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The operational impacts of governmental restructuring of the airline industry in China

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The Operational Impacts of Governmental Restructuring of the Airline Industry in China

In July 2000, the Civil Aviation Administration of China (CAAC) called for the consolidation of the 10 state-owned air carriers into three groups, headed by Air China, China Eastern, and China Southern. A few months later in November 2000, the State Council of China mandated that this consolidation be accomplished by the third quarter of 2001. As part of this mandate, the CAAC yielded its management control of air carriers with its focus now being on safety and regulatory issues. Furthermore, the CAAC was required to divest itself of assets held in many of the state-owned airlines and its interests in more than 120 airports around China, except Beijing Capital Airport.

Utilizing data from the International Civil Aviation Organization for 2003 and 2004, this study investigates the operational impacts of this industry restructuring. The relative operational efficiency of Air China, China Eastern, and China Southern is compared to a sample of Asian, European and United States flag carriers. Data envelopment analysis is utilized to derive efficiency scores for individual airlines. The operational efficiency model used in this study is derived from that utilized by Schefczyk (1993). The underlying structural drivers of efficiency are then investigated via a tobit analysis with implications for managerial policy discussed.

by Carl A. Scheraga

INTRODUCTION

Before 2001, the Chinese commercial aviation industry was overseen and controlled by the Civil Aviation Administration of China (CAAC). The Chinese government implemented a comprehensive set of regulations and policies that covered all aspects of airline operations. This regulatory regime approved domestic, regional, and international route allocations. Controls were put into place that set guidelines for published fares and aircraft acquisition, as well as standards for aircraft maintenance, jet fuel prices, airport operations, and air traffic control. In addition, the CAAC owned some of the country's largest airlines.

As detailed by Efendioglu and Murray (2003), by 2001 China had 31 international, regional and domestic carriers. These included 10 CAAC airlines and 21 Provincial airlines. The CAAC airlines controlled about an 80.5% share of the passenger market and an 84.7% share of the cargo market. Furthermore, the CAAC had an average 85% ownership share in its airlines. The priority of airlines was to build market share with profitability often compromised. In addition to being impacted by operational inefficiencies, profits were also significantly affected by the increase in fuel costs, low load factors, and the inability of many Chinese airlines to structure routes that allowed for the achievement of economies of scale. An exacerbating factor was China's attempt to become part of the World Trade Organization (WTO), which increased the opportunities for foreign carriers to enter the Chinese market.

In July 2000, the CAAC called for the merging of the 10 large state-owned airlines into three groups to be headed by Air China, China Southern Airlines, and China Eastern Airlines. This was formalized in November 2000 when the State Council of China issued a directive for the merger of these airlines in a formal restructuring of the Chinese airline industry. Part of this directive decreed that the CAACP would yield management control of airlines, instead focusing on safety and regulatory issues.

Air China consolidated with China National Aviation Corporation, China Southwest Airlines, and Zhejiang Airlines. China Eastern Airlines absorbed Air Great Wall, China

Yunnan Airlines and China Northwest Airlines. Similarly, China Southern Airlines absorbed China Northern Airlines, China Xinjiang Airlines and Zhongyuan Airlines (Efendioglu and Murray 2003).

This study benchmarks the operational efficiency of the consolidated Chinese airlines against a set of global flag carriers with significant international operations for the year 2003. This set is detailed in Table 1. The year 2003 is the most recent one available in terms of the data utilized. In addition, it is the first year for which consolidated operations data was available. Thus the study is preliminary in nature, representing a starting point for the development of operations strategies for the three consolidated Chinese airlines.

A significant factor which must be kept in mind throughout the discussion of this study is the SARS virus epidemic that severely impacted Chinese airlines. Passenger numbers dropped, flights were cancelled, and deliveries of new aircraft were delayed. However, it should also be noted that other airlines in the region also felt the impact of the viral outbreak. Major carriers affected included Japan Airlines and Thai Airways.

MODEL FRAMEWORK AND VARIABLES

The behavioral model utilized to describe airline operational efficiency is that employed by Schefczyk (1993). He defines a framework described by two outputs and three inputs. The outputs are (1) revenue passenger-kilometers and (2) Non-passenger revenue ton-kilometers. The inputs are (1) available ton-kilometers, (2) operating cost and (3) non-flight assets. Available ton-kilometers reflect available aircraft capacity. The figure for operating cost reflects operating cost excluding capital and aircraft cost captured by available ton-kilometers. Non-flight assets reflect all assets not included in available ton-kilometers such as facilities, reservation systems and current assets.

