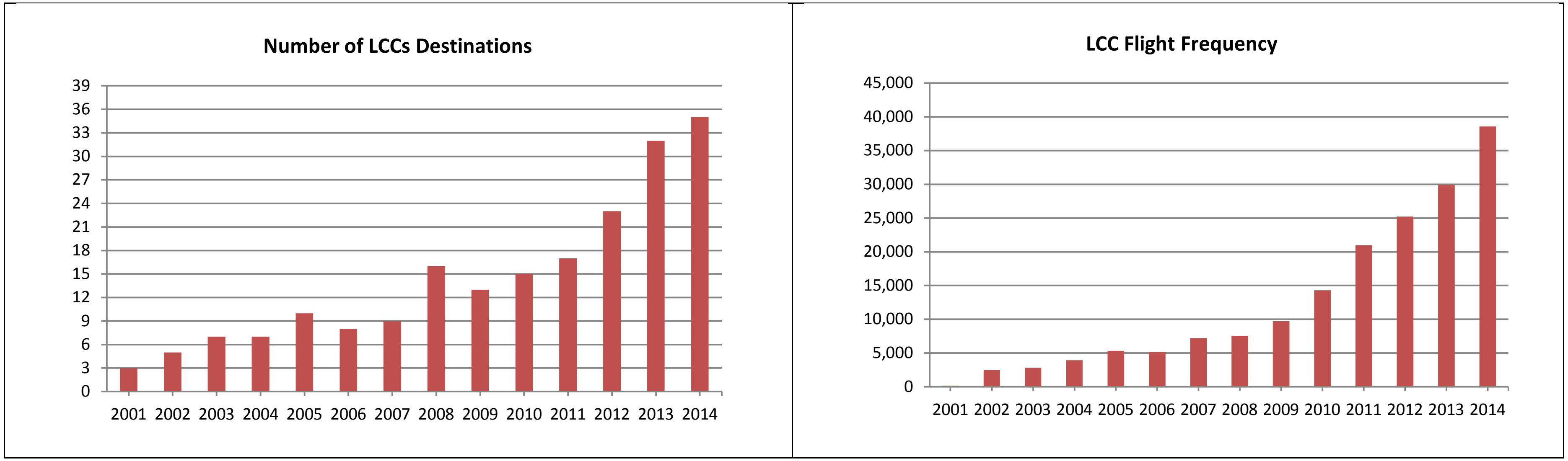


Figure 1. Development of Hong Kong's LCC Sector (2001–2014)

LCC growth accelerated substantially after the global financial crisis. As reported in Figure 1 and Table 1, during 2001–2009 seven LCCs entered the routes out of HKIA. This number more than doubled in the subsequent five years (reaching 18 as of 2014). Some of the largest LCCs in Asia already entered the market, notably the AirAsia Group (AirAsia, AirAsia Philippines, Thai AirAsia), Cebu Pacific Air, Jetstar Asia, Juenyao Airlines, Spring Airlines, SCOOT, and Tiger Airways. Annual LCC flights increased from 168 in 2001 to 38,561 in 2014. Similar growth patterns can be identified for destinations served. As reported in Table 2, the number of routes with LCC service increased from 3 in 2001 to 13 in 2009, and subsequently tripled to 35 in 2014. Other than the unsuccessful services to London and Vancouver during 2006–2008, virtually all 35 LCC routes in 2014 involved Asian destinations. Southeast Asian cities are among the first receiving LCC services, and remain as one of the most important regions in terms of network coverage (18 destinations as of 2014). Other important markets are mainland China (8 destinations) and North Asia (7 destinations). Hong Kong's LCC sector currently has both frequent services to hubs (e.g., Bangkok, Kuala Lumpur, Manila, Nartia, Seoul/Incheon, Shanghai/Pudong, and Singapore) and direct flights to second-tier airports and holiday destinations (e.g., Busan, Cebu, Clark, Phuket, and Osaka/Kansai)

Table 1. Low-Cost Carriers Operating in Hong Kong (2001–2014)

Low-cost carriers	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Air Busan											*	*	*	*
AirAsia								*	*	*	*	*	*	*
Airphil Express											*	*	*	
Airasia Philippines												*	*	*
Bangkok Airways					*	*	*	*	*	*	*	*	*	*
Cebu Pacific Air	*	*	*	*	*	*	*	*	*	*	*	*	*	*
EASTAR JET													*	*
HK Express													*	*
JEJU AIR										*	*	*	*	*
Jetstar Asia				*	*	*	*	*	*	*	*	*	*	*
Jin Air											*	*	*	*
Juneyao Airlines										*	*	*	*	*
Oasis Hong Kong						*	*	*						
Oriental Thai		*	*	*	*	*	*	*	*	*	*	*	*	*
PAL Express													*	*
Peach Aviation												*	*	*
SCOOT													*	*
South East Asian Airlines											*	*	*	
Spring Airlines										*	*	*	*	*
Thai AirAsia								*	*	*	*	*	*	*
Tigerair Airways										*	*	*	*	*
Valuair				*	*				*					
Total	1	2	2	4	5	5	5	7	7	11	14	16	20	18

Table 2. Routes and Destinations Served by Low-Cost Carriers (2001–2014)

Routes / Destinations	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
MAINLAND CHINA														
Chongqing												*	*	
Hangzhou												*	*	
Huangshan														*
Kunming													*	*
Luoyang													*	
Nanjing												*	*	
Ningbo														*
Shanghai/PVG										*	*	*	*	*
Shenzhen														*
Shenyang												*	*	
Shijiazhuang										*	*	*	*	*
Yantai														*
Xiamen												*	*	
Zhengzhou														*
NORTH ASIA														
Busan											*	*	*	*
Cheju											*			
Fukuoka														*
Hiroshima								*						
Nagoya														*
Osaka/Kansai												*	*	*
Seoul/ICN										*	*	*	*	*
Tokyo/HND													*	*
Tokyo/NRT					*					*	*			*
SOUTHEAST ASIA														
Bangkok		*	*	*	*	*	*	*	*	*	*	*	*	*
Bangkok/								*	*			*	*	*
Cebu				*	*	*	*	*	*	*	*	*	*	*
Chiang Mai			*				*	*					*	*
Clark								*	*	*	*	*	*	*
Davao						*		*	*					
Denpasar													*	*
Hailar														*
Hasanudin									*					
Hat Yai			*											
Iloilo												*	*	*
Jakarta													*	*
Kalibo												*	*	*
Kota Kinabalu										*	*	*	*	*
Kuala Lumpur								*	*	*	*	*	*	*
Laoag	*	*	*	*	*									
Manila	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Penang									*	*	*	*	*	*
Phuket	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Samui					*	*	*	*	*	*	*	*	*	*
Singapore				*	*	*	*	*	*	*	*	*	*	*
Surabaya													*	*
Subic Bay		*	*	*	*									
Utapao								*						
TAIWAN														
Taichung													*	*
Taipei					*									
OTHER														
London/Gatwick						*	*	*						
Macau								*	*	*	*		*	*
Ulan Bator														
Vancouver							*	*						
TOTAL	**3**	**5**	**7**	**7**	**10**	**8**	**9**	**16**	**13**	**15**	**17**	**23**	**32**	**35**

Some high density routes have been served by multiple LCCs. As of 2014, Bangkok was served by two LCCs (Bangkok Airways and Oriental Thai), which accounted for 4.4% (0.13 million) of the route market; Singapore was served by three LCCs (Jetstar Asia, Tigerair, and SCOOT), which jointly controlled 21.5% of the market share (0.80 million); Shanghai was served by two mainland LCCs (Spring Airlines and Juneyao Airlines, both are privately owned), with a combined market share of 13.2% (0.47 million) on that route. On a few routes to the secondary airport (Bangkok Don Mueang International Airport, code DMK) and tourist destinations (e.g. Hailar, Huangshan, Iloilo, Samui, Shijiazhuang, and Yantai), only LCCs provide scheduled services. Among all routes out of Hong Kong, the majority of markets have at most one LCC during 2001–2014. Such a diversified pattern of LCC service makes Hong Kong an ideal case for a systematic empirical analysis.

Large LCCs control the majority of low-cost segment in Hong Kong. In terms of passenger volume, the top ten carriers had a combined market share of 85.82% of the low-cost segment, or 7.50% of the overall market as of 2014 (for a breakdown by airline, see Table 3). The leading carriers in 2014 were HK Express (22.94%), AirAsia Group (19.80%), and Cebu Pacific Air (11.68%), followed by Tiger Airways, Spring Airlines, Jetstar Asia, and SCOOT. Although Hong Kong-based FSAs such as Cathay Pacific/Dragon Air and Hong Kong Airlines[1] have maintained significant market shares over the years, foreign LCCs have controlled a lion's share in the low cost segment. Long-haul LCC services were introduced by Oasis Hong Kong (a local airline), first between Hong Kong and London/Gatwick from October 2006 to April 2008, followed the route between Hong Kong and Vancouver from June 2007 to April 2008. However, this carrier ceased operation in April 2008, partly due to fierce competition with incumbent FSAs (Wensveen and Leick 2009, Daft and Albers 2012, and Whyte and Lohmann 2015). In June 2013, Hong Kong Express (the sister carrier of Hong Kong Airlines) announced its change of business model from an FSA to an LCC, renaming itself as HK Express. Since then the carrier aggressively cut its cost, which helped it to become Hong Kong's largest LCC in 2014.

[1] Dragon Air is wholly owned by Cathay Pacific, whereas Hong Kong Airlines is partially owned and controlled by the Hainan Airlines (the fourth largest carrier in mainland China)

Table 3. Ten Major LCCs Operating in Hong Kong (2014)

Airlines	**Routes / Destinations**	**Year of Entry**	**Share of HKIA's LCC Passenger Traffic**	**Share of HKIA's total Passenger Traffic**
Cebu Pacific Air	Busan, Cebu, Clark, Davao, Iloilo, Kalibo, Laoag, Manila, Shnaghai/Pudong, Subic Bay	2001	11.68%	1.02%
Orient Thai	Bangkok, Bangkok/DMK, Chiang Mai, Hat Yai, Phuket, Utapao, Tokyo/NRT	2002	2.49%	0.22%
Jetstar Asia	Singapore	2004	4.78%	0.42%
Bangkok Airways	Bangkok, Chiang Mai, Hasanudin, Hiroshima, Samui	2005	2.27%	0.20%
AirAsia Group (AirAsia, AirAsia Philippines,* Thai AirAsia)	Bangkok, Bangkok/DMK, Chiang Mai, Clark, Don Muang, Kota Kinabalu, Kuala Lumpur, Penang, Phuket, Utapao	2008	19.80%	1.73%
Spring Airlines	Chongqing, Hangzhou, Luoyang Nanjing, Shanghai/Pudong, Shenyang, Shijiazhuang, Xiamen	2010	6.64%	0.58%
Juneyao Airways	Shanghai/Pudong	2010	2.36%	0.21%
Tiger Airways	Bangkok, Clark, Denpasar, Jakarta, Singapore, Surabaya	2010	8.85%	0.77%
HK Express	Busan, Chiang Mai, Fukuoka, Hailar, Huangshan, Kota Kinabalu, Kunming, Nagoya, Ningbo, Osaka/Kansai, Penang, Phuket, Seoul/Incheon, Taichung, Tokyo/Haneda, Tokyo/Narita, Yantai, Zhengzhou	2013	22.94%	2.00%
SCOOT	Singapore	2013	4.01%	0.35%

In summary, the low-cost sector in Hong Kong has experienced a significant growth in traffic volume, flight frequency, and number of destinations. Although HK Express has substantially expanded its operations, the sector has been primarily controlled by foreign LCCs of different sizes and nationalities. These LCCs together provide services to both hubs and second-tier airports in the region, allowing the low-cost sector to outpace the overall market growth. As the aviation market in Hong Kong is being further liberalized and the Hong Kong International Airport is quickly approaching its capacity limit, incumbent FSAs may defend their dominance more aggressively in the years to come. It is unclear whether LCCs can continue their fast expansion in the Hong Kong aviation market. Therefore, it is important to identify the growth pattern and growth drivers of the low-cost sector. In our study, this objective is achieved by empirically examining LCCs' route entry patterns. Because the market under our investigation is very diverse in terms of airline profiles and route characteristics, our study is expected to provide valuable insights about the Hong Kong and Asian aviation markets.

3. Econometric model of LCC route entry

To model the determinants of an airline's route entry decision, many studies have used discrete choice models based on industry data and observed airline network configurations (see, e.g., Boguslaski et al. 2004, Oliveira 2008, Homsombat et al. 2014, and Fu et al. 2015). The underlying assumption is that an airline will only serve a route if it is profitable to do so. Therefore, a carrier's network configuration pattern, or its route entry decisions, provides valuable information about the airline's operating profit at the route level, which is not directly observable (latent) to researchers. Let an LCC's latent profit π^* of serving a route be specified as in Equation (1):

$$\ln\pi^* = \mathbf{ln}\boldsymbol{x}'\boldsymbol{\varphi} + \mu \,, \tag{1}$$

which is a function of a vector of control variables $\boldsymbol{x}$ ($\boldsymbol{x}'$ is the transpose of $\boldsymbol{x}$) and a stochastic error term μ. Let Y denotes the LCC's entry decision, and C denotes the fixed costs or a profit threshold for the airline to serve a route (i.e., the minimum profit acceptable to the airline to enter a route, or the opportunity cost associated with a new market entry). Therefore, the carrier's route entry decision can be specified as a function of the latent profit function in Equation (1), such that $Y_i = 1$ if $\pi^* - C > 0$, and $Y_i = 0$ if $\pi^* - C \leq 0$. The probability of route entry can be expressed as in Equation (2):

$$\text{Prob}(Y_i = 1|\boldsymbol{x}) = \text{Prob}\left(\frac{\pi^*}{C} > 1\middle|\,\boldsymbol{x}\right) = \text{Prob}(\mathbf{ln}\boldsymbol{x}'\boldsymbol{\varphi} - \ln C + \mu > 0|\boldsymbol{x}). \tag{2}$$

With the assumption that $\mu_i \sim iid\ N(0,1)$, this probit model can be estimated with a maximum likelihood method for a particular LCC. Ideally, such an entry model could be estimated for each LCC using data observed on routes to/from Hong Kong. However, such an approach is not feasible due to data limitation. Absent a regional open skies agreement, a foreign LCC can only serve routes linking its home country to Hong Kong due to nationality requirements and flight freedom regulation contained in bilateral Air Service Agreements (ASAs). Other constraints, such as single designation and airport slot constraints, may also prevent Hong Kong-based airlines to freely schedule flights from Hong Kong to foreign countries. Since most LCC services to Hong Kong were only initiated in recent years, the sample size will be quite small if estimation is carried out for a particular LCC. Even if such a model can be estimated for each LCC, it is difficult to identify whether the estimates reflect airline-specific pattern or simply large variance due to small sample size. Therefore, in this paper we define $Y_i = 1$ if at least one LCC serves route i, and the entry model is estimated with pooled data of all LCC services in all city-pairs out of Hong Kong. This is clearly a simplification, which implicitly assumes that all LCCs are similarly affected by the factors we considered in our entry model. In such a case, threshold C may be regarded as the lowest possible profit to attract an LCC to the route, and the estimation results reflect the LCC entry pattern to Hong Kong in general, instead of the decision process of any particular airline.

Therefore, caution should be exercised in the interpretation of modelling results, and our estimation results shall be revisited when larger samples can be obtained with more LCCs service in the coming years. With these cautions in mind, among the 187 observations with LCC entry (there were cases in which an LCC left the market), 150 of them are served by one LCC only and 33 involved two LCCs. Therefore, it is likely that our estimation will provide similar information to the estimated one airline's entry decisions in previous studies.

Let LCCs' entry decision be affected by the factors defined below, the probability of entry can be specified as the following general functional form in Equation (3):

$$(3) \qquad \text{Prob}(LCC\_route_{it} = 1|\boldsymbol{x}) = \text{Prob}\left(\begin{array}{c} -\ln C + \ln\pi^*(Dist_i, Density_i, \\ HHI_i, MarketPo_i, SE\_Asia_i \\ , ASENA_i, China_i, China\_lib_l, year) > 0 \end{array} \middle| \boldsymbol{x} \right),$$

where

LCC_route_{it} is a binary variable that indicates the entry of at least one LCC on route i at time t ;
$Dist_i$ is the flying distance of route i in miles;
$Density_i$ is the aggregate scheduled seats on route i;
HHI_i is the Herfindahl-Hirschman Index on route i , which is used to measure the market concentration;
$MarketPo_t$ is the yearly total scheduled seats at the Hong Kong International Airport, a variable used to capture the market potential;
SE_Asia_i is a dummy variable that equals to 1 if it is a route flying to a Southeastern Asian country.
$ASENA_i$ is a dummy variable that captures the potential effect of the ASENA single aviation market (SAM) on the LCC entry in Hong Kong. The variable equals to 1 if route i serves an ASENA country after year 2008 when the ASENA single aviation market started to take effect by removing bilateral restrictions on inter-capital flights among the ASENA countries. The full adoption of SAM in Southeast countries took place in January 2015, although some regulations remain in certain markets.
$China_i$ is the dummy variable that equals to 1 if route i flies to mainland China. Inclusion of this dummy variable acknowledges the close political and economic tie between the mainland China and Hong Kong.
$China\_lib_l$ is a dummy variable that captures the impact of China's aviation liberalization on the LCC entry in Hong Kong. The variable equals to 1 for Chinese routes after year 2005, when the private investment in airlines was allowed by the Chinese government.

$year$ is a yearly linear trend variable to capture possible time evolving patterns.

The inclusion of variables $Density_i$ and HHI_i may introduce endogeneity in model estimation, because passenger traffic volume and market shares are affected by LCC entries. One possible solution is to use the data prior to LCC entries. In addition to internal planning, airlines need to coordinate with external partners and authorities to secure airport slots and facilities, report to air traffic control authorities, coordinate with partner/alliance airlines, update ticketing agents and computer reservation systems, and conduct marketing and sales activities. Therefore, although some schedule adjustments are possible, airlines typically revise their flight schedule plans twice a year (i.e. the summer schedule and the winter schedule). Flight schedules in the current season reflect the planning and market conditions in the previous scheduling season. Therefore, lagged values of $Density_i$ and HHI_i from the previous season are largely exogenous to the current LCC entry patterns. Equation (4) is thus used for model estimation:

$$(4) \quad \text{Prob}(LCC\_route_{it} = 1|\boldsymbol{x}) = \text{Prob}\left(\begin{array}{c} -\ln C + \ln\pi^*(Dist_i, Density_i, \\ HHI_i, MarketPo_i, SE\_Asia_i \\ , ASENA_i, China_i, China\_lib_i, year) > 0 \end{array}\middle| \boldsymbol{x}\right)$$

$$= \text{Prob}(-\ln C + \varphi_0 + \varphi_1 \ln Dist_i + \varphi_2 \ln Dist\_2_i + \varphi_3 \ln Density_{it-1} + \varphi_4 \ln HHI_{it-1} + \varphi_5 \ln MarketPo_t + \varphi_6 SE\_Asia_i + \varphi_7 ASENA_{it} + \varphi_8 China_i + \varphi_9 China\_lib_{it} + \varphi_{10} year_t + \mu_i > 0 \,|\boldsymbol{x})$$ [2]

Airlines' 4th quarter schedule in a year is used to construct the dependent variable. Specifically, LCC_route_{it} equals to 1 when there are at least 30 flights scheduled on route i in the 4th quarter of year t. In comparison, the variables of $Density_{it-1}$ and HHI_{it-1} adopt the values in the 2nd quarter of the same year. Other explanatory variables of $MarketPo_t$, SE_Asia_{it}, $ASENA_{it}$, $China_{it}$, $China\_lib_{it}$, and $year_t$ have the same values in the 2nd and 4th quarters of a year. Such a specification controls the possible endogeneity problem in estimation.

Amemiya (1978) proposed to use a Generalized Least Squares (AGLS) estimator to control for endogeneity, which is consistent and asymptotically more efficient than standard two-stage estimators for binary response models (Newey 1987). Such an approach is also tested in our study to estimate the model with endogenous $Density_{it}$ and HHI_{it}, with $Density_{it-1}$ and HHI_{it-1} values in the 2nd quarter as the instruments. Estimation results can be compared with those obtained from the model as specified in Equation (4), so that we can check the influences of the possible endogenous variables, and also validate the robustness of our estimations. The structural AGLS model is specified as in Equation (5):

$$(5) \qquad Y^* = Y^*B + Z\Gamma + \varepsilon \,,$$

with $Y^* = [\pi^*, Density, HHI]'$ and Z being the vector of exogenous variables as described in Equation (4). Equation (5) implies the following reduced form Equation (6):

$$(6) \qquad Y^* = Z\Phi + u \,,$$

where $\Phi = \Gamma(I - B)^{-1}$, and $u = \varepsilon(I - B)^{-1}$. Let $y_1^* = \pi^*$ and $y_{(1)}^* = [\ln Density, \ln HHI]'$. Amemiya's method is a two-stage procedure as follows: in the first stage, the reduced Equation (6) is estimated. The reduced equation π^* can be estimated as a standard probit model, while $\ln Density$ and $\ln HHI$ are estimated with ordinary least squares (OLS). The second stage is to estimate the following structural Equation (7) of our interest:

[2] This econometric model set-up does not allow us to uniquely identify the LCC minimum entry profit threshold C and the constant of the log-profit function φ_0. We obtain the estimate of the sum of $-\ln C + \varphi_0$.

(7) $$y_1^* = y_1^* \beta_1 + Z\gamma_1 + \varepsilon_1.$$

Let $J = [0,1,1]$ be the selection matrix such that $y_{(1)}^* = Y^* J$. It follows from Equations (6) and (7) that

(8) $$y_1^* = Y^* J\beta_1 + Z\gamma_1 + \varepsilon_1 = Z(\Phi J\beta_1 + \gamma_1) + u_1,$$

where $u_1 = uJ\beta_1 + \varepsilon_1$. Let ϕ_1 denote the first column of Φ. Combining Equations (6) and (8), we have Equation (9)

(9) $$\phi_1 = \Phi J\beta_1 + \gamma_1.$$

Let $\widehat{\Phi}$ be the first stage estimate of Φ. Amemiya's method uses a GLS to estimate

(10) $$\hat{\phi}_1 = \widehat{\Phi} J\beta_1 + \gamma_1 + \xi_1$$

Suppose $\sqrt{n}\xi_1 \longrightarrow_d N(0, \Omega_1)$ and $\widehat{\Omega}_1$ is a consistent estimator of Ω_1. The AGLS estimator $\hat{\beta}_1$ and $\hat{\gamma}_1$ are obtained with the following minimum distance estimator in Equation (11), which is equivalent to a GLS estimator:

(11) $$\underset{\beta_1,\gamma_1}{\text{Min}}(\hat{\phi}_1 - \widehat{\Phi}J\beta_1 + \gamma_1)'\widehat{\Omega}_1^{-1}(\hat{\phi}_1 - \widehat{\Phi}J\beta_1 + \gamma_1).$$

4. Econometric estimation and results interpretation

A route market in this study is defined as a non-directional non-stop Origin-Destination (OD) airport pair. Quarterly airline schedule data, which include scheduled seats and frequency for each airline, are compiled for all routes to/from Hong Kong during 2001–2014 using the Official Airline Guide (OAG) database. An LCC entry is defined if at least one LCC has more than thirty scheduled flights on that route in a quarter. This minimum frequency filter rules out charter flights and non-regular services. The HHI Index is calculated using airlines' scheduled seat shares on a route. Density variable is constructed as the sum of scheduled seats by all carriers. The route distance data is also retrieved from the OAG database. Summary statistics of the variables are reported in Table 4.

Table 4. Descriptive Statistics of Sample Data

Variable	Obs	Mean	Std. Dev.	Min	Max
LCC_route	1870	0.099	0.299	0	1
Dist	1870	2,355	2,170	73	8,108
Density_t	1870	71,270	141,809	300	1,222,464
Density_t-1	1870	68,959	138,551	328	1,225,716
HHI_t	1870	6,822	2,890	1,125	10,000
HHI_t-1	1870	6,716	2,910	738	10,000
MarketPo	1870	129,051	33,480	79,439	181,326
SE_Asia	1870	0.17	0.38	0	1
ASENA	1870	0.07	0.26	0	1
China	1870	0.35	0.48	0	1
China_lib	1870	0.21	0.41	0	1

Table 5 presents estimation results obtained from the standard probit model and the AGLS model that corrects the endogeneity problem using the lagged density and HHI variables as instruments. The Smith-Blundell test (1986) for the AGLS model rejected the null hypothesis that $Density_{it}$ and HHI_{it} are exogenous, supporting the use of AGLS estimation. The first stage AGLS estimation results for the reduced equations of $Density_{it}$ and HHI_{it} are summarized in Table A1 in the Appendix. The coefficients of the lagged variables are significant in the first stage, indicating the validity and relevance to use them as instruments.

Table 5. Estimation Results of Alternative Models

	Standard Probit				**AGLS**	
	Coef.	**p>|z|**	**Marginal Effect**	**p>|z|**	**Coef.**	**p>|z|**
lnDist	3.430**	0.018	0.369**	0.016	3.173***	0.003
lnDist_2	-0.273***	0.008	-0.029***	0.007	-0.252***	0.001
lnDensity_t					0.242***	0.009
lnDensity_t-1	0.193***	0.001	0.021***	0.001		
lnHHI_t					-0.602***	0.015
lnHHI_t-1	-0.451***	0.006	-0.049***	0.005		
lnMarketPo	2.510***	0.002	0.270***	0.002	2.415***	0.006
SE_Asia	0.855***	0.000	0.092***	0.000	1.120***	0.000
ASENA	0.247	0.243	0.027	0.243	0.134	0.562
China	-3.720***	0.000	-0.400***	0.000	-3.667	0.981
China_lib	3.679***	0.000	0.395***	0.000	3.743	0.981
year	-0.012	0.764	-0.001	0.765	0.006	0.883
_cons	-15.383	0.835			-48.703	0.520
No. of Obs	1870				1870	
Estimation	Max Likelihood				Min Distance	
Wald chi-sq	2591.7				236.6	
Pseudo R2	0.398					
log pseudo likelihood	-363.500					
Smith-Blundell Wald test of exogeneity					Chi2=21.13 Prob >chi2=	0.000

Note: *** significant at 1% level; ** significant at 5% level.

The estimates obtained for the two models are quite consistent, validating our model specification and estimation procedure. The positive coefficient of $\ln Dist_i$ and negative coefficient of squared $\ln Dist_i$ together revealed a concave effect of route distance on LCC entry in Hong Kong. Specifically, the likelihood of LCC entry increases with distance on routes shorter than 540 miles (870 kilometers)[3], but decreases on longer routes. This is consistent with the LCC entry pattern observed in the US and European markets, which are both deregulated/liberalized (Fu et al. 2010). Such a pattern is partly ascribed to LCCs' diminishing cost advantage over FSAs over longer routes, where a large aircraft brings a significant cost saving per seat.

$Density_i$ and HHI_i have significant and positive coefficients in both models. The interpretation of density is relatively straightforward: LCCs prefer to enter market with large market potential. The interpretation of HHI Index could be more ambiguous: On one hand, this suggests that LCCs are not deterred by the market dominance of incumbent FSAs on highly concentrated routes. In fact, studies in other markets found evidence that some LCCs followed the incumbents, possibly learning from other firms' past entry decisions. Oliveria (2008) noted that Gol Air, a Brazilian LCC, had a route entry pattern to follow legacy carriers. Bresnahan and Reiss (1991) found that with the assumption of contestable market, the number of competitors at equilibrium increases with the market size. Toivanen and Waterson (2005) found a positive effect of rival presence on the probability of entry in the UK fast food industry, which they ascribed to firm learning effects since the presence of rivals increases the estimate of market size. However, it is also possible that market prices in those highly-concentrated routes are high, which attracted LCC entries. Fu et al. (2015) investigated Spring Airlines' entry pattern in the Chinese domestic market. They suggested that the LCC adopted a "cream skimming" strategy to enter high-priced routes, allowing the carrier to achieve both a very high load factor and considerable profitability.

Overall, the market potential explanation seems to receive a better empirical support, as evidenced by the significantly positive $MarketPo_t$ coefficient. That is, despite the shortage of airport capacity, the growing aviation market in Hong Kong still attracted more LCCs in the region. In particular, the LCC sector in Southeast Asia has experienced significant growth in recent years. Moreover, the adjacent geographic location and its well-developed LCC market make the Southeast Asian destinations more likely to be served by LCCs to/from Hong Kong. The liberalization among ASENA countries since 2008 also contributed to LCC market growth, as evidenced by the positive coefficient of the ASENA variable. However, the coefficient is not statistically significant, probably due to the fact that such an on-going liberalization process has been constrained within ASENA countries.

One surprising result of the analysis is that *ceteris paribus*, LCCs are less likely to enter routes linking mainland China and Hong Kong. Incumbent FSAs, notably Cathay Pacific/Dragon Air in Hong Kong and the "Big Three" airlines (Air China, China Southern Airlines, China Eastern Airlines) in mainland China, are all well established in the Hong Kong–mainland markets with high frequencies and large capacities. However, the fact that LCC entry was not deterred by high market concentration suggests that LCCs would otherwise have had significant services in these markets. The coefficient of the China liberalization variable (i.e. *China_lib*) is positive and significant in the standard probit model. Although it is not statistically significant in AGLS estimation, the estimated coefficient is positive and of large value. Therefore, it is fairly clear that LCC entries are positively influenced by deregulation. The negative effects of mainland China's routes and positive effects of deregulation jointly suggested that government policies, mostly in mainland China, have constrained the growth of LCC services, although this problem has been partially addressed by deregulation and liberalization. Fu et al. (2015b) noted that although Chinese FSAs are now among the world's largest airlines in terms of passenger volume, the protective air transport policies have not helped Chinese airlines to achieve global competitiveness in

[3] Destinations in Taiwan, Southern China, part of Philippine, Vietnam, and Thailand are within a radius of 870 kilometers around Hong Kong.

international markets. Fu et al. (2015b) further argued that the Chinese government should progressively liberalize its bilateral ASAs and encourage domestic LCCs to compete in regional markets. Empirical findings in this study support such claims and recommendations.

Summary and conclusions

LCCs in Asia has achieved substantial growth in recent years, bringing significant benefits to the region's travellers and overall economy. Although certain growth patterns are similar to those observed in North America and Europe, LCCs in Asia operate in different environments in terms of regulatory policy, passenger preference, market structure, and airport access. Despite the significant changes LCCs are expected to bring into Asia's aviation markets, few studies have empirically examined these airlines' operation and management strategies. The low-cost sector in Hong Kong has experienced significant growth since the first service offering in 2001 and exhibited huge diversity in terms of destinations, size and service of carriers, and route characteristics. This study aims to provide a better understanding of the region's LCC sector by empirically analysing the LCC entry pattern in Hong Kong. Two alternative models have been tested, namely a standard probit model and an AGLS estimation which controls for possible endogeneity effects.

