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Four Mergers: Applied AI, Blockchain Tech, Airports, and Airlines

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ABSTRACT

Airline sustainability, airport efficiency, passengers' net gain and social optimality would be a matter of a great incorporation of human technical and intellectual talents towards an all winning economic and financial arrangement. That cannot be easily imagined without a system of law and order and a successful implementation of ethical and moral principles and culture. The author has analyzed the efficiency of blockchain technology, AI, and airport-airlines integration, each in separate published studies. In this study, the theoretical focus is on the four essential players – airlines, airports, AI, and blockchain technology for optimization of collective social gain through internalization of the existing externalities among airlines, airports, and passengers. This would best be implemented via an interactive financial strategy, in which airports and airlines would be independently run, but commonly owned, as in a holding-company concept. The stakeholders, airports, airlines, and passengers of all kinds could reduce their costs and optimize their net gains. Through lower airfare, airlines can serve more passengers, who would use more of the two-tier airports' landside and airside services. All that can be effectively operationalized through the advantageous integrated application of AI and blockchain technology within the merged airlines and airports, say, Airportlines. Using this proposed model, one may apply stepwise regression along with linear programming procedures, to explore optimal airport fees and allocation of resources through a collective cost minimization and/or revenue maximization, including those of airlines, airports, and the general customers, through some mandatorily established optimal government regulations.

INTRODUCTION

The current airline industry's continual challenges are altogether probably a more manageable task through some effective applications of potential managerial, technological, and financial innovations. Given the current serious structural problems, mixed with the ever-growing adverse external factors, such as environmental concerns, fuel, increasing costs of anti-terrorism, etc., all would necessitate some vintage and smarter overall management of the competitive complexities in providing landside and airside services. Some airline-airport forms of partnerships and alliances are probably more critically needed now than before.

While the operational history of both airlines and airports reveal clear examples of various types of cooperation and mergers, among each industry and then across the two industries, this paper is focused on internalization of externalities, to be secured through the mergers of certain airports and their affiliated airlines, and enjoyed by the main three stakeholders, airlines, airports, and most importantly passengers (of all kinds) under the controlling shadows of dynamic and optimal government regulations against the potential abuses of the primary objectives of the ultimate economic growth and efficiency. Our suggested main tools are AI and blockchain technology management.

THE BACKGROUND LITERATURE

The contemporary literature highlights some different methods of operational revenue and/or cost sharing among some airports and airlines, where they serve. One such method is a legally binding agreement, "airport use agreements," specifying how the airport operational risks and responsibilities are to be shared by the two parties. The terms, the conditions of the airline's use of an airport, the methods of calculation of the airline's fees to pay for the airport's services and facilities, along with the airline's rights and privileges are specified.

More generally, such airport-airline financial relationships, in airport pricing and investment, at the major U.S. commercial airports have been summarized by the following three methods (FAA, 2025 and many earlier years, as also addressed and analyzed by Hamzaee, R.G., and Vasigh, B., 2006):

- The Residual Cost Agreement: All airlines agree to pay any costs of running the airport, unless the parts that are allocated to other users or covered by non-airline sources of revenue. In that way, airlines using the airport services would agree to maintain the airport financially self-supporting by making up any possible shortages remaining after the actual costs for all airport users have been offset by non-airline sources of revenue.
- The Compensatory Approach: Risk of running the airport would be on the airport, and airlines should pay all the fees, rental rates and charges for the actual costs of the facilities and services that they use.
- The Hybrid Approach: which would include a mixture of both above methods; for instance, Washington airports have revenue-sharing elements in their agreements with the participating airlines. Profits or losses at the end of any given year from the entirety of the airport operations, including commercial facilities, are shared between the airport operators and airlines. However, airlines' shares of profits will be placed as credit towards offsetting the next year's fees. More of relevant methods are discussed in FAA publications, such as:

The airline and airport industries both have continued to be pressured by all the competitive and global environmental forces in many regional, national, and global markets, as have been reported in many published pieces, including Hamzaee and Vasigh (2006, 2002, 2001, 1997), Achim and Lang (2018) reported that the effects of the aviation industry's deregulation have been revealed to be a regular enlargement of its market size to double as much every 15 years.

On the issue of efficiency and economic contribution of airline-airport industries, I provided a relevant theoretical proposition (Hamzaee, 2019), which would call for a more effective effort focused on an optimal airport-airlines mergers under the currently experienced explosive growth of massive data, blockchain technology, and AI advantages for more reliable and effective operations, given the numerous challenges faced by the aviation industry around the world.

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More recently, we provided an AI-focused framework (Hamzaee R.G., and Salimi, M., 2024), where an assessment of both potential efficiencies in productivity and potential costs of AI in an economy, industry, or a business unit was presented. Developed through an integration of that experience with the magnificent advantages of the evolving blockchain technology (Hamzaee R.G., and Salimi, M., December 2024), and more seminal works of, e.g., Catalini, C. (April 24, 2017), it would be more appropriate now to discuss the central theme of this research framework, a collective welfare optimization of airport-airline-passengers' (social) welfare.

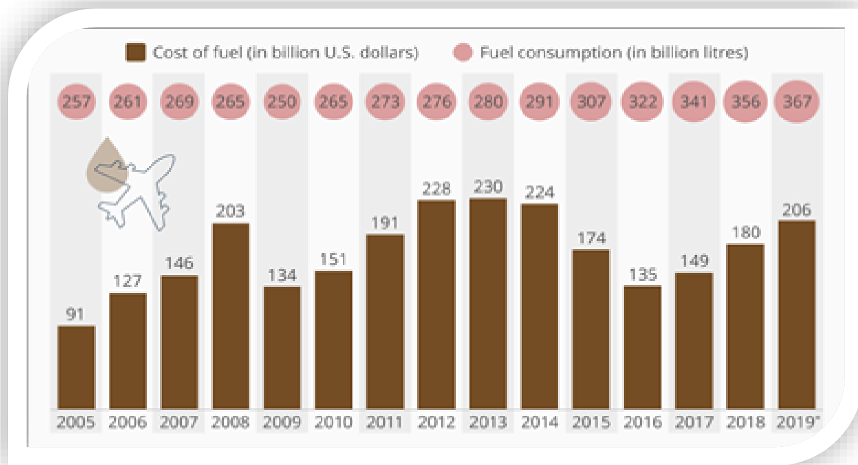

Figure 1: Worldwide Commercial Airlines' Increasing Trend in Fuel's Consumption & Cost
Source: IATA, ICAO, as presented by Statista

The fuel expenses (Figures 1 and 2) have continued to mark growing trends, the cost of replacement of older aircraft, tower controllers-related complications, essentially vital government regulations, and safety issues are altogether pushing various incentives for either mergers, affiliations, or even cost sharing with airports in some regions.

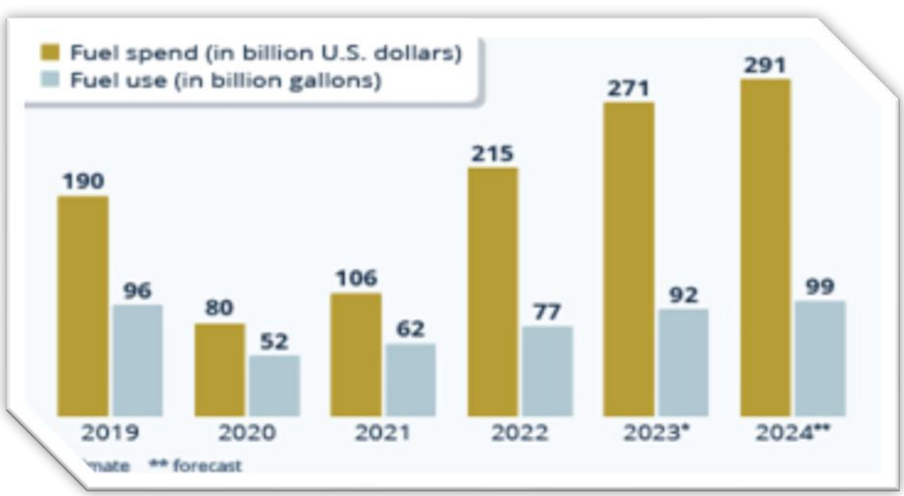

Figure 2: Worldwide Commercial Airlines' Increasing Trend in Fuel's Consumption & Cost
Source: IATA, ICAO, and presented by Statista

Figure 3: Increasing Safety Issues in the U.S., Experienced by Boeing Planes
Source: National Transportation Safety Board via Seattle Times, and presented by Statista

Figure 4: Even More Problems Faced by the Air Transportation Industry: The U.S. Probationary Federal Workers Laying Off as of February 20, 2025
Sources: Government Executive, Fed Managers, Federal News Network, Media Reports, all compiled into the tabulated report by Statista

According to Catalini, C. (2017, p.1)), hinging on an earlier study by (Agrawal et al, 2016-2017), the integration of AI and blockchain technology would enable businesses to be more efficient in reducing production costs and making more reliable predictions, and the human judgement would be left as "a last barrier before full automation." (p. 1)

Yet, while Wingate D., Burnes, B. L., and Barney, J. B. (Summer 2025) confirm the positive impacts on transformation of economies and markets, they warn that the lasting advantageous differentiation would beg for human passion and creativity. Hence, it is intuitively recognized that joining the adoption of AI is not a choice, since the AI infrastructure is already built and continuously evolving. Even if the AI adoption may not reveal a lasting impact in most industries, it's a necessity to do the commonly normal business, in which AI is a common vehicle of normal movement and beyond.

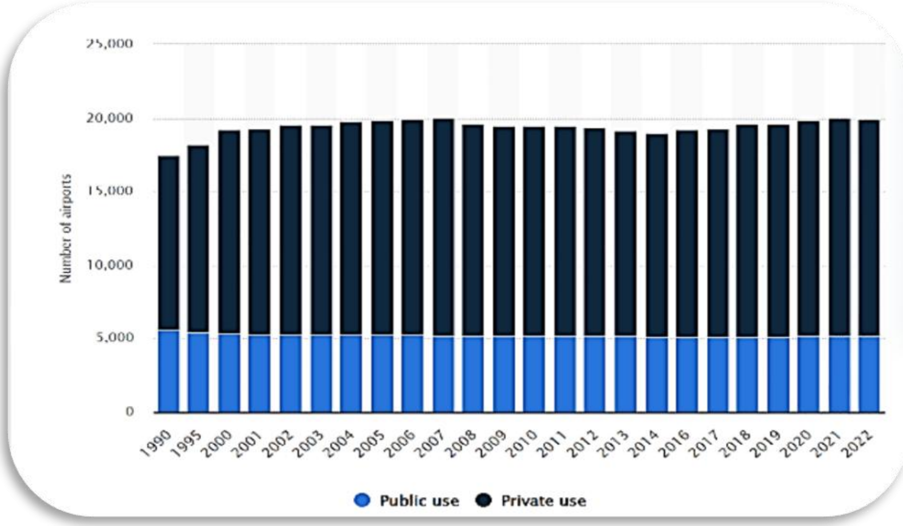

Figure 5: Number of Public and Private Airports in the United States from 1990 to 2022

Source: Statista, 2025

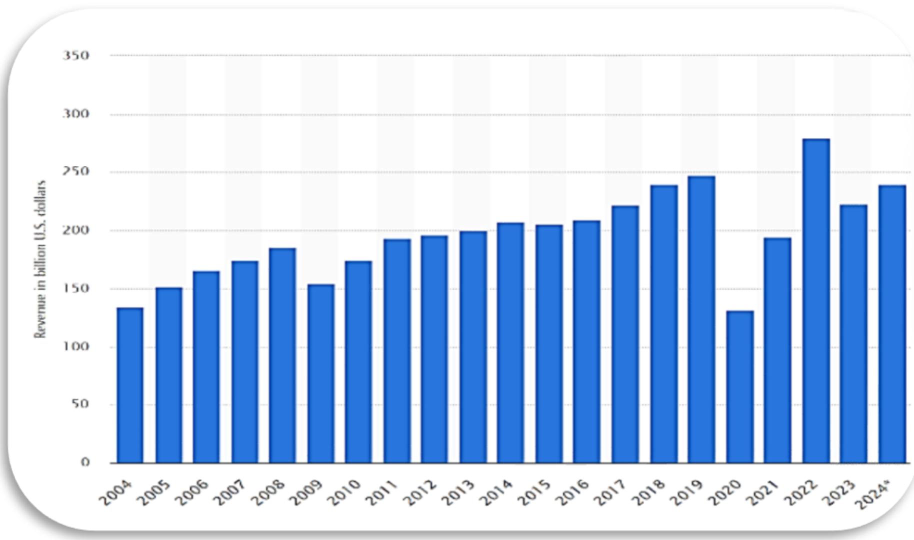

Figure 6: Total operating revenue streams of U.S. airlines from 2004 to 2024*(in billion U.S. dollars)*

Source: Statista, 2025

THEORETICAL FRAMEWORK

The alliance and/or mergers advocated by this author could take one or more of various patterns to be optimally implemented. One general way could be very much like bank-holding companies, where the entire multi-firm and main structural property is defined as commonly owned, the operational management of each firm is independently run. I propose that the legally-set share of ownership, in this model, could be defined through a great Factor of Incentivization, FOI, for higher sales and/or assets to achieve by each of the two general groups of partners, airports and airlines, on the one hand, and among all companies of each group, on the other.

$$FOI_{Rev} = \frac{TGR_{ALi}}{TGR_{MER}} \quad (1)$$

$$FOI_{Asset} = \frac{TAT_{ALi}}{TAT_{MER}} \quad (2)$$

That could be summarized in the following ratios: FOI_{Rev} = the set Factor of Incentivization (& ownership), in terms of relative sales revenues for all i = 1, 2, …., k airlines, and FOI_{Asset} = the set Factor of Incentivization & ownership, in relative assets for all i = 1, 2, …., k airlines; TGR_{ALi}, and TGR_{MER} = total gross revenues of an airline, and the Airportlines' (or the merger's), respectively. Also, TAT_{ALi} = total Assets of the i-th airliner, and TAT_{MER} = the merger's Total Assets. The second setting to propose would be:

$$FOI^{Port}_{REV} = \frac{TGR_{Ap\,j}}{TGR_{MER}} \quad (3)$$

$$FOI^{Port}_{Asset} = \frac{TAT_{Ap\,j}}{MER_{TAT}} \quad (4)$$

Where: FOI^{Port}_{REV} = the set Factor of Incentivization (and ownership), in relative sales revenue for all j = 1, 2, …., m airports, and FOI^{Port}_{Asset} = the set Factor of Incentivization (and ownership), in relative assets for all j = 1, 2, …., m airports; = $TGR_{Ap\,j}$= total gross revenues of the jth airport. Also, $TAT_{Ap\,j}$ = total Assets of the j-th airport, where:

- $ALR_{i,\,t}$ = the i-th airline revenue share in time t, $MER_{Rev,\,t-1}$ = the merged total revenues in the last period $_{t-1}$, and $MER_{TAT,\,t-1}$ = the merged total assets in the last period t- 1.

In absence of an adopted blockchain technology and AI, that type of integration of information, ledgers, and data could not even be a feasible task. The need for an AI and/or a blockchain to use the huge time series data stored permanently by a blockchain into ledgers (reported accounting statements) and coded for both blockchain and AI applications would be critically and emphatically noticeable. Blockchain here would intensify competition, while cryptocurrencies could be issued and used in daily trades with lower price incentives to the customers, as contrasted with the alternative credit cards, checks, or cash payments. As another advantage of both blockchain and AI usage in this merger analysis, one may think of how accurately each airline's and each airport's revenues and assets earned in the previous period t-1, should be determined, as a prerequisite to determination of their shares of the entire Airportline's (merger's) for each of the incorporated airlines and airports for the period t.

There will be a dependable accounting platform set on the blockchain to be used forever through the permanently stored ledgers, useful for tax purposes, dynamic accounting, and share distribution in an automatic fashion, where AI is applied all along. Yet in an MIT Sloan Management Review article, Feurriegel, et al. (Spring 2025) argue that ML (machine learning) is not necessarily leading to the ideal solution when some intuitive or statistical associations among the variables are detected for exploring more possibilities of causal relationship, e.g., whether or not more R&D investment would be really the ideal choice for higher earnings, and if so, by how much.

Those, I argue, are the fine-tuning efforts that must be supplemented by the researcher's further strives into intervention with machine learning. As an example, for the time series data, one extra methodological diagnostic attempt is incorporation of VAR technics, in which among all important and remotely possible variables considered, those with the highest explanatory contributions to each one-standard-deviation of the targeted (dependent) variable, would be detected and included for the most appropriate decision making. Several related research works are Litterman, R. (1982), Sargent, T.J., and Sims, C.A. (1977), and Hamzaee, R.G., and Salimi, M. (2025).

To derive the integrated (Airportlines') PPC, output-resource constraints must be formulated as follows:

$$\begin{bmatrix} a_{1AS} & a_{1LS} \\ a_{2AS} & a_{2LS} \\ \cdots & \cdots \\ \cdots & \cdots \\ a_{nAS} & a_{nLS} \end{bmatrix} \begin{bmatrix} Q_1 \\ Q_2 \end{bmatrix} \leq \begin{bmatrix} R_1 \\ R_2 \\ .. \\ .. \\ R_n \end{bmatrix} \tag{5}$$

Or simply restated: $a_{n,2}.Q_{2,1} \leq R_{n,1}$ (6)

Where:

- $\mathbf{a_{i'AS}}$ = the amount of the **i'-th** resource necessary to produce one indexed unit of airside output (landing & departure), for all i' = 1, 2, …, n
- $\mathbf{a_{i'LS}}$ = the amount of the i'-th resource necessary to produce one indexed unit of landside services to customers at the airport, for i'= 1, 2, …, n
- Q_1 = the total indexed quantity of airside output (quantity of a composite output of
- landing/passengers + take off/passengers + miles/passengers, or alike)
- Q_2 = the total indexed quantity of landside output, such as real income from airport business rental, airport maintenance bases, parking revenues, etc.
- $R_{i'}$ = the total indexed quantity of the i'th utilized resource, for all i' = 1, 2, …, n

In Figure 7, given that neither the consumption nor the production of either type of Q_1 or Q_2 would be infinitesimally divisible, it is assumed that the PPF is not a continuous function, which is realistically more appropriate than otherwise. Yet, we may consider both cases. In case the producers' PPC and passengers' utility function are assumed to be continuous functions, then we adopt Figure 8.

Table 1: AI Model's Descriptions of Resource Examples

Total indexed quantity of the 13 samples of used resource	Some 13 examples and types of airside & landside resources being used
R_1	quantity of Gas
R_2	number of pilots
R_3	number of airside personnel
R_4	number of aircraft
R_5	number of runways
R_6	number of maintenance bases
R_7	number of maintenance technicians and engineers
R_8	number of tower controllers
R_9	amount of computer hardware and software to utilize
R_8	number of airlines' on-land employees excluding airside personnel, technicians and engineers
R_9	number of landside operational employees
R_{10}	number of security personnel
R_{11}	number of janitorial employees
R_{12}	real value of security facilities
R_{13}	number of airport restaurants

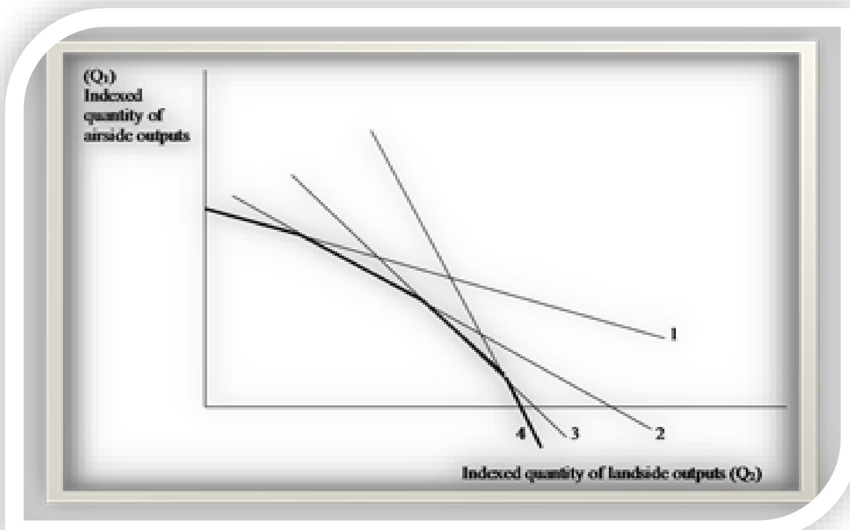

Figure 7: Derivation of a PPC through Linear Programming

Now to present our passengers' consolidated utility function (general welfare function), the following model will be more appropriate:

$$U_{\rho t} = \mathrm{f}\,(Q_{1\mathrm{t}}, \mathrm{Q}_{2\mathrm{t}}) \quad (7)$$

$$\mathrm{PB}_t = \mathrm{p}_{1\mathrm{t}}.\, Q_{1\mathrm{t}} + \mathrm{p}_{2\mathrm{t}}.\, Q_{2\mathrm{t}} \quad (8)$$

$$Q_{2\mathrm{t}} = \frac{\mathrm{PB}_t\text{-}\mathrm{p}_{1\mathrm{t}}.\, Q_{1\mathrm{t}}}{p_{2\mathrm{t}}} \quad (9)$$

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$$U_{\rho t} = f\left(Q_{1t}, \frac{PB_t - p_{1t} \cdot Q_{1t}}{p_{2t}}\right) \quad (10)$$

$$W_t = U_t = \sum_{\rho=1}^{N} U_\rho\,(Q_{1t}, Q_{2t}) \quad (11)$$

where, $U_{\rho t}$ = an individual passenger's or user's utility of airlines' and/or airports' airside and landside outputs in period t
U_t = consolidated utility or pleasure (general welfare) in usage of airlines' and airports' airside and landside outputs for all air travelers in period t
PB_t = pasengers' real or inflation-adjusted budget in period t
p_{1t} = indexed price of all airside output in period t; p_{2t} = indexed price of all landside output in period t.

To consider the social welfare (utility) function across all passengers in the industry, equation (11) would represent the entire total utility for all the relevant passengers during a certain period up to current period t.

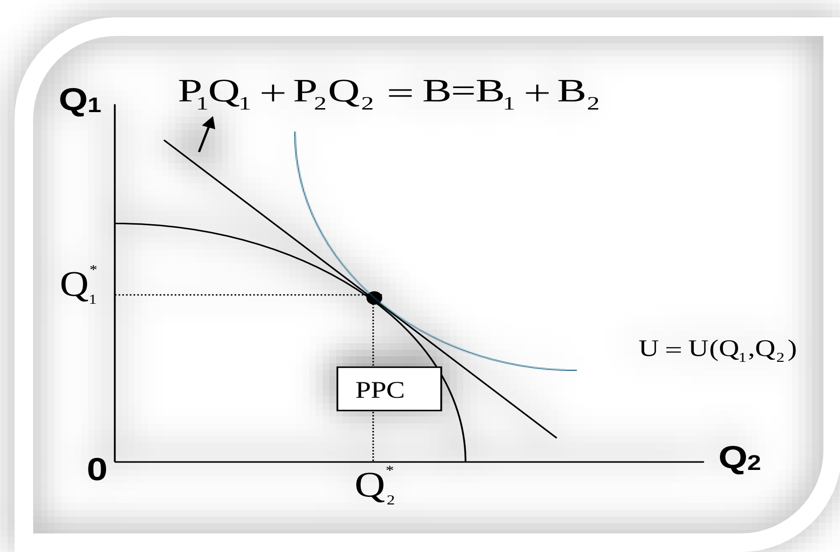

Figure 8: The optimum solution for all three groups is the same, Q^*_1 and Q^*_2.

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