Revenue passenger-kilometers are the sum of revenue passenger-kilometers for scheduled and charter (non-scheduled) services. Non-passenger revenue ton-kilometers include ton-kilometers for freight and mail for both scheduled and non-scheduled services. Available ton-kilometers are a sum of available ton-kilometers for scheduled and charter (non-scheduled) services. Operating cost is computed as total operating expenses minus aircraft rent, depreciation, and amortization. Non-flight assets are computed as total assets minus flight equipment at cost, purchase deposits for flight equipment, and flight equipment under capital

Table 1: Sample Airlines

NAME	ICAO ID
Aerolines Argentinas	ARG
Aeromexico	AMX
Air Canada	ACA
Air China	CCA
Air France	AFR
Air India	AIC
All Nippon Airways	ANA
American Airlines	AAL
Asiana Airlines	AAR
Austrian Airline Group	AUA
British Airways	BAW
Cathay Pacific	CPA
China Eastern Airlines	CES
China Southern Airlines	CSN
Continental Airlines	COA
CSA Czech Airlines	CSA
Delta Airlines	DAL
EL AL	ELY
Iberia	IBE
KLM	KLM
Korean Air	KAL
LOT Polish Airlines	LOT
Lufthansa	DLH
Malaysia Airlines	MAS
Mexicana	MXA
Northwest Airlines	NWA
Pakistan International Airlines	PIA
Scandinavian Airlines	SAS
Singapore Airlines	SIA
SriLankian Airlines	ALK
TAP Air Portugal	TAP
Tarom	ROT
Thai Airways International	THA
United Airlines	UAL

leases at cost, with accumulated depreciation for flight equipment and accumulated depreciation for flight equipment under capital leases added back in.

Data envelopment analysis (DEA), discussed below, is used to assess the relative efficiency of individual airlines described by this behavioral model.

This study investigates the impact of a set of operational and environmental variables which previous studies have shown to affect operational efficiency (Caves et al. 1984; Banker and Johnston, 1993; Schefczyk 1993; Siau and Van Lindt 1997; and Fethi et al. 2002). These include: average flight length, passenger revenues as a percentage of total revenues, scheduled service revenues as a percentage of total revenues, international passenger revenue kilometers as a percentage of total passenger revenue-kilometers, and average load factor. These variables, in effect, describe the environment in which an airline operates.

Average flight length captures economies of distance which posits that there is a negative correlation between average flight length and unit cost. For a given aircraft size, increasing the distance of a flight results in larger output volume as measured either in passenger revenue-kilometers or ton-kilometers. It must be noted that empirically this suggested effect has been shown to be ambiguous (Caves et al. 1981 and Tretheway 1984).

The passenger focus for an airline is described by passenger revenues as a percentage of total revenues. As Oum and Yu (1999) note, air cargo accounts for a large portion of total output for many Asian and European carriers based in export-oriented countries. U.S. carriers have traditionally been primarily passenger-focused in their operations. Cargo service is seen as requiring less input than passenger services, but it generates less revenue. Specific operational advantages in carrying cargo as opposed to passengers have been suggested by O'Connor (2001). Cargo is usually carried one-way while passengers usually travel roundtrip. Passengers have a preference for day travel while cargo generally moves at night. Unlike passengers, shippers and recipients of cargo are not concerned about indirect routes or plane changes as long as the cargo arrives when expected. Additionally, the aesthetics of the aircraft environment are not a concern in the transport of cargo.

Scheduled service revenues as a percentage of total revenues are anticipated to have a positive impact on operational efficiency. Scheduled flights require different product and marketing facilities than unscheduled charter flights. An increase in the percentage of regularly scheduled services allows for a rationalization of operational routines leading to greater overall efficiency if the necessary concomitant resources and systems are in place.

The international focus of an airline is captured by international passenger revenue kilometers, as a percentage of total passenger revenue-kilometers. A priori, what the impact of this measure should be on operational efficiency is not unambiguous. On the one hand, Fethi et al. (2002) suggest that an increase in the international focus of an airline exposes it to spatial disparities in its operating environment. In structuring bilateral agreements, the international air transport system has tended to focus on individual or small sets of routes between countries. This has impeded the achievement of high levels of efficiency over global networks of air services. There are unresolved issues with regard to ownership and control, cabotage and the right of establishment. There is still divergence across geographic regions with regard to competition law and policy in air transport. There are differences in fiscal policies with air transport being subjected to many taxes which finance general governmental expenditure. Customs clearance can impede both speed and reliability. Finally, airport infrastructure constraints can significantly affect the level of competition in particular markets.

On the other hand, international carriers have been able to take advantage of strategic alliances with other global competitors (Dana and Dana 1998). One of the early examples of such strategies is the relationship between KLM and Northwest Airlines. This alliance began in 1989 when KLM purchased one-fifth of Northwest Airlines. An open-sky treaty between the Netherlands and the United States gave both airlines unrestricted rights between their respective countries. The two airlines implemented a joint marketing program, a global business class program, and code-sharing arrangements. In addition, each of the two airlines was also cooperating closely with other respective partners.

Bilateral agreements have proliferated in the industry. In 1998, when regulations were relaxed between Japan and the United States, American Airlines and Japan Airlines began code-sharing. This agreement gave Japan Airlines access to almost 300 airports served by American Airlines and its subsidiary American Eagle. Similarly, destinations of Japan Airlines were opened to American Airlines. Japan Airlines is particularly interesting in that its flights use aircraft, crew, and duty-free facilities of numerous other large global carriers. Strategic alliances have allowed global airlines to coordinate their flights and to cooperate in aircraft acquisition and fleet maintenance. Joint purchasing of airplanes and spare parts gives such collectives of buyers greater bargaining power vis-à-vis suppliers.

