An Assessment of Economic and Environmental Costs Involved in Domestic Air Transportation in Comparison with Road Transport Alternatives: A Case Study on Colombo - Batticaloa Sector

T. L. Gunaruwan[1] and M.H.S. Dilrukshi *[2]
[1] *Department of Economics, University of Colombo, Sri Lanka*
[2] *Graduate School of Management, Kyoto University, Japan*
**m.dilrukshi.75u@st.kyoto-u.ac.jp*

INTRODUCTION

Aviation could be considered as the only swift globalized transportation network. Hence, it has occupied an important place in domestic and global business. The aviation industry has been playing a vital role in economic growth, job creation, and facilitation of trade. Concerning those aspects, domestic aviation could also be considered an important activity that could promote the economic dynamism of a nation. Moreover, the increasing value of people's time has necessitated reducing time spent on transport; thus, increased attention is drawn to aviation services concerning internal travel as well, which requires significantly less travel time compared to other modes of transport. Henceforth, promoting domestic aviation has become vital, not only in larger countries but also in small islands like Sri Lanka.

The presence of sustained domestic scheduled air services is imperative for a country to promote internal travel by air. Moreover, for people to opt for aviation over other modes of transport, a safe air transport system should be provided at an affordable price. In the Sri Lankan context, given that the Government cannot afford to spend its scarce capital resources with pressing demands elsewhere, an alternative strategy may be to invite private investment for infrastructure development and flight operations. This may necessitate Viability Gap Financing (VGF) if private airline operators become unable to attract sufficient passenger demand at financially viable airfares to cover costs. Yet, any such VGF payments through State coffers need a socio-economic justification.

The present study is an attempt to inquire whether adequate Generalized Cost-based transport economic advantages compared to

alternative modes of internal transportation could be there to justify VGF-supported domestic passenger aviation in Sri Lanka.

The foremost objective of this study was to assess whether a private domestic passenger airline in Sri Lanka could generate adequate socio-economic advantages to justify a VGF payment to support such a commercial operation. It mainly focused, among many components, on the travel time-saving aspect of the Generalized Cost of domestic air transportation vis-à-vis two potentially competing modes, namely, car and air-conditioned bus that would be perceived by an average passenger. In addition, it also attempted to take into account the positive externalities that would be associated with domestic air transport operations in Sri Lanka.

LITERATURE REVIEW

The profitability of domestic air services, even in developed countries, is not promising. The continued volatility in the resources sector and the inherent seasonality of tourism have led to softening the demand from regional and business communities, which has unsurprisingly resulted in lower profit margins for regional airlines (Merkert, 2017). In this context, the financial viability of domestic passenger aviation in a small country like Sri Lanka becomes particularly questionable.

A commercial airline operation producing national benefits, however, could become a candidate for financial support from the Government if it does not secure adequate financial returns to the operator. Yet, such support cannot be justified unless the operation could potentially generate socio-economic net benefits to the nation.

It is in this context that the concept of Generalized Cost (CG) of transport, which incorporates financial costs and other opportunity costs (such as additional travel times, reliability of travel times), becomes applicable in transport planning (Koopmans, Groot, Warffemius, Annema, 2013).

METHODOLOGY

The study adopted the approach of assessing the relative advantage a passenger would see in shifting to aviation, particularly from road-based transport modes, by attempting to estimate the Generalized Cost of transport. The premise was that there should be a perceived cost reduction, both monetary and non-monetary costs of a journey, for a passenger to shift modes. Thus, the condition on which such a shift could be sought based on the Generalized Cost of transport was derived.

Next, the differences in vehicle operating costs including fuel cost, and emissions also were brought into the analysis. Such economic costs were compared, together with the economic value of time spent on travel, to examine whether there could be any significant net benefit to the economy by road passengers (car and air-conditioned bus) shifting to aviation mode, to assess whether there could be any justification (or not) for the State to pay through a VGF to support financially unattractive air transport operations. The proposed (in 2019) Colombo-Batticaloa air service was used as the source of information and data, and also as a case to mirror the potential.

