Transport Policy 17 (2010) 259–265

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Productivity growth and biased technological change in Japanese airports

Carlos Pestana Barros [a], Shunsuke Managi [b,c,*], Yuichiro Yoshida [d]

[a] *Instituto de Economia e Gestão, Technical University of Lisbon, Rua Miguel Lupi 20, 1249-078 Lisbon, Portugal*
[b] *Graduate School of Environmental Studies, Tohoku University, 6-6-20 Aramaki-Aza Aoba, Aoba-Ku, Sendai, 980-8579, Japan*
[c] *Institute for Global Environmental Strategies, Japan*
[d] *National Graduate Institute for Policy Studies, 7-22-6 Roppongi, Minato-ku, Tokyo 106-8677, Japan*

ARTICLE INFO

Available online 2 February 2010

Keywords:
Japan
Airports
Productivity
Technological change
Policy implications

ABSTRACT

In this paper, the productivities of Japanese airports over the period of 1987–2005 are analyzed using the Malmquist index, and technological bias is investigated. During this period, airports on average became less efficient and experienced technological regress. Our results indicate that the traditional growth accounting method, which assumes Hicks neutral technological change, is not appropriate for analyzing changes in productivity for Japanese airports.

1. Introduction

A committee on the future of airports under the Ministry of Land, Infrastructure, and Transport formed in July 2007 and suggested a drastic change in Japanese aviation policy through a major revision of the half-century-old Airport Development Act. The background of this major revision was a progressive deregulation and liberalization since 1998, during which airlines' reform proceeded much faster and further than that of airports, combined with the need to enhance airports' operational managerial efficiency. The revision received cabinet approval in March 2008 and took a new name, the "Airport Act," deleting the term "Development." In this new Airport Act, definitions of three airport categories were abolished in a way that all airports have become classified either as "major international airports" or "all others," and surprisingly, Osaka International Airport (Itami) is included among the category-1 airports in the "all others" group.

In this aspect, it is important to understand how the airport industry has performed over the past decades and to analyze changes in the industry performances, especially from the viewpoint of competitiveness, i.e., productivity. The airport market receives considerable economic scrutiny, with an emphasis on performance (see Oum and Yu, 2004). Two alternative models have been adopted, namely, the non-parametric data envelopment analysis (DEA) (Sarkis, 2000; Gillen and Lall, 2001; Adler and Berechman, 2001; Fernandes and Pacheco, 2002; Sarkis and Talluri, 2004; Yoshida and Fujimoto, 2004; Barros and Dieke, 2007) and the parametric stochastic frontier model (Pels et al., 2001; Martín et al, 2009).

The motivation for this research is as follows. First, prior research on Japanese airport productivity using a DEA model, such as the studies by Yoshida (2004) and Yoshida and Fujimoto (2004), has shown that the technical efficiency of Japanese airports was mixed. This is because of the domestic economic development and political process behind the decision to construct airports, with the blame placed on the regulatory system for excessive construction (see Ohta, 1999; Feldhoff, 2002, 2003). Second, the 1998 restriction on Japanese airports was lifted, increasing competition for the market. Finally, the growth of Asian economies is forcing Japanese airports to increase their productivity to compete in the transportation market. This study analyzes the productivity of Japanese airports over two decades by assessing the recently developed productivity measurement techniques of the Malmquist productivity index with biased technological change.

This study is structured as follows. Section 2 presents the institutional setting of Japanese airports. Section 3 presents the productivity models. Section 4 presents the data and the results. Section 5 provides some concluding remarks.

2. Background

Domestic aviation in Japan is dual-centric, with Tokyo International Airport and Osaka International Airport being the two hubs. These hub airports form an aviation network with other airports in Japan. Some of the other airports have relatively large background economic area and hence form domestic trunk routes with Tokyo and Osaka.

---

[*] Corresponding author at: Graduate School of Environmental Studies, Tohoku University, 6-6-20 Aramaki-Aza Aoba, Aoba-Ku, Sendai, 980-8579, Japan. Tel.: +81 45 339 3751; fax: +81 45 339 3707.

E-mail addresses: cbarros@iseg.utl.pt (C. Pestana Barros), managi.s@gmail.com (S. Managi), yoshida@grips.ac.jp (Y. Yoshida).

0967-070X/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tranpol.2010.01.009

In 1956, the expenditure on airport development was only about 100 million yen. However, a rapid increase in passenger volume resulted in the use of larger aircraft. The expenditure on airport development expanded to almost ten billion yen by 1966, including a cost of two billion yen for development of Narita Airport. In addition, a series of accidents in the same period called for strategic airport development and better aviation security. This has resulted in the Five-Year Airport Development Plan, which was to begin in 1967.

In addition to the Five-Year Airport Development Plan, government policies, such as the First, Second and Third Comprehensive National Development Plans, have placed a strong emphasis on development of regional airports as well. The background for this development was a political campaign claiming geographically uniform and even development of Japan, which is never justifiable from an economic point of view; it only accelerated public expenditure on social infrastructures, especially in rural areas, discouraging the agglomeration of population and economic activities in major cities.

Due to the strong influence of the Fourth Comprehensive National Development Plan, the fifth five-year plan was enacted in 1986, which followed the “one-prefecture one-airport” doctrine. As one of its policy objectives, the Fourth Comprehensive National Development Plan promoted international aviation of Japanese airports. This latter objective became the main target of the sixth five-year plan, resulting in further development and expansion of regional airports into international airports. This happened due to the introduction of a runway-length index called TRW, which obviously encouraged extension of runways in regional and rural airports, which are in areas where the land price is much lower than in metropolitan areas.

Japanese airports have been heavily regulated under the Airport Development Act and the airport development special account. The series of Five-Year Airport Development Plans, funded by the pooled budget of the special accounts, acted as a soft-budget constraint to the government and resulted in excessive development and an increase in the number of regional airports. However, the development and expansion of major airports such as Narita and Haneda faced difficulties and remained stagnant. Regional airports have been developed in Japan due to political interests, as in many other countries. For example, Chubu was developed recently via strong private initiative, and its development received full local support. As a result, an unbalanced domestic aviation system has resulted with excessive capacity in many regional airports while major airports in the Tokyo area are facing capacity constraints.

In 1996, the seventh Five-Year Airport Development Plan rectified its policy target to emphasize the development of trunk-route airports in metropolitan areas. This finally brought an end to the history of old-fashioned airport development policies in Japan that started in 1970. In 2003, the Airport Development Plans were merged into a Social Infrastructure Key Improvement Plan, through which the political environment and its policy targets finally changed from the development of regional airports to better utilization and improved efficiency of existing airports, as well as a more focused investment toward expanding the capacity of hub airports in the Tokyo area. Now, the construction of a new runway at Haneda and expansion of the second runway at Narita are under way; both measures will reduce the capacity constraint of these airports, though only to a certain extent (see also Nakagawa et al., 2005).

3. Methodology

We estimate the efficiency and total factor productivity change for Japanese airports using DEA. There is extensive literature on benchmarking applied to a diverse range of economic fields (see Humphreys and Francis, 2002; Humphreys et al., 2002; Graham, 2005). The reciprocal of the Shephard (1970) input distance function serves as a measure of Farrell (1957) input efficiency. Linking input efficiency indexes across time allows us to estimate the Malmquist productivity index. This index can be decomposed into change in resource use due to efficiency change and change in resource use due to technological change. Furthermore, we use the approach of Färe and Grosskopf (1996) and decompose technological change into an index of output-biased technological change, an index of input-biased technological change, and an index of the magnitude of technological change.

Holding outputs constant, the reciprocal of the input distance function provides the ratio of minimum inputs to actual inputs employed and serves as a measure of technical efficiency. Let $x^t = (x_1^t, \ldots, x_N^t)$ represent a vector of N non-negative inputs in period t, and let $y^t = (y_1^t, \ldots, y_M^t)$ represent a vector of M non-negative outputs produced in period t. The input requirement set in period t represents the feasible input combinations that can produce outputs and is represented as

$$L^t(y^t) = \{x^t : \ x^t \text{ can produce } y^t\}. \tag{1}$$

The isoquant for the input requirement set is defined as

$$ISOQ\ L^t(y^t) = \left\{x^t : \ \frac{x^t}{\lambda} \notin L^t(y) \text{ for } \lambda > 1\right\}. \tag{2}$$

The Shephard input distance function is defined as

$$D_i^t(y^t, x^t) = \max\left\{\lambda : \ \frac{x^t}{\lambda} \in L^t(y^t)\right\}. \tag{3}$$

The reciprocal of the Shephard input distance function equals the ratio of minimum inputs to actual inputs employed and serves as a measure of Farrell input technical efficiency. Efficient decision-making units (DMUs) use inputs that are part of the $ISOQ\ L^t(y^t)$ and have $D_i^t(y^t, x^t) = 1$. Inefficient DMUs have $D_i^t(y^t, x^t) > 1$.

We estimate the reciprocal of the Shephard input distance function using a linear programming method called DEA. We assume that there are $k=1,\ldots,K$ DMUs. The DEA piecewise linear constant returns to scale input requirement set takes the form:

$$L^t(y^t) = \left\{x^t : \ \sum_{k=1}^{K} z_k^t x_{kn}^t \le x_n, n = 1, \ldots, N, \right. \\ \left. \sum_{k=1}^{K} z_k^t y_{km}^t \ge y_m, \ m = 1, \ldots, M, \ z_k^t \ge 0, \ k = 1, \ldots, K\right\}. \tag{4}$$

The DEA input requirement set uses linear combinations of the observed inputs and outputs of the K DMUs using the K intensity variables z_k^t to construct a best-practice technology. The $N+M$ inequality constraints associated with inputs and outputs imply that no less input can be used to produce no more output than a linear combination of observed inputs and outputs of the K DMUs. Constraining the K intensity variables to be non-negative allows for constant returns to scale.

To compute input technical efficiency for DMU “o” we solve the following linear programming problem:

$$1/D_i^t(y^t, x^t) = \max_{z,\lambda}\left\{\lambda^{-1} : \ \sum_{k=1}^{K} z_k^t x_{kn}^t \le \lambda^{-1} x_{on}^t, \ \ n = 1, \ldots, N, \right. \\ \left. \sum_{k=1}^{K} z_k^t y_{km}^t \ge y_{om}^t, m = 1, \ldots, M, \ \ z_k^t \ge 0, k = 1, \ldots, K\right\}. \tag{5}$$

Following the approaches of Färe and Grosskopf (1996) and Managi and Karemera (2004), total factor productivity growth can be estimated using the Malmquist input-based index of total factor productivity growth. This index can be decomposed into separate indexes measuring efficiency change and technological