Another strategic innovation, international franchising, often allows the franchisee to use the franchiser's airline code and to operate airplanes carrying the external markings of the franchiser. Furthermore, the use of local franchisees may also allow an airline to enter the restricted domestic markets of foreign countries.

Scheraga (2004) examined the relationship between the strategic focus of airline customer service activities and operational efficiency (dollars per revenue-passenger kilometer). Customer service activities included two categories: 1) passenger services, and 2) ticketing, sales and promotion. The results of this study suggested that, when these customer service activities distract airlines from focusing on those core competencies that allow them to design the operation of their networks of air services from a value-based perspective, there are negative impacts on operating efficiency.

There is evidence that there is a positive correlation between average passenger load factors and operational performance (Caves et al. 1981, 1983). Oum and Yu (1999) suggest that average passenger load factor reflects an airline's control of the choice of aircraft and flight frequencies. A higher passenger load factor indicates better utilization of aircraft and thus it should positively impact operational efficiency.

Finally, several financial measures of operational performance are examined. These include the current ratio, the operating ratio, the net profit margin, the return on investment, and the yield. The current ratio is the ratio of current assets to current liabilities. A ratio of 1.00 is normally considered to reflect a sound level for the airline industry. A ratio less than 1.00 suggests than an airline may not be generating adequate cash to meet short-term obligations as they become due. A current ratio well above 1.00 suggests an airline may be generating more cash than can profitably be re-invested for longer-term objectives. At the same time however, such behavior may be reasonable if the airline is stockpiling cash for potential acquisitions of other companies or is expecting a future period of aircraft deliveries which will be bunched together (Morrell 2002).

The operating ratio is defined as operating revenue expressed as a percentage of operating expenditure. It can be thought of as being similar to the margin on sales. This ratio gives an indication of management's efficiency in controlling costs and increasing revenues. Because this ratio can be distorted by changes in depreciation policy or a change from ownership of aircraft to operating leases, an alternative form is often used. The alternative definition of the operating ratio is operating profit, after interest charges, expressed as a percentage of operating revenues.

Return on investment is the pre-tax profit before interest paid as a percentage of average total long-term capital employed. This ratio gives an indication of how successful an airline's management is in its investment of the long-term capital under its control. The yield is the revenue generated per revenue-ton kilometer flown. This ratio captures the impact of an airline's choices with regard to load management, average stage length, and passenger mix.

The financial and operating data utilized in the study came from the International Civil Aviation Organization's (ICAO) two databases, *Financial Data: Commercial Air Carriers*, for

2003, and *Traffic: Commercial Air Carriers*, for 2003 and 2004. The 2004 data was necessary so that the traffic data could be carefully matched to the financial data to allow for the fact that different airlines had different fiscal year ending dates. All financial data is converted to U.S. dollars at the rate of exchange which is the average of the 12 month International Transport Association (IATA) rates for the year reported. In those cases where the rate changed considerably only in the last month of the financial year, the rate prevailing prior to this change was adopted. If the rate for a currency changed frequently during the year reported, a 12-month average was used. Because exchange rates capture the effects of changes in relative inflation and interest rates as well as trade deficits or surpluses, the conversion of all financial values to a common currency helps to capture the impacts of idiosyncratic forces on country-specific economies.

The ICAO databases are utilized to insure quality and uniformity of the information provided by airlines. There are standardized reporting forms with all reported items carefully checked by ICAO statisticians. Note that all three Chinese airlines were already issuing equity that was being traded on international markets during the period of this study. Such international financial activity demanded accuracy and full disclosure of information on the part of these airlines. As noted above, an added incentive for accurate financial reporting accuracy was China's desire to enter the World Trade Organization.

METHODOLOGY

The methodology employed is this study is data envelopment analysis (DEA) and is used to compare the relative efficiencies of the 34 global flag-carrier airlines in the sample. Given a set of inputs and a corresponding set of outputs, a production plan/function is efficient if there is no way to produce more outputs with the same inputs or to produce the same outputs with fewer inputs. In the case of DEA, the production function (and hence the production frontier) is generated from the actual data. DEA is a nonparametric technique that makes no assumptions about the form of the production function. Instead, it estimates, in the case of this study, an empirical best practice production frontier from the observed inputs and outputs of the individual airlines. The DEA best practice frontier is piecewise linear and approximates the true production function. An airline is efficient when comparisons with other airlines indicate no inefficiency in the utilization of inputs and outputs as measured by its position relative to the efficient production frontier.

The analysis in this study employs two variations of the two-stage optimization procedure for data envelopment analysis as specified by Ali and Seiford (1993a). This approach differs from the models of Charnes, Cooper and Rhodes (CCR) (1978) and Banker, Charnes and Cooper (BCC) (1984). The choice of the two-stage optimization process does not question the validity of the CCR and BCC models. However, the two-stage optimization procedure is a robust computational methodology that relieves the researcher of the need to make discretionary assumptions about some of the underlying parameters in these latter two models. As Ali and Seiford (1993b) note, improper choices in the values of these parameters can lead to serious computational errors.

The first variation of this procedure is the base DEA model. Using the notation of Ali and Seiford (1993a), consider the case of n airlines, each utilizing, in varying amounts, m distinct inputs to produce s different outputs. The objective of DEA can be specified so as to minimize total waste in inputs and outputs. Thus, the objective is:

$$(1) \quad \min_{\lambda_j, s_r, e_i} \left(\sum_{r=1}^{s} \mu_{rl} s_r + \sum_{i=1}^{m} \upsilon_{il} e_i \right)$$

The variable s_r is the amount of slack in, or foregone amount of output r, while the variable e_i is the excess amount of input i utilized. The values μ_{rl} and υ_{il} are shadow prices, or the marginal value, of a unit of output or input, and λ_j is an n x 1 vector of constants utilized in the constraints outlined below and is necessary in the specification of the convexity conditions. The slack variables allow for the identification of specific inefficiencies in the utilization of inputs and deficiencies in the generation of outputs.

One would like the projections and efficiency scores derived to be independent of the units of measurement of the data. To achieve this "units-invariant" property, the analysis specified airline specific bounds on the values of μ_{rl} and υ_{il}. Given x_{il}, the amount of input i used by airline l, and y_{rl}, the amount of output r for airline l, these bounds are defined by:

(2) $\mu_{rl} = 1/y_{rl}, \quad r = 1,\ldots,s \text{ and } \upsilon_{il} = 1/x_{il},$
$i = 1,\ldots,m$

The associated resource constraints and convexity conditions, for the base model allowing for potential variable returns-to-scale, are discussed in detail in Ali and Seiford (1993a). These are:

(3) $$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r = y_{rl} \quad r = 1,\ldots,s$$

$$-\sum_{j=1}^{n} x_{ij}\lambda_j - e_i = -x_{il} \quad i = 1,\ldots,m$$

(4) $$\sum_{j=1}^{n} \lambda_j = 1$$

(5) $\lambda_j \geq 0 \quad j = 1,\ldots,n$

(6) $s_r \geq 0 \quad r = 1,\ldots,s$

(7) $e_i \geq 0 \quad i = 1,\ldots,m$

The solution to the above problem identifies, for each airline, l, a projected point on the efficient frontier, $(\hat{x}_l, \hat{y}_l)$ where the items x_l and y_l are the vectorsof inputs and outputs. The essence of the efficiency evaluation of a particular airline (with an actual achieved combination of x_l and y_l) is the identification of excesses in input utilization (x_l- $\hat{x}_l$) and deficiencies in output ($\hat{y}_l$ - y_l). A particular airline is deemed efficient if $(x_l, y_l) = (\hat{x}_l, \hat{y}_l)$, the airline thus lying on the efficient frontier. Thus, one possible measure of inefficiency, Δ^l, can be defined by:

(8) $$\Delta^l = \mu^l(\hat{y}_l - y_l) = \upsilon_l(x_l - \hat{x})$$

For efficient airlines $\Delta^l = 0$.

The base model embodies an approach consistent with a "systems-oriented" philosophy where input and output variables are simultaneously determined. Furthermore, it provides a means of measuring total inefficiency in both the utilization of inputs and production of outputs. However, to investigate policy implications for managerial strategies a second model, the input oriented model, was also utilized.

The projected point $(\hat{x}_l, \hat{y}_l)$ defined above, suggests one possible path of movement between the observed point and the projected point. Such a movement to the envelopment surface would be accomplished along the vector $(s^l, -e^l)$. The vector $(s^l, -e^l)$ defines a combination of output augmentation and input reduction. This combination potentially may consist of two components. The first is a proportional change in output augmentation and input reduction. The second is a set of additional (non-proportional) residual output augmentation and input reduction after the initial proportional changes have taken place. This can be written as follows:

Thus for each airline, the output vector can

(9) $s^l = \rho y_l + \delta_s^l \quad and \quad e^l = \gamma x_l + \delta_e^l$

be increased proportionately (in each vector component) by a factor of ρ with individual non-proportional residual component increases in each of the separate output variables given by δ^l_s. Similarly, the input vector for an airline can be decreased proportionately (in each vector component) by a factor of γ with individual non-proportional residual component decreases in each of the separate input variables given by δ^l_e. Note that at least one element of the δ^l_s and δ^l_e vectors is zero.

In the case of the input oriented model, as opposed to the base model, one set of variables, inputs, takes priority over the other. For the input orientation model, proportional movement to the envelopment surface from the observed point is first achieved in input-space. That is, the model seeks a projected point so that γ is maximized.

Because this model requires, in the first stage, the maximization of γ, it effectively identifies the intermediate point $[(1-\gamma)x_l, y_l]$. Letting $\theta = 1-\gamma$, for the input oriented model the input constraint is now replaced by:

$$(10) \quad -\sum_{j=1}^{n} x_{ij}\lambda_j + \theta^l x_{il} - \delta_i^l = 0 \quad i = 1,\ldots,m$$

Notice, that effectively, the input oriented model requires the solution of the linear program with regard to the intermediate point $[(1-\gamma)x_l, y_l]$. The projected point obtained with this orientation can differ from that obtained from the non-oriented base model. However, the projected point will still lie on the envelopment surface and $\Delta^l = 0$.