FINDINGS AND DISCUSSION

The general condition for a passenger to move away from a given road-based mode to aviation could be modeled using the concept of Generalized Cost of transport, as depicted below:

$$(F_A * d_A) + E < (F_R * d_R) + (VoT*H)$$

Where, F_A: Air Fare per km

d_A: Distance of the air trip in km

F_R: Fare per km of the road-based mode

d_R: Distance by road in km

E: Extra cost the air passenger has to incur to travel to/from airport

H: Travel time saving if the aviation mode is opted for

VoT: Value of Time per hour of the passenger

Thus, the condition for VoT of a passenger shifting to aviation could be expressed as $VoT > [(F_A * d_A) + E - (F_R * d_R)] / H$

The resultant minimum VoT levels for a passenger currently using car and air-conditioned bus modes to travel to Batticaloa from Colombo (d_R = 330 km), for instance, to move to aviation mode, at the proposed airfare of USD 100 per one-way air trip (F_A of approximately 91.32 Rs/seat-km at d_A = 219), could then be worked out as indicated in Table 1.

Table 1: Value of Time

Mode shift to Aviation from	Car	A/c Bus

Travel time for one way trip ǂ	6 hrs	7 hrs
Time-saving if traveled by air ǂ	2.25 hrs	3.25 hrs
Fare per one-way trip (F_R * d_R) #	LKR 8580	LKR 1200
Min VoT to shift to aviation (LKR/hour)	6400	6700

Notes: ǂ *Assumed averages. For air travel, airborne time of 45 minutes and travel times to/from airports, and dwelling time at airports at both ends totaling 3 hours were considered.*

Road transport costs to and from the two airports were estimated to be LKR 3000 (one way).

These results revealed that a Sri Lankan Road traveler should have a minimum of LKR 6400 per hour of income for him/her to perceive an adequate Generalized Cost advantage (in terms of comparative fares and the value of time saved) to shift to aviation mode. It is noteworthy that this amount is nearly seven-fold the earning per hour of an average working person in Sri Lanka, assessable based on the Gross Domestic Product in 2019; thus, there would not be many, even within the present car user category, having such high-income earning capacities to possess sufficient VoT to opt for air travel to Batticaloa if flight services were available. It would be further unlikely that such high-income earners could be found in the category of passengers traveling by bus.

As the next step, the economic and externality costs associated with the three different modes of transport considered were comparatively examined (Table 2).

Table 2: Economic Cost Comparison

Mode of Travel	Air	Car	A/C Bus
Distance (Km)	219	330	330
Fuel usage per one-way passenger litres) (at assumed seat occupancy factors of 50% in air travel, 2 seats in cars, and 25 seats in buses)	13.08 of Av fuel + petrol	11 of petrol	5.28 of diesel
Fuel Cost per passenger trip (LKR for one way)	3008	1540	739
Other Vehicle Operating Costs in LKR (including Maintenance, Ownership, but excluding Fuel)	3843	1990	581
CO_2 emissions per passenger trip (Kg) (incl car travel to/from airport for air travel, at 2.4 kg/l of	31.4	26.4	13.7

petrol and Av fuel, and 2.6 kg/l of diesel)			
Cost of CO_2 Emissions (LKR) at 86 $/MT [(c)]	540	454	236
Total (excluding VoT) cost per passenger trip (LKR)	7391	3984	1556

Notes:

(a) ART 72-500 needs 2.53 l/100 seat km of Aviation fuel (Wikipedia, 2021)

(b) Emission coefficients adopted from (Ricke, K., Droet,L., Caldeira,K. and Tavoni, M., 2018)

(c) ICAO data were used in estimating Flight Operating Costs (ICAO, 2017)

(d) Road vehicle operating costs would vary depending on the type of vehicle. In this study, the full cost of LKR 21.29 and LKR 110 per km were assumed for car and A/C bus use, respectively.

The results of the analysis indicated that the differences in costs between road transport and aviation modes would significