Journal of Asian Economics, 22 (2011) 203–212

Air cargo transport in APEC: Regulation and effects on merchandise trade

Massimo Geloso Grosso, OECD.

Ben Shepherd, Principal.

March 13, 2011.

developing trade consultants
policy • research • capacity building

349 5th Avenue
New York, NY 10016
Ben@Developing-Trade.com

Journal of Asian Economics 22 (2011) 203–212

Contents lists available at ScienceDirect

Journal of Asian Economics

Air cargo transport in APEC: Regulation and effects on merchandise trade☆

Massimo Geloso Grosso [a], Ben Shepherd [b,*]

[a] OECD Trade and Agriculture Directorate, Paris, France
[b] Developing Trade Consultants Ltd., New York, United States

ARTICLE INFO

Article history:
Received 3 April 2010
Received in revised form 25 February 2011
Accepted 27 February 2011
Available online 13 March 2011

JEL classification:
F13
F15
L93

Keywords:
Asia-Pacific
Trade policy
Air transport

ABSTRACT

This study aims at assessing the link between a more liberal air cargo regime and increased bilateral merchandise trade in the Asia Pacific region, under the auspices of APEC. Results from a gravity model using the Air Liberalisation Index (ALI) developed by the WTO Secretariat provide strong support for two hypotheses. First, more liberal air services policies are positively, significantly and robustly associated with higher bilateral trade in merchandise. The results also show that air transport policy matters more for some sectors than for others. A particularly strong relationship is found between bilateral liberalisation and trade in manufactured goods, time sensitive products, and parts and components. Prior to taking account of general equilibrium effects, the estimates imply that a one point increase in the ALI is associated with an increase of 4% in bilateral parts and components trade, which is the sector found to be most sensitive to the degree of aviation liberalisation. These findings have important policy implications. In particular, economies actively seeking greater integration in international production networks could greatly benefit from a more liberal aviation policy regime.

1. Introduction

Since the 1980s, with the reduction of tariffs and other trade barriers, there has been a marked trend towards international integration of economic activity. This has resulted in large volumes of products, raw materials and components flowing across international borders as part of global supply chains. Advanced manufacturing requires a complex international network of assembly and production sites, shipping parts from one location to the other, and often back to its origin following processing and assembling of products.[1] Emerging economies in the Asia-Pacific region, in particular, have been at the centre of location strategies by multinational firms in sectors such as electronics and clothing to take advantage

☆ Trade policy analyst in the OECD Trade and Agriculture Directorate; Principal, Developing Trade Consultants. Comments to: Massimo.Geloso-Grosso@OECD.org and Ben@Developing-Trade.com. The views expressed are those of the authors and should not be attributed to the OECD or any other organisation to which they are associated. The authors wish to express their gratitude to Pierre Latrille and Antonia Carzaniga at the WTO for their support in making this paper possible. The authors are also grateful to Patrick Jomini and Pascal Achard for initial discussions and comments during the preparation of the study.

* Corresponding author. Tel.: +1 2024136128.
E-mail address: ben@developing-trade.com (B. Shepherd).

[1] Exports of manufactured products, particularly in industries characterised by international production sharing, contain a considerable amount of imports. In 2001, for example, the import content represented 32% of export value in the electronics sector in China, 65% in Thailand and 72% in the Philippines (Nordås, Pinali, & Geloso Grosso, 2006).

1049-0078/$ – see front matter
doi:10.1016/j.asieco.2011.02.004

of lower labour and material costs. For example, through the 1990s Philips Semiconductor and Dell Computer benefited significantly in terms of cost and shipping time reduction by locating sourcing operations respectively in Thailand and Malaysia (Kasarda, Green, & Sullivan, 2004).

Underlying these developments is also the emergence of a new commercial environment in which time is playing an increasingly important role for competitive success. A prominent advance in production, distribution and inventory control methods is commonly known as ''just-in-time'', under which all elements in the value chain are synchronised to decrease production and delivery cycles and reduce inventories. The logic behind just-in-time operations is that inventory costs have become prohibitively high in the production and distribution of many manufacturing products in the new global economy. Early delivery can increase warehousing and inventory expenses, while late delivery can result in costly interruptions of production and foregone sales. Product life spans are also shortening in several industries, such as electronics, pharmaceuticals and designer clothes.

The speed and enhanced reliability of air cargo play an essential role in the implementation of international production networks and just-in-time supply chain management. According to IATA, air cargo currently accounts for 35% of the value of world trade (IATA, 2006) and the share is considered to be higher in the Asia-Pacific region. Advanced manufacturing firms are also increasingly locating at sites near air cargo hubs to optimise their location strategies. In many Asian economies, these developments have helped foster investment in aviation infrastructure. Airports in Kuala Lumpur, Singapore and Thailand's new Bangkok International Airport are setting world standards for security and efficiency, operating round the clock. China has made remarkable infrastructure investments in its busiest airports, with major expansions in Beijing, Guangzhou and Shanghai (Senguttuvan, 2006).

The existing regulatory framework that governs the air cargo industry, which was set forth in the Chicago Conference of 1944, is under increasing pressure to keep pace with worldwide trade and economic expansion. The international regulatory system prevents free route development, network optimisation and flexible service design by different categories of providers. Air cargo carriers have different needs than passenger carriers. The unbalanced nature of cargo flows often requires a second or third stop in order to make routes profitable. Flexibility in the provision of air cargo services has become increasingly necessary as part of today's internationally fragmented supply chains and just-in-time manufacturing practices. Other restrictions affecting carriers' operations, such as diversification into ancillary services, constrain the provision of integrated air cargo services.

The objective of this study is to examine the link between a more liberal air cargo regime and increased bilateral trade in the Asia-Pacific region, under the auspices of APEC. The next section provides some background on the regulation of air cargo services in APEC economies, followed by estimates on the sensitivity of different types of merchandise trade in APEC to the liberalisation of air cargo services. The last section concludes.