The input oriented model seeks a projected point such that the proportional reduction in inputs is maximized. The implicit underlying premise in such an orientation is that the primary objective of the airline under evaluation is to gain efficiency by reducing excess input utilization while continuing to operate with its current technology mix (reflected in actual input ratios).

As noted above, satisfaction of the primary or first-stage objective may not be sufficient for the attainment of the envelopment surface and hence efficiency. In general, in the second-stage, a non-oriented projection has to be applied to the intermediate point.

The input-oriented model generates another valuable piece of information. In addition to the maximization of γ, a measure of efficiency for the input oriented mode is generated which is related to the weighted-ratios of the CCR model (1978) and defined as:

Input efficiency, ι^l, is the multiple of the input

$$(11) \quad i^l = 1 - \Delta_I^l \quad where \quad \Delta_I^l = \frac{\Delta^l}{\upsilon^l x_i}$$

vector that would place the relatively inefficient airline on the efficient production frontier. Effectively, ι^l measures the total inefficiency in terms of proportional input reduction. Also note, that, for an efficient airline, $\iota^l = 1$. Thus, if ι^l takes on the value of 0.75 for a particular airline, this is equivalent to saying that this relatively inefficient airline could reduce all inputs by the proportion 1 – 0.75, or 25% and move to the efficient production frontier.

The efficiency measure ι^l does convey information with regard to managerial policy. Consider the following case. Suppose airline A has a peer group of airlines with comparatively efficient production techniques allowing them to achieve the levels of output of airline A more efficiently. If ι^l is very small, then the production technology of airline A is very badly chosen. The airline would be prudent to shift the input/production technology with a focus on increasing levels of output. If, on the other hand, ι^l is close to 1, then the airline could remain with its current production technology and achieve the same levels of output with a small scaling down of inputs. Thus, utilization of the input-oriented model in conjunction with the base model allows the researcher to not only develop assessment measures of inefficiency but also to evaluate the efficacy of managerial strategies.

The software utilized for the data envelopment analysis was an updated version of that utilized by Schefczyk (1993), Integrated Data Envelopment Analysis System, Version 6.1.7 obtained from 1 Consulting.

In investigating the impact of the above operational and environmental variables on relative operational efficiency, note that ι^l is a censured variable, i.e. $0 \leq \iota^l \geq 1$. Utilization of ordinary least squares yields biased and inconsistent parameter estimates (Pindyck and Rubinfeld 1991, p. 276). The more appropriate tobit technique is that developed by Tobin (1958) for a left-censured variable. A transformation suggested by Fethi et al. (2002) is utilized to transform ι^l into a left-censured variable. This new variable is defined as $(1/\iota^l) - 1$ which is greater than or equal to zero in a continuous fashion. Thus, for the transformed value of ι^l, an efficient airline will have a value of zero, while an inefficient airline will have a value greater than zero. The tobit analysis was performed using the LIFEREG procedure in the SAS statistical package.

RESULTS

As shown in Table 2, the input-oriented model generated values for ι^l for Air China, China Eastern Airlines, and China Southern Airlines that are respectively 0.86, 0.71, and 0.58. While Air China is one-half of a standard deviation below the mean value of ι^l, China Eastern Airlines is two standard deviations below the

Table 2: Sample Input-Oriented Operating Efficiencies

NAME	ι^I
Aerolines Argentinas	1.00
Aeromexico	0.94
Air Canada	0.84
Air China	0.86
Air France	1.00
Air India	0.95
All Nippon Airways	0.73
American Airlines	1.00
Asiana Airlines	0.91
Austrian Airline Group	0.92
British Airways	0.89
Cathay Pacific	1.00
China Eastern Airlines	0.71
China Southern Airlines	0.58
Continental Airlines	1.00
CSA Czech Airlines	1.00
Delta Airlines	0.89
EL AL	1.00
Iberia	0.87
KLM	1.00
Korean Air	0.76
LOT Polish Airlines	0.86
Lufthansa	1.00
Malaysia Airlines	1.00
Mexicana	0.81
Northwest Airlines	0.90
Pakistan International Airlines	0.90
Scandinavian Airlines	0.85
Singapore Airlines	1.00
SriLankian Airlines	1.00
TAP Air Portugal	0.91
Tarom	1.00
Thai Airways International	1.00
United Airlines	1.00

	Mean	Std. Dev.	Min.	Max.
ι^I	0.91	0.10	0.58	1.00

mean and China Southern Airlines is more than three standard deviations below the mean. In fact, China Eastern Airlines and China Southern Airlines demonstrated the two lowest values for ι^l in the sample of 34 airlines.

It is tempting to conclude that an exogenous phenomenon such as the SARS outbreak in China is the driver of these results. Recall, however, that as noted above, a very small value for ι^l is suggestive of the need for an airline to reconsider the input configuration that it is utilizing to produce a given set of outputs. This can be further seen by examining the results of the base model for the three Chinese airlines in Table 3. In the case of all three Chinese airlines, there is no inefficiency with regard to the input of available capacity as measured by available ton-kilometers. Furthermore, in the case of Air China, there is no inefficiency with regard to the output of revenue passenger-kilometers. For all three airlines, the largest output inefficiencies are with regard to non-passenger ton-kilometers. As shown in Table 4a, for the entire sample, the average value for the percentage of revenues from passenger services was 80.5%. The respective values (from Table 4b) for Air China, China Eastern Airlines, and China Southern Airlines were 73, 76, and 89%. Thus, at least for the former two airlines, a significant portion of their revenues are generated by freight and mail services. Furthermore, Table 3 indicates that all three airlines demonstrated very large inefficiencies with regard to operating cost (reflecting operating cost excluding capital and aircraft cost reflected in available ton-kilometers) and non-flight assets (e.g. facilities, reservation systems, current assets).

Note that operating costs include fuel cost. On average, fuel can constitute 14–16% of operating costs. For some of the major airlines in the industry, this may be as much as 20%. Furthermore, shorter haul airlines typically get lower fuel efficiency because take-offs and landings consume high amounts of jet fuel. However, it must also be noted that rising fuel costs were not unique to the three Chinese airlines.

Tables 5a and 5b present the tobit regressions results describing the impact of the operational and environmental variables discussed above. Recall, that for the transformed value of ι^l, an efficient airline will have a value of zero, while an inefficient airline will have a value greater than zero. Thus variables positively correlated with ι^l will be negatively correlated with the transformed value of ι^l. Except, for expenditures on passenger services per revenue passenger-kilometer, all of the operational and environmental variables are statistically significant at the 10% level or better. Table 5a demonstrates that except for the percentage of revenues from scheduled operations, the signs on the coefficients of the variables are logically intuitive. The implied negative impact of an increase in the percentage of revenues from scheduled operations is, at first, somewhat puzzling. However, a statistically significant correlation was found between this variable and the percentage of revenues from passenger services. Therefore, an interaction term between these two variables was introduced into the regression. Table 5b demonstrates a more reasonable scenario as the interaction variable is positive. An increase in the percentage of

Table 3: Input and Output Percentage Inefficiencies
Air China (CCA), China Eastern Airlines (CES), China Southern Airlines (CSN)

	CCA (%)	CES (%)	CSN (%)
INPUT			
Available Ton-Km	**0**	**0**	**0**
Operating Cost	-30.83	-33.62	-36.22
Non-Flight Assets	-44.74	-43.52	-24.24
OUTPUT			
Revenue Passenger-Km	**0**	21.54	40.38
Non-Passenger Ton-Km	20.19	43.24	90.30

Negative/Positive Sign = Necessary Reduction/Increase Required to Achieve Efficiency

Table 4a: Sample Descriptive Statistics: Tobit Regression Variables
Dependent Variable: Transformed Iota: [(1/ι') – 1]

Variable	Mean	Std. Dev.	Min.	Max.
Percentage of Revenues from International Operations	73.03%	28.05%	19.00%	100%
Percentage of Revenues from Scheduled Operations	88.62%	7.40%	68.00%	100%
Percentage of Revenues from Passenger Services	80.50%	8.82%	56.00%	94.00%
Average Stage-Length	1,799.41 Km	960.31 Km	850.00 Km	5,550.00 Km
Passenger Load Factor	71.32%	4.96%	60.00%	80.00%
Expenditures on Passenger Services per Revenue Passenger-Km	$0.0197	$0.0058	$0.0029	$0.0333
Expenditures on Ticketing Sales and Promotion per Revenue Passenger-Km	$0.0111	$0.0051	$0.0029	$0.0025

Table 4b: Descriptive Statistics: Tobit Regression Variables
Dependent Variable: Transformed Iota: [(1/ι') – 1]

Variable	CCA	CES	CSN
Percentage of Revenues from International Operations	38% (-1.25)	29 (-1.57)	19% (-1.93)
Percentage of Revenues from Scheduled Operations	89% (0.05)	94% (0.73)	99% (1.40)
Percentage of Revenues from Passenger Services	73% (-0.85)	76% (-0.51)	89% (0.96%)
Average Stage-Length	1,618.14 Km (-0.19)	1,306.93 Km (-0.51)	1,246.96 Km (-0.58)
Passenger Load Factor	66% (-1.07)	61% (-2.08)	64% (-1.48)
Expenditures on Passenger Services per Revenue Passenger-Km	$0.0032 (-2.84)	$0.0043 (-2.66)	$0.0045 (-2.62)
Expenditures on Ticketing Sales and Promotion per Revenue Passenger-Km	$0.0070 (-0.80)	$0.0100 (-0.22)	$0.0122 (0.22)

(Figures in parentheses represent number of standard deviations above or below the mean for the entire sample.)

Table 5a: Tobit Regression Results
Dependent Variable: Transformed ι^l

Variable	Estimate	Chi-Square	Pr>ChiSq
Intercept	1.2360	3.9322	**0.0474**
Percentage of Revenues from International Operations	-0.3011	6.7807	**0.0092**
Percentage of Revenues from Scheduled Operations	0.9072	3.4558	**0.0630**
Percentage of Revenues from Passenger Services	-0.8756	5.0864	**0.0241**
Average Stage-Length	-0.0001104	3.4474	**0.0634**
Passenger Load Factor	-1.4199	4.9365	**0.0263**
Expenditures on Passenger Services per Revenue Passenger-Km	-2.0230	0.1495	**0.6990**
Expenditures on Ticketing Sales and Promotion per Revenue Passenger-Km	13.8660	2.8307	**0.0925**

Table 5b: Regression Results with Interaction Term
Dependent Variable: Transformed ι^l

Variable	Estimate	Chi-Square	Pr>ChiSq
Intercept	14.0271	12.6022	**0.0004**
Percentage of Revenues from International Operations	-0.2960	9.0537	**0.0026**
Percentage of Revenues from Scheduled Operations	-13.2794	9.4635	**0.0021**
Percentage of Revenues from Passenger Services	-17.1145	12.0534	**0.0005**
Percentage of Revenues from Scheduled Operations X Percentage of Revenues from Passenger Services	17.9920	10.9494	**0.0009**
Average Stage-Length	-0.00013	4.3971	**0.0360**
Passenger Load Factor	-1.3784	6.4045	**0.0114**
Expenditures on Passenger Services per Revenue Passenger-Km	-4.9759	1.2641	**0.2609**
Expenditures on Ticketing Sales and Promotion per Revenue Passenger-Km	14.8527	4.6704	**0.0307**

revenues from scheduled operations, per se, has a positive impact on relative operational efficiency. However, airlines in the sample that had higher values for this variable also tended to have higher percentages of revenues from passenger services, that is, higher values of scheduled passenger services. This, then, had a negative impact on operational efficiency. This is also consistent with the operational advantages of carrying cargo suggested by O'Connor (2001) and noted above. These advantages are not trivial in the sample of this study as Table 4a indicates about 20% of revenues, on average, were generated from non-passenger services (freight and mail).

The results reported in Table 5b and the information in Tables 4a and 4b allow for a discussion of the impact of the operational and environmental variables on Air China, China Eastern Airlines, and China Southern Airlines. All three airlines are significantly lower than the sample average with regard to the percentage of revenues from international operations. Thus they are not capturing the positive impacts on operational efficiency of global strategic alliances, bilateral agreements, and international franchising.

The three Chinese airlines are significantly lower than the sample average with regard to passenger load factors. Some of this certainly can be attributed to the SARS epidemic and, as suggested by the regression results, will negatively impact relative operational efficiency. However, as noted above, to label this factor as the overwhelming determinant of the relative operational inefficiency of the three Chinese airlines would be simplistic and misleading.

All three Chinese airlines are somewhat below the sample average with regard to average stage length. Thus, as compared to other airlines in the sample, they are not as effectively taking advantage of economies of distance, which drive an inverse relationship between average flight length and unit cost – a relationship that enhances operational efficiency.

Air China and China Eastern Airlines are below the sample mean for the percentage of revenues from passenger services but above the sample mean for percentage of revenues from scheduled services. Given the statistically significant impact of the interaction term discussed above, should they decide to increase the percentage of revenues from scheduled passenger services, they will have to be careful in ensuring that the necessary resources and systems are in place to maintain or enhance operational efficiency. Additionally, Air China and China Eastern Airlines are below the sample mean for expenditures on ticketing sales and promotion per revenue passenger-kilometer. However, as the regression results demonstrate, these expenditures tend to negatively impact operational efficiency. Thus, the behavior of these two airlines may be economically reasonable as compared to China Southern Airlines that is above the sample mean.

Tables 6a and 6b allow for a comparison of the three Chinese airlines relative to the entire sample with regard to several performance measures. For the current ratio, all three airlines are significantly below the sample mean of 0.82, let alone the desired value of 1.00. Air China, China Eastern Airlines, and China

Table 6a: Sample Descriptive Statistics: Performance Measures

Variable	Mean	Std. Dev.	Min.	Max.
Current Ratio	0.82	0.29	0.42	1.47
Operating Ratio	1.01	0.06	0.89	1.15
Alternative Operating Ratio	-0.02	0.07	-0.18	0.18
Net Profit Margin	-0.01	0.08	-0.27	0.10
Return on Investment	0.01	0.12	-0.33	0.31
Yield	0.78	0.29	0.32	1.46

Table 6b: Individual Airline Performance Measures

NAME	Current Ratio	Oper. Ratio	Alt. Oper. Ratio	Net Prof. Margin	ROI	Yield
Aerolines Argentinas	0.64	1.00	0.04	0.05	0.02	0.57
Aeromexico	0.64	0.94	-0.08	-0.07	-0.27	0.82
Air Canada	0.62	0.89	-0.18	-0.27	-0.33	0.72
Air China	0.45	1.09	0.18	0.01	-0.06	0.58
Air France	0.77	1.01	0.01	0.01	0.01	0.71
Air India	0.67	0.98	-0.03	0.00	0.02	0.72
All Nippon Airways	1.10	1.03	0.01	0.01	0.04	1.46
American Airlines	0.72	0.92	-0.11	-0.08	-0.05	0.85
Asiana Airlines	0.42	1.01	-0.01	-0.02	0.02	0.58
Austrian Airline Group	0.76	1.03	0.01	0.02	0.02	0.93
British Airways	0.65	1.07	0.04	0.02	0.05	0.76
Cathay Pacific	1.39	1.02	0.00	0.05	0.04	0.38
China Eastern Airlines	0.52	1.04	-0.03	-0.06	0.02	0.62
China Southern Airlines	0.52	1.04	-0.04	-0.01	0.03	0.62
Continental Airlines	0.91	1.00	-0.04	0.01	0.06	0.76
CSA Czech Airlines	0.84	1.05	0.03	0.04	0.06	1.10
Delta Airlines	0.81	0.92	-0.13	-0.06	-0.04	0.95
EL AL	0.51	1.02	0.00	0.01	0.03	0.57
Iberia	1.36	1.03	0.04	0.02	0.05	1.04
KLM	0.90	1.01	0.00	0.00	0.02	0.62
Korean Air	0.68	1.05	-0.01	-0.04	0.02	0.58
LOT Polish Airlines	0.92	1.00	0.00	-0.04	-0.04	1.10
Lufthansa	1.47	1.00	-0.04	-0.10	-0.04	0.65
Malaysia Airlines	1.39	1.02	0.02	0.08	0.19	0.35
Mexicana	0.53	0.96	-0.06	-0.08	-0.15	1.08
Northwest Airlines	0.88	0.97	-0.08	0.05	0.06	0.69
Pakistan International Airlines	0.97	1.13	0.06	0.03	0.19	0.57
Scandinavian Airlines	0.91	0.95	-0.08	-0.02	0.00	1.39
Singapore Airlines	0.89	1.02	0.02	0.06	0.02	0.32
SriLankian Airlines	1.23	1.07	0.06	0.10	0.31	0.54
TAP Air Portugal	0.85	1.02	0.02	0.00	0.00	1.02
Tarom	0.92	0.98	-0.08	-0.05	0.01	1.42
Thai Airways International	0.64	1.15	0.10	0.09	0.19	0.54
United Airlines	0.46	0.90	-0.15	-0.23	-0.18	0.74

Southern Airlines had values of 0.45, 0.52, and 0.52 respectively. Thus, they are certainly not generating adequate cash to meet short-term obligations. The three airlines are above the sample mean for the operating ratio measure. In this regard, they are better than a significant number of airlines in the sample with regard to their management's efficiency in controlling costs and increasing revenues. For the alternative specification of this measure, Air China is well above the sample average, while China Eastern Airlines and China Southern Airlines are slightly below it. There is no consistent pattern for the Chinese airlines on the net profit margin and return on investment measures. Air China is above the sample mean with regard to net profit margin; China Southern Airlines is at the mean; and China Eastern Airlines is below it. However, China Eastern Airlines and China Southern Airlines are above the sample mean with regard to return on investment while Air China is below it. Most interestingly, all three airlines are below the sample mean value for the yield measure. This would seem to be consistent with the low values of ι^l as well as the values for some of the operational and environmental variables for these airlines. The yield measure, as noted above, reflects choices with regard to load management, average stage length, and passenger mix.

CONCLUSION

It is interesting to examine the chairman's statement in each of the 2004 (a year after this study) annual reports for Air China (2005), China Eastern Airlines (2005), and China Southern Airlines (2005). There are some consistent patterns in perceived operational needs – needs highlighted by the analysis of this study. The Air China annual report highlights the need for functional integration to transform and streamline the organizational structure to enhance operations efficiency. The China Southern Airlines annual report describes the adoption of measures to optimize service offerings, flight schedules and route networks by improving integrated management and resources allocation. In a similar manner, the China Eastern Airlines annual report highlights the need to "beef up" the management of flight equipment in a comprehensive manner.

All three airlines focus on the importance of cargo operations. Air China sees the need to deploy more air cargo capacity while optimizing the cargo transportation network. China Southern Airlines seeks to strengthen the cargo operation to further penetrate international and regional markets. China Eastern Airlines sees itself continuing the strategy for developing the cargo transport business and promoting the development of aviation logistics. Finally, all three airlines perceive a need for better budget management.

Wang Yongtao (2002), an industry researcher with Air China, has emphasized that a key issue in the Air China consolidation is management. He noted that "if the consolidation (Air China Group) just combines the assets of the three airlines and lacks improvement in management, the reform will achieve no effective result." Further, he suggests that "only when the new group pays enough attention to efficiency and market demands, can the air group expect a better future." This preliminary study has sought to identify specific areas of operations management practices, relative to a large comparative set of global flag carriers, that need to be addressed in order to achieve operational efficiency.

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