Overall, the two econometric approaches offered quite consistent findings and implications: (1) Despite the adoption of long-distance low-cost models by both a carrier in Hong Kong and other Asian airlines, geographic distance still plays an important role in LCCs' decisions of entry to Hong Kong. Without many secondary airports to use in the region, Asian LCCs have carefully chosen destinations where they could maintain cost advantages; (2) LCCs have not been deterred by incumbent FSAs' dominance on a route or at an airport, and have a clear preference for high density routes. Since many trunk routes in Asia are linked to hub airports and metropolitan regions, securing sufficient number of airport slots is an issue. Incumbent FSAs often control a large number of "grandfathered" slots and can use larger aircraft where needed. It is difficult for entrant LCCs who use a single type of narrow-body aircraft. One notable example is Haneda Airport in Tokyo, where capacity shortage had limited the growth of LCC services until major expansion project in 2010. AirAsia encountered similar problems when planning services to Beijing. HKIA has already hit capacity limits in many day time intervals. Such an issue can be addressed by timely airport capacity expansion and/or efficient slot allocation (Shen et al. 2015). Since the construction of a third runway at HKIA has already been approved, the Civil Aviation Department of Hong Kong may consider alternative ways to improve the slot allocation process, especially when extra capacities are available (e.g., with the upgrade of Air Traffic Control system and future runway addition). Where appropriate, slot allocation may be considered in conjunction with the liberalization of international markets (Li et al. 2010); (3) Despite the fact that Hong Kong is a Special Administration Region of China, air routes between Hong Kong and mainland China have been difficult markets to penetrate. Although deregulations by mainland China's authorities have alleviated such a problem over the years, there is a need for the Civil Aviation Administration of China (CAAC) to push for further liberalization. LCCs should be given sufficient access to hub airports and also high density routes in domestic and international markets. Many dominant airlines in Asian countries have significant influences over airport slot allocation and international policy (Fu et al 2015b). Therefore, government interventions and regulatory reviews may be needed to ensure that LCCs can compete with incumbent airlines on a level playing field.

Some of the above findings are likely to hold for the region's aviation market in general. Although started late compared to peers in North America and Europe, some Asian LCCs have achieved tremendous growth over the past decade. As of 2011, the market penetration rates of LCC services in Australia, Malaysia, Philippines, South Korea, and Thailand were already higher than the world's average (Homsombat et al. 2011). However, in other Asian markets such as mainland China, Hong Kong, Japan, and Taiwan, LCCs still accounted for relatively small percentage of the market. Our analysis suggests that the dominance of incumbent FSAs and the lack of secondary airports are not critical to the growth of LCCs. However, government regulations and airport access are main impediment factors. It is important for regulators in the region to liberalize aviation markets, provide sufficient airport capacity, and promote efficient allocation of airport slots. These would allow air passengers in both metropolitan areas and smaller cites to enjoy the benefits of low–cost travel.

Although the use of alternative estimation approaches helps the control of possible endogeneity issue, due to data limitation we were forced to estimate LCCs' entry patterns with pooled schedule data. Such a procedure implies the assumption that LCCs in our sample had similar decision-making processes for route entry. With expanded LCC services in the years to come, it will be useful to conduct airline-specific analysis when larger datasets are available. Where airfare data can be obtained, it will be valuable to complement entry study with airfare change analysis. In addition, it would be useful to include proxy variables for specific regulations and airport slots constraints, thus some of our conclusions can be more directly and clearly supported. Because there are many country-pairs in our sample and most Asian countries do not reveal the details of bilateral ASAs, we were not able to control specific aviation regulations in the empirical estimation. This forced us to make judgements based on our understanding of country-specific policies on international markets. With more detailed information of regulatory constraints (e.g. regulations on route entry, airline designation, seat capacity, airfares, airport access and slots, etc.), our conclusions can be more directly tested and validated by empirical analysis. More specific policy recommendations can also be offered. Our study provides a timely update of the LCC sector in Asia's international markets. There is a need for more comprehensive and rigorous analysis when better data are available to researchers.

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Appendix A. Estimation results - AGLS first stage estimation.

Table A1. AGLS first stage estimation for reduced equations

of $lnDensity_{it}$ and $lnHHI_{it}$

lnHHI_t	**Coef.**	**P>t**	**lnDensity_t**	**Coef.**	**P>t**
lnHHI_t-1	0.868***	0.000	lnDensity_t-1	0.734***	0.000
lnDensity_t-1	-0.028***	0.000	lnHHI_t-1	-0.442***	0.000
lnDist	-0.180***	0.003	lnDist	-0.257*	0.065
lnDist_2	0.014***	0.001	lnDist_2	0.008	0.391
lnMarketPo	-0.039	0.574	lnMarketPo	0.359**	0.029
SE_Asia	0.046**	0.012	SE_Asia	-0.015	0.715
ASENA	-0.055**	0.020	ASENA	-0.006	0.916
China	0.032*	0.088	China	0.128***	0.004
China_lib	0.002	0.895	China_lib	-0.176***	0.000
year	0.005	0.212	year	-0.006	0.471
_cons	-6.648	0.305	_cons	10.783	0.478
No. of Obs	1870		No. of Obs	1870	
R-squared	0.854		R-squared	0.880	
F statistics	1085.7		F statistics	1368.5	

Note: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.