2. Background on the regulation of air cargo services in APEC

Fig. 1 below presents the average level of aviation openness for APEC economies, as proxied by the Air Liberalisation Index (ALI) developed by the WTO Secretariat,[2] indicating that the US, Chile and New Zealand have the most open regimes, while China and Russia are among the most restrictive. In general, the regime accorded to cargo flights is more liberal than for passenger flights. For instance, in recent years several bilateral air service agreements (ASAs) have incorporated more flexible capacity regimes for cargo services, e.g. through negotiated incremental capacity increases. Ownership and control regulation is also more flexible in the case of cargo services, since there is often no need to protect the national flag. In addition, different categories of air cargo providers are not subject to the same regulatory mechanisms. A case in point is pricing provisions, which tend to affect different categories of providers to varying degrees. On certain routes, for example, integrated express providers are free to set their own rates with limited if any government intervention.

Yet, the business community has repeatedly called for continued reform of the existing regulatory framework to ensure that it is better suited to the specific characteristics of air cargo. This is evident in relation to traffic rights. To meet the needs of their manufacturing customers and operate efficiently in hub-and-spoke systems, modern air cargo services increasingly require the ability to route cargo and operate capacity as trade volumes dictate, picking up and dropping off cargo at any point along that route. As such, to provide flexibility for planning air cargo services, the capacity to exercise 5th and 7th freedom traffic rights is considered particularly important. By allowing for triangular operations and improved return traffic possibilities, these rights would also take better account of the fact that air cargo flows are often unbalanced. Similarly, the ability to operate charters represents a significant source of flexibility for the air cargo industry, particularly in responding to seasonal peak loads.

Air cargo carriers are also constrained by a range of other regulations affecting their operations. Foreign ownership restrictions are typically in place preventing foreign carriers from gaining a controlling interest in domestic airlines. Air carriers may not be permitted to diversify into complementary air cargo functions, such as ground transportation and warehousing. Laws in some countries restrict ground handling to particular firms or the airport authority, or prevent airlines from offering such services. For example, in Hong Kong air cargo carriers must use one of three franchise companies for cargo

[2] The value of the ALI ranges between zero for very restrictive agreements, and 50 for very liberal ones (WTO, 2006). The bilateral scores have been averaged here (with available data for partner countries) to present indicators of restrictiveness by country.

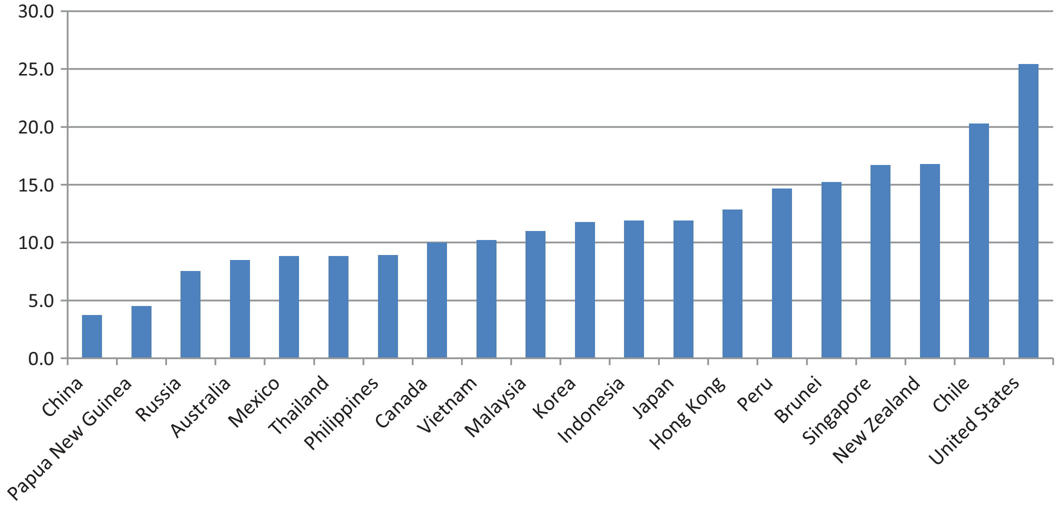

Fig. 1. Average levels of aviation openness by APEC economy.
Source: WTO.

loading. In other countries such as Australia, China and Indonesia airlines are prohibited from providing their own ground handling services. The time required for customs to clear air cargo in airports represents another prominent hindrance to service providers.

3. Sensitivity of merchandise trade to the liberalisation of air cargo in APEC

3.1. Literature review

Despite the growing importance of the air cargo sector as a facilitator of international trade, little formal research has analysed the impact of liberalisation (or lack thereof) on trade flows. A number of empirical studies have analysed the effects of transport costs on trade flows, at times specifically incorporating air shipping costs. A widely used framework for analysis is the gravity model, which describes bilateral trade as a function of GDP, distance and other geographical and institutional variables. Limao and Venables (2001) employ a gravity model that explicitly includes transport costs, in addition to distance, to analyse bilateral trade flows. The study finds that a 10% increase in transport costs reduces trade volumes by 20%.

Hummels (2001) explicitly takes account of the effects of transport time in a detailed study of US imports. He finds that an increase of shipping time of one day reduces the probability of exports to the US by 1% (for all goods) and 1.5% (for manufactured goods). The study includes direct estimates of the tariff equivalents of time and finds that air shipping cost declines are equivalent to reducing tariffs on manufactured goods from 32% to 9% ad-valorem. Nordås et al. (2006) extend Hummels' analysis and estimate the impact of time on the probability to export and on trade volumes to Australia, Japan and the UK. The authors find that time has a large and robust impact on the probability to export, and the impact is strongest in the electronics sector. Time also has a large impact on trade volumes, and again the effect is greater for electronics.

The US International Trade Commission undertook a broad investigation of logistics services covering a wide range of restrictions affecting different segments of the industry, including air cargo (US ITC, 2005). The study found that both US merchandise exports and foreign merchandise exports shipped through the US are sensitive to the availability and quality of logistics services in the importing country. Lower levels of trade impediments related to logistics services in the importing country, especially with respect to airports, seaports, and customs procedures, are associated with higher US merchandise exports. The effects on international trade are most robust for US airborne exports, since they tend to be made up of time-sensitive products. In another study, Wilson, Mann, and Otsuki (2005) use a gravity model to show that trade facilitation, including the efficiency of air transport markets, can play a major role in promoting trade.

Work on the potential impact of reforming the air transport industry specifically has so far focused on passenger services, with very few studies examining the air cargo component. Using simple correlation analysis, Kasarda et al. (2004) report a statistically significant relationship between aviation liberalisation (defined as the number of existing bilateral agreements) in 63 nations and the volume of air cargo. Micco and Serebrisky (2004) analyse the effects of open skies agreements signed by the US with its aviation partners on air transport costs. The study finds that the long-term effect of signing these agreements is to reduce air freight costs by around 8%.

More recently, Achard (2009) employed a gravity model to estimate the impact of regulation on air cargo flows, using data collected by IATA on the top 100 routes worldwide between 2002 and 2007. The analysis employs the CALI as a cargo-based variant of the WTO ALI, which is built by using both expert judgment and statistical techniques. In particular, it uses principal component analysis as pioneered by Gonenc and Nicoletti (2000) and more recently applied again to air passenger services by Piermartini and Rousova (2008). The study provides evidence that air transport liberalisation is associated with larger bilateral cargo flows.

3.2. Methodology

This paper extends previous empirical work in two directions. First, it uses the WTO's ALI to investigate the impact of aviation policy on bilateral trade in APEC. The ALI has previously been used to analyse the determinants of bilateral air passenger traffic (Geloso Grosso, 2008; Piermartini & Rousova, 2008), with Achard (2009) being the only study so far applying (a variant of) it to air cargo. The approach here differs from Achard's in that the analysis focuses on a single region (APEC) in which air transport is particularly important, and it uses bilateral trade data rather than cargo flows as the dependent variable. Even though the ALI has in principle been developed for passenger traffic, most segments of air cargo are also governed by the bilateral air transport system and a significant amount of merchandise travels as belly cargo on passenger services.[3]

Furthermore, the use of bilateral trade data as the dependent variable makes it possible to examine the potential for air liberalisation to affect some sectors more strongly than others. Due to data limitations, past work has not been able to do that. In particular, this paper uses previous results from the international trade literature to separate time sensitive and time insensitive goods, and parts and components from final goods trade. In the Asia Pacific region there is good reason to expect that access to affordably priced and reliable air transport services is most important for manufacturers of time sensitive goods, and parts and components.

Against this background, the standard gravity model of bilateral goods trade is employed in this study to test two hypotheses:

1. Greater bilateral air transport liberalisation, as measured by the ALI, is associated with larger bilateral trade flows.
2. Air transport liberalisation has a stronger effect on trade in sectors such as time sensitive goods and parts and components, than on others such as time insensitive goods and final products.

3.2.1. The gravity model

The empirical analysis here uses a version of the Anderson and Van Wincoop (2003) gravity model. The gravity model is the workhorse of the applied international trade literature. It is well suited to this analysis because it allows for bilateral trade costs to play an important role in determining the observed pattern of international trade flows. It is consistent with the model's theoretical underpinnings to introduce data on the degree of aviation liberalisation on each bilateral route as one determinant of bilateral trade costs. The two hypotheses set out above follow directly from the intuition that air transport liberalisation can be expected to reduce trade costs, and to do so more significantly for time sensitive sectors.

First, a gravity model is estimated for APEC economies using data on total imports (i.e. summing over sectors) as the dependent variable. The model takes the following form:

$$\log(X_{ij}) = \log(E_j) + \log(Y_i) - \log(Y) + (1-\sigma)\log(t_{ij}) - (1-\sigma)\log(P_j) - (1-\sigma)\log(\Pi_i) + \varepsilon_{ij} \quad (1)$$

where X_{ij} is exports from country i to country j, proxied here by better-quality import data; E_j and Y_i are respectively country j's expenditure and country i's production; Y is worldwide output; σ is the intra-sectoral elasticity of substitution (i.e. the elasticity of substitution among product varieties within a sector); t_{ij} is the bilateral trade cost function; and ε_{ij} is a residual satisfying standard assumptions. The two terms $(P_j)^{1-\sigma} = \sum_{i=1}^{N} \Pi_i^{\sigma-1}\omega_i(t_{ij})^{1-\sigma}$ and $(\Pi_i)^{1-\sigma} = \sum_{j=1}^{N} P_j^{\sigma-1}\omega_j(t_{ij})^{1-\sigma}$, with ω_i being the country's share in global (N countries) output or expenditure, represent respectively inward and outward multilateral resistance. The first of these terms captures the dependence of j's imports on trade costs across all suppliers, while the second captures the dependence of i's exports on trade costs across all destination markets.

Anderson and Van Wincoop (2003) show that inclusion of the multilateral resistance terms in the model is vital in order to ensure unbiased parameter estimates, and to take account of general equilibrium effects in counterfactual simulations. However, it is not necessary to estimate these complex, non-linear functions of trade costs and prices directly. Consistent estimates of the parameters of the trade cost function, which is the main point of interest here, can be obtained by including appropriate dimensions of fixed effects. In the simple case of a single sector (e.g. total imports), fixed effects by exporter and importer control for the size of each economy, as well as inward and outward multilateral resistance. The model becomes:

$$\log(X_{ij}) = c + \sum_{i=1}^{N} d_i + \sum_{j=1}^{N} f_j + (1-\sigma)\log(t_{ij}) + \varepsilon_{ij} \quad (2)$$

where the d and f terms are, respectively, exporter and importer fixed effects.

[3] The CALI developed by Achard (2009) could not be employed since it is not available for enough routes in the sample used here. Achard (2009) also reports that simple correlation coefficients between the ALI and the CALI for selected routes range from 0.6 to 0.9 depending on the weighting scheme used. Thus, the ALI can be considered as an acceptable proxy for policy restrictions affecting cargo. In any case, the gravity model employed in this study will give consistent estimates of the impact of aviation policy on trade provided that the measurement error associated with the ALI is not systematically related to noise in the trade data, which is unlikely.

All that remains is to specify the trade cost function t. To do this, the analysis uses the ALI and a set of control variables that are standard in the gravity modelling literature: distance as a proxy for transport costs; a geographical contiguity (common border) dummy; a common language dummy; a common coloniser dummy; a dummy for the existence of a colonial relationship between two countries; and bilateral tariffs. Thus:

$$\log(t_{ij}) = b_1\text{ALI}_{ij} + b_2\log(1+\text{tariff}_{ij}) + b_3\log(\text{dist}_{ij}) + b_4\text{border}_{ij} + b_5\text{language}_{ij} + b_6\text{comcol}_{ij} + b_7\text{colony}_{ij} \quad (3)$$

Since the interest here is in identifying sector-specific impacts of air transport liberalisation, in addition a version of the gravity model is needed that can be used with sectoral data. Such a model is given by a simple rearrangement of (1), in which k indexes sectors, and the model parameters are allowed to vary across sectors.

$$\log(X_{ij}^k) = \log(E_j^k) + \log(Y_i^k) - \log(Y^k) + (1-\sigma_k)\log(t_{ij}^k) - (1-\sigma_k)\log(P_j^k) - (1-\sigma_k)\log(\Pi_i^k) + \varepsilon_{ij}^k \quad (4)$$

3.2.2. Estimation issues

Traditionally, gravity models such as the one set out here have been estimated by ordinary least squares (OLS). However, recent work by Santos and Tenreyro (2006) shows that OLS estimates can be highly unreliable in this type of log-linearised model when the error term in the original non-linear model is heteroskedastic. Unlike standard heteroskedasticity, which can lead to bias in the estimated variance–covariance matrix only, the type of heteroskedasticity identified by Santos and Tenreyro (2006) can produce serious bias in the coefficient estimates as well. To deal with this problem, the authors suggest using the Poisson pseudo-maximum likelihood (PPML) estimator. Poisson produces consistent parameter estimates under relatively weak assumptions (the data need not follow a Poisson distribution) and is robust to the multiplicative heteroskedasticity investigated by Santos and Tenreyro (2006).[4]

The question of whether a particular dataset is subject to the type of heteroskedasticity that can be dealt with by Poisson estimation is, of course, an empirical one. To test whether the OLS log-linearised model is appropriate, the fitted values from Poisson regressions are used to perform a Park test (Santos and Tenreyro, 2006, Eq. (11)). The null hypothesis for that test is that the OLS model is adequate. Next, the fitted values are again used to test the null hypothesis that the PPML model is adequate (Santos and Tenreyro, 2006, Eq. (13)).

In all cases, strong evidence is found that OLS is an inappropriate estimator: the null hypothesis is rejected at the 1% level. By contrast, the second test statistic rejects the null hypothesis of Poisson in one baseline regression (10%), and three robustness regressions (10% or 5%). Following the logic of Santos and Tenreyro (2006), these results suggest that Poisson should clearly be the workhorse estimator for this dataset. Even in the four outlier cases mentioned, the PPML estimator will still provide consistent parameter estimates, even though they could conceivably be made more efficient by adopting a different heteroskedasticity assumption. In what follows, the analysis therefore reports Poisson results only, and includes the probability values associated with both sets of test statistics.

3.3. The dataset

The policy variable for the empirical analysis is the ALI developed by the WTO Secretariat (WTO, 2006). The effective date for the index is 2005; that is also the base year for the regressions here, which are necessarily cross-sectional. The ALI is calculated by selecting the provisions of bilateral ASAs deemed to be particularly important for market access and assigning a score between zero and 8 to each restriction. Zero indicates the most restrictive measure and eight the least restrictive. These scores are then averaged in consultation with a group of experts using weights intended to reflect the relative importance of each restriction. The ALI is the sum of the weighted scores obtained by a given ASA, and ranges between zero for very restrictive agreements and 50 for very liberal ones.

The scores attributed can also be altered to take into account the specific situation of a country pair, in particular by giving more weight to: (1) fifth freedom traffic rights (e.g. for geographically remote countries such as Australia and New Zealand); (2) withholding, in particular community of interest and principal place of business; and (3) multiple designation. It is important to note that the ALI is a bilateral measure applied to each ASA. For example, the Australia-New Zealand air link has a different ALI score from Australia–USA due to the existence of independent agreements in each case. In the regressions that follow, the ALI is used in this raw, bilateral form; it is not averaged across importers or exporters.

The dependent variable is bilateral trade between APEC economies. These data are sourced from the United Nations COMTRADE database, accessed via the World Bank's WITS interface. Import data are supplemented by mirror (export) data in the case of missing values. The small number of observations (approximately 2%) for which neither import nor export data are available are coded as zero. Great circle distance and the other geographical and institutional variables are from the CEPII distance dataset.[5] Bilateral effectively applied tariffs are sourced from UNCTAD's TRAINS database via WITS.

---

[4] Another advantage of the PPML estimator is that observations for which trade is zero can be included in the estimation sample. In the present case, however, very few observations fall into this category; Poisson is used primarily as a means of dealing with heteroskedasticity. The criticisms that have been leveled at the PPML estimator as a means of dealing with zeros—e.g. Helpman et al. (2008), Martin and Pham (2009), Martinez-Zarzoso, Nowak-Lehmann, and Vollmer (2006)—are therefore much less relevant here.

[5] These data are freely available at http://www.cepii.fr/anglaisgraph/bdd/distances.htm.

Table 1
Baseline regression results – PPML, reporter and partner fixed effects (2005).

	1 Aggregate	2 Manufacturing	3 Agriculture	4 Time sensitive	5 Time insensitive	6 Parts and Components	7 Final goods	8 Parts and components
ALI	0.013	0.014*	0.004	0.017*	0.020	0.040***	−0.001	
	[0.008]	[0.008]	[0.017]	[0.010]	[0.013]	[0.009]	[0.009]	
Ln (1 + tariff)	−5.387***	−5.172***	−4.907**	−2.585	−7.720***			
	[1.706]	[1.515]	[2.260]	[2.428]	[2.315]			
Ln (distance)	−0.548***	−0.599***	−0.717***	−0.537***	−0.722***	−0.802***	−0.634***	−0.803***
	[0.045]	[0.046]	[0.081]	[0.078]	[0.090]	[0.076]	[0.060]	[0.076]
Common border	0.379**	0.085	0.783***	−0.147	0.135	−0.577**	0.026	−0.739***
	[0.165]	[0.153]	[0.256]	[0.251]	[0.249]	[0.251]	[0.202]	[0.258]
Common language	0.041	0.055	−0.103	0.017	−0.139	0.258**	0.106	0.340***
	[0.097]	[0.095]	[0.180]	[0.109]	[0.190]	[0.114]	[0.101]	[0.128]
Common coloniser	0.316	0.354	0.104	0.151	0.580*	0.226	0.179	0.333
	[0.300]	[0.268]	[0.499]	[0.279]	[0.345]	[0.298]	[0.344]	[0.275]
Colony	−0.295**	−0.134	−0.150	0.062	0.151	−0.095	−0.361*	−0.001
	[0.121]	[0.106]	[0.248]	[0.111]	[0.211]	[0.183]	[0.193]	[0.179]
5th freedom								0.416***
								[0.123]
7th freedom								0.533***
								[0.200]
Multiple designation								0.419***
								[0.152]
Free determination								−0.095
								[0.118]
Free pricing								1.642***
								[0.228]
Cooperative agrt.								0.361***
								[0.132]
PPOB								−1.348***
								[0.420]
Observations	240	240	240	239	237	248	248	248
R^2	0.969	0.967	0.985	0.953	0.991	0.985	0.981	0.987
Prob. (H0: OLS)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Prob. (H0: Poisson)	0.471	0.234	0.498	0.054*	0.579	0.877	0.198	0.960

Note: Robust standard errors corrected for clustering by country pair are reported in brackets. Statistical significance as follows: ***(1%), **(5%), and *(10%).

3.4. Regression results

Table 1 presents the baseline estimation results. Column 1 uses total imports (Eqs. (1) and (2)) above. The model performs strongly, accounting for 97% of the variation in bilateral trade.[6] The coefficient on aviation liberalisation as measured by the ALI is positive, which is in line with expectations. It is only marginally significant at the 10% level (prob. = 0.103). Its magnitude suggests that, as an impact measure, a one point increase in the ALI score of a given ASA is associated with a 1.3% increase in bilateral trade; however, this assessment does not account for general equilibrium effects.

The signs and magnitudes of the control variables are largely in line with expectations as well: distance and tariffs have negative and 1% significant coefficients, while geographical contiguity has a positive and 5% significant coefficient. The only exception is the colonisation dummy, which is negative and statistically significant. However, this variable is only equal to unity in six observations (2.5% of the sample). This is unlikely to constitute a sufficient amount of variation to support valid inference; indeed, the colony dummy is statistically insignificant in nearly all other regressions reported here. Its unexpected sign is therefore not a major issue in interpreting the results.

Results using total imports may mask important cross-sectoral differences. Hummels (2001) shows that some goods are more time sensitive than others, either due to their physical characteristics, or possibly the way in which their production process is managed. To examine these possibilities further, a number of sectoral splits are exploited in the data by estimating separate models for different classes of goods (see Eq. (3) above). Treating the data in this way allows the researcher to account for possible cross-sectional heterogeneity that might affect results using total imports, due to the fact that multilateral resistance varies across sectors, as does the intra-sectoral elasticity of substitution. At the same time, this approach makes it possible to exploit differences in product characteristics, including time sensitivity, to ensure the robustness of the first hypothesis and to test the second one.

Results from the first sectoral split, manufacturing (HS chapters 25–97) versus agricultural products (HS chapters 1–24), are in columns 2 and 3 of Table 1. The ALI is positively and significantly (10%) associated with bilateral trade flows in

6 The R^2 is calculated as the square of the correlation between actual and fitted values from the Poisson regression.

manufactured goods. In the case of agricultural products, though the association is still positive, it is considerably smaller in magnitude and statistically insignificant. Since the semi-elasticity for manufactures is nearly identical in magnitude to the coefficient on the ALI in the total imports regression, it can be concluded that the bulk of the trade effects of air liberalisation in APEC passes through industrial products rather than agriculture. This finding seems intuitive given the importance of trade in manufactured goods within the region, as well as the relatively high levels of agricultural protection in many APEC countries.

Next, the analysis follows Djankov, Freund, and Pham (2010) and trade in manufactured goods is unpacked into two sub-sectors: time sensitive and time insensitive products. To do so, the results from Hummels (2001) are used, coupled with the product lists contained in Table 7 of the working paper version of Djankov et al. (2010). Under this approach, time sensitive and insensitive products are defined using the three two-digit SITC categories that exhibit the highest and lowest degrees of time sensitivity according to Hummels (2001).[7] Again, the regression results tend to support the second hypothesis: the coefficient on the ALI is positive and 10% significant in the case of time sensitive goods, but it is statistically insignificant for time insensitive products. Nevertheless, the difference between the two coefficients is not large and the ALI coefficient in the time insensitive goods equation is significant at the 15% level. Thus, results from this sectoral split are not as strong as anticipated. However, they are consistent with the observation that time insensitive goods would generally not tend to travel by air, hence the insignificance of the ALI coefficient.

As a final sectoral separation, trade in parts and components is considered versus trade in final goods. Ando and Kimura (2003) show that the rise of production networking, with its reliance on moving parts and components across borders quickly and reliably, has been a remarkable characteristic of trade relations in East Asia over recent years. Given the importance of low inventory carrying costs and just-in-time management techniques in creating and sustaining networked production, the speed at which trade takes place can be critical. It therefore seems plausible that parts and components might be more sensitive to aviation policy liberalisation than final goods, since air transport is a ready means of moving parts and components quickly within a production network.

To define parts and components versus final goods, the product lists compiled by Ando and Kimura (2003) are used here. Results are presented in columns 6 and 7 of Table 1. In this case, the data strongly support the second hypothesis. The ALI coefficient is positive and 1% significant for parts and components trade. Its magnitude is at least double that of the coefficients in the previous columns of Table 1: a one point increase in the ALI is associated with an increase of 4% in bilateral parts and components trade, prior to taking account of general equilibrium effects. By contrast, the ALI coefficient for final goods trade is statistically insignificant. Moreover, the difference between the estimated ALI coefficients in the two equations is statistically significant at the 5% level, which suggests that the impact of air liberalisation on parts and components trade is more important than for trade in final goods.

The previous regressions provide evidence that there is an economically and statistically significant association between aviation liberalisation and goods trade, but they do not allow identification of the effects of particular measures. To examine this question in more detail, a final regression is run using the parts and components data, in which the different policy elements of the ALI are entered separately. The ALI is replaced with a series of dummies equal to unity if particular policies are included in an ASA. There is sufficient variation in the data to allow separate identification of the impacts of: fifth freedom rights; seventh freedom rights; multiple airline designation; free determination of capacity; free pricing; allowing cooperative agreements among airlines; and provision for principal place of business.

Results from this exercise are shown in column 8 of Table 1. With only two exceptions, the individual policies carry positive and statistically significant (1%) coefficients with sensible magnitudes. Thus, liberalisation along each of these dimensions is associated with more bilateral trade. The effect is especially strong for free pricing, which indicates that this is a particularly important policy from a trade point of view. However, granting fifth and seventh freedom rights, as well as multiple designation and allowing cooperative agreements among airlines, also have economically significant impacts.

The only exceptions in column 8 of Table 1 are free determination of capacity and the provision for principal place of business. In the former case, the coefficient is statistically insignificant. In the latter case, however, the coefficient is negative and significant at 1% level. The negative sign may be due to fact that, unlike the other regulatory components which are full liberalisation measures, principal place of business is still a restriction (although less burdensome than other withholding measures). This result however will require further investigation.

3.4.1. Robustness checks

The regressions presented above are estimated using all APEC country pairs for which the ALI has been calculated. However, not all of these countries in fact have an existing bilateral air link. In some cases, passengers and cargo must transit through a regional hub, such as Singapore, before reaching their final destination. As a result, a bilateral measure like the ALI might be a more meaningful indicator of trade costs for country pairs that have a direct air link. If the first hypothesis above is correct, one would expect to see stronger evidence of a link between the ALI and bilateral trade when the sample is limited to country pairs with a direct air link only.

[7] Time sensitive products are defined as: office machines (SITC code 75), electrical machinery (77), and photographic apparatus (88). Time insensitive products are: textile yarns and fabrics (65), non-metallic minerals (66), and furniture (82).

Table 2
Robustness checks using country-pairs with a direct air link only – PPML, reporter and partner fixed effects (2005).

	1 Aggregate	2 Manufacturing	3 Agriculture	4 Time sensitive	5 Time insensitive	6 Parts and components	7 Final goods
ALI	0.024***	0.019**	0.022	0.022**	0.027*	0.045***	0.000
	[0.008]	[0.008]	[0.019]	[0.010]	[0.014]	[0.009]	[0.009]
Ln (1 + tariff)	−7.134***	−6.669***	−3.922	−5.007**	−6.355**		
	[2.254]	[1.859]	[2.833]	[2.377]	[3.164]		
Ln (distance)	−0.559***	−0.605***	−0.726***	−0.511***	−0.732***	−0.780***	−0.629***
	[0.040]	[0.043]	[0.079]	[0.071]	[0.094]	[0.065]	[0.060]
Common border	0.218	−0.033	0.639**	−0.236	0.083	−0.606***	−0.022
	[0.159]	[0.149]	[0.274]	[0.227]	[0.260]	[0.214]	[0.202]
Common language	0.005	0.037	−0.193	−0.053	−0.185	0.170*	0.065
	[0.094]	[0.095]	[0.212]	[0.112]	[0.200]	[0.102]	[0.104]
Common coloniser	0.526*	0.479*	0.273	0.297	0.605*	0.362	0.221
	[0.291]	[0.257]	[0.535]	[0.259]	[0.358]	[0.282]	[0.341]
Colony	−0.324***	−0.151	−0.190	0.043	0.149	−0.117	−0.361*
	[0.112]	[0.108]	[0.211]	[0.112]	[0.218]	[0.161]	[0.198]
Observations	198	198	198	198	196	206	206
R^2	0.971	0.967	0.974	0.910	0.982	0.974	0.963
Prob. (H0: OLS)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Prob. (H0: Poisson)	0.534	0.276	0.193	0.108	0.692	0.735	0.283

Note: Robust standard errors corrected for clustering by country pair are reported in brackets. Statistical significance as follows: ***(1%), **(5%), and *(10%).

To investigate this possibility further, the regressions in the first seven columns of Table 1 are re-estimated limiting the sample to only those country pairs with an existing bilateral air service (see Table 2). As expected, the ALI coefficient is greater in all seven regressions than in the corresponding regressions from Table 1. Statistical significance has also increased in most cases. Once again, the effect of aviation liberalisation on trade is particularly strong for manufactured goods, especially parts and components. These additional results provide strong support for both hypotheses outlined above.

Another dimension in which robustness checks are important is the measurement of policy restrictiveness. The ALI has much to commend it as an indicator of liberalisation in aviation markets. It is based on professional judgment as to the relative restrictiveness of different measures, and has also been shown to correspond closely with alternative weighting methodologies such as factor analysis (Piermartini & Rousova, 2008). The possibility remains, however, that the relative economic impacts of different policies might be better captured with an alternative set of weights. As the results in this study using disaggregated policy measures suggest, there may be considerable variance across restrictions.

To examine whether the findings are robust to these further considerations, the model is re-estimated using the three variants of the ALI discussed above. Results are presented in Tables 3 and 4, using total imports, and data for the sectors found

Table 3
Robustness checks using variants of the ALI with aggregate trade and manufacturing – PPML, reporter and partner fixed effects (2005).

	1 Aggregate	2 Aggregate	3 Aggregate	4 Manufacturing	5 Manufacturing	6 Manufacturing
ALI 5th	0.018**			0.018***		
	[0.007]			[0.007]		
ALI designation		0.013*			0.014*	
		[0.008]			[0.007]	
ALI ownership			0.015			0.016*
			[0.009]			[0.009]
Ln (1 + tariff)	−5.229***	−5.456***	−5.379***	−4.957***	−5.238***	−5.155***
	[1.705]	[1.702]	[1.706]	[1.428]	[1.519]	[1.514]
Ln (distance)	−0.565***	−0.545***	−0.548***	−0.621***	−0.595***	−0.599***
	[0.046]	[0.045]	[0.045]	[0.048]	[0.046]	[0.046]
Common border	0.327**	0.368**	0.381**	0.016	0.076	0.089
	[0.164]	[0.168]	[0.165]	[0.159]	[0.156]	[0.153]
Common language	0.057	0.051	0.040	0.078	0.066	0.054
	[0.098]	[0.098]	[0.097]	[0.097]	[0.099]	[0.096]
Common coloniser	0.336	0.322	0.311	0.371	0.355	0.347
	[0.301]	[0.299]	[0.300]	[0.269]	[0.268]	[0.268]
Colony	−0.339***	−0.292**	−0.293**	−0.183*	−0.131	−0.131
	[0.123]	[0.118]	[0.121]	[0.103]	[0.107]	[0.106]
Observations	240	240	240	240	240	240
R^2	0.972	0.969	0.969	0.969	0.967	0.967
Prob. (H0: OLS)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Prob. (H0: Poisson)	0.526	0.476	0.468	0.269	0.234	0.229

Note: Robust standard errors corrected for clustering by country pair are reported in brackets. Statistical significance as follows: ***(1%), **(5%), and *(10%).

Table 4
Robustness checks using variants of the ALI with time sensitive goods, parts and components – PPML, reporter and partner fixed effects (2005).

	1	2	3	4	5	6
	Time sensitive	Time sensitive	Time sensitive	Parts and components	Parts and components	Parts and components
ALI 5th	0.016*			0.037***		
	[0.009]			[0.008]		
ALI designation		0.016			0.038***	
		[0.010]			[0.009]	
ALI ownership			0.019			0.045***
			[0.012]			[0.011]
Ln (1 + tariff)	−2.349	−2.734	−2.569			
	[2.425]	[2.447]	[2.426]			
Ln (distance)	−0.557***	−0.530***	−0.536***	−0.843***	−0.794***	−0.802***
	[0.081]	[0.078]	[0.078]	[0.082]	[0.074]	[0.076]
Common border	−0.227	−0.150	−0.145	−0.776***	−0.596**	−0.575**
	[0.265]	[0.252]	[0.251]	[0.268]	[0.250]	[0.249]
Common language	0.037	0.027	0.016	0.304**	0.282**	0.256**
	[0.120]	[0.115]	[0.110]	[0.120]	[0.113]	[0.115]
Common coloniser	0.145	0.147	0.146	0.220	0.209	0.216
	[0.278]	[0.280]	[0.279]	[0.302]	[0.295]	[0.299]
Colony	0.048	0.067	0.065	−0.133	−0.090	−0.093
	[0.115]	[0.112]	[0.112]	[0.200]	[0.168]	[0.182]
Observations	239	239	239	248	248	248
R^2	0.911	0.909	0.909	0.972	0.971	0.970
Prob. (H0: OLS)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Prob. (H0: Poisson)	0.042**	0.046**	0.052*	0.378	0.771	0.898

Note: Robust standard errors corrected for clustering by country pair are reported in brackets. Statistical significance as follows: ***(1%), **(5%), and *(10%).

to be most sensitive to the degree of liberalisation in aviation markets. In terms of sign, magnitude and significance, the performance of these alternative liberalisation measures is very similar to that of the standard ALI. In three cases, the robustness measures are not statistically significant at the 10% level; however, each of these coefficients has a significance level of 12% or higher, which suggests that it would be inappropriate to draw conclusions from these isolated results. Taken together, the results are robust to the use of these other measures of liberalisation.[8]

4. Conclusions

This paper has shown the importance of air transport and the policy regime that governs it for merchandise trade within APEC. As has been frequently pointed out in the literature, the Asia-Pacific region has experienced rapid trade expansion over recent decades, which has led to a high degree of international integration in some areas. Simultaneously, the region has seen remarkable growth in the importance of transnational production networks characterised by vertical disintegration, small inventories and just-in-time management. Networked production requires an environment allowing for rapid, affordable and reliable international transportation links, particularly with respect to air transport

The gravity model used in this paper provides strong support for two hypotheses with important policy implications. First, more liberal air services policies are positively, significantly and robustly associated with higher bilateral merchandise trade. This impact is greater for country-pairs that have a direct air transport link, but is also significant for country-pairs that rely on transit through third countries. These findings highlight the importance of moving forward on air transport liberalisation both bilaterally and through regional or multilateral fora like APEC and the WTO. The positive spillovers from more liberal aviation regimes can be significant.

In addition, the results of this study show that air transport policy matters more for some sectors than others. Particularly strong relationships are found between bilateral liberalisation and trade in manufactured goods, time sensitive products, and parts and components. Prior to taking account of general equilibrium effects, the estimates imply that a one point increase in the ALI is associated with an increase of 4% in bilateral parts and components trade, the sector found to be most sensitive to the degree of aviation liberalisation. These findings are intuitively appealing, since one of the main advantages of

[8] Additional results (available on request) show that these findings are also robust to the possible endogeneity of the ALI to bilateral trade. The age of each ASA is a strong instrument for the degree of bilateral liberalisation (first stage $F = 12.40^{***}$): older ASAs tend to be less liberal, as indicated by a negative and 1% significant coefficient in the first stage regression. Moreover, ASA age cannot conceivably affect bilateral trade except through the degree of aviation market liberalisation—including the degree to which individual agreements are actually implement in practice, i.e. the extent to which the ALI is a noisy measure of liberalization—so it therefore satisfies the excludability restriction on instrument validity as well. Running two stage least squares on the parts and components data gives an ALI coefficient that is positive but statistically insignificant. However, a Hausman test fails to reject the null hypothesis that the ALI is in fact exogenous ($\chi^2(1) = 0.136$; prob. = 0.712). It is preferable, therefore, to rely on the results presented here rather than on instrumental variables results.

air transport over other transportation modes is speed. From a policy perspective, the results suggest that APEC economies actively seeking greater integration in international networks of production would do well to look at the potential for moving towards a more liberal aviation policy regime.

References

Achard, P. (2009). The regulation of international air cargo services, Master Thesis, Groupe d'Économie Mondiale, Sciences Po.

Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *The American Economic Review, 93*(1), 170–192.

Ando, M., & F. Kimura (2003). The formation of international production and distribution networks in East Asia, Working Paper No. 10167, National Bureau of Economic Research.

Djankov, S., Freund, C., & Pham, C. (2010). Trading on time. *Review of Economics and Statistics, 92*(1), 166–173.

Geloso Grosso, M. (2008). Liberalising air passenger services in APEC, Working Paper, Groupe d'Économie Mondiale, University of Sciences Politiques, November.

Gonenc, R., & Nicoletti, G. (2000). *Regulation, market structure and performance in air passenger transport*. Paris: OECD.

Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating trade flows: Trading partners and trading volumes. *Quarterly Journal of Economics, 123*(2), 441–487.

Hummels, D. (2001). *Time as a trade barrier*. Mimeo, Purdue University.

IATA. (2006). Air freight 2006: Brighter skies ahead. *Economic Briefings February.*

Kasarda, J. D., Green, J., & Sullivan, D. (2004). Air cargo: Engine of economic development, study commissioned by the International Air Cargo Association (TIACA).

Limao, L., & Venables, A. J. (2001). Infrastructure, geographical disadvantage, transport costs and trade. *World Bank Economic Review, 15*, 451–479.

Martin, W., & Pham, C. (2009). Estimating the gravity model when zero trade flows are frequent, Working Paper. Available from http://www.deakin.edu.au/buslaw/aef/workingpapers/papers/2008_03eco.pdf

Martinez-Zarzoso, I., Nowak-Lehmann, F., & Vollmer, S. (2006). The log of gravity revisited, CeGE Discussion Paper 64. University of Goettingen. Available from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=999908

Micco, A., & Serebrisky, T. (2004). Infrastructure, competition regimes, and air transport costs: Cross-country evidence. World Bank Policy Research Working Paper No. 3355. Available from SSRN: http://ssrn.com/abstract=610399

Nordås, H. K., Pinali, E., & Geloso Grosso, M. (2006), Time and logistics as a trade barrier, OECD Trade Policy Working Paper No. 35.

Piermartini, R., & Rousova, L. (2008). Liberalisation of air transport services and passenger traffic. Staff Working Paper ERSD-2008-06, World Trade Organisation, December.

Santos, S., & Tenreyro, S. (2006). The log of gravity. *Review of Economics and Statistics, 88*(November (4)), 641–658.

Senguttuvan, P. S. (2006). Air cargo: Engine for economic growth and development – a case study of asian region". *Paper presented at the National Urban Freight Conference*. Los Angeles, USA: METRANS Transportation Centre, School of Policy, Planning and Development University of Southern California.

US International Trade Commission (ITC) (2005). Logistics services: An overview of the global market and potential effects of removing trade impediments, Investigation No. 332-463, USITC Publication 3770.

Wilson, J. S., Mann, C. L., & Otsuki, T. (2005). Assessing the benefits of trade facilitation: A global perspective. *The World Economy, Blackwell Publishing 28(6) pp. 841–871, 06.*

WTO (2006). Second review of the air transport annex: Developments in the air transport sector (Part II). Quantitative Air Service Agreements Review (QUASAR) (Volumes I and II): Note by the Secretariat", document S/C/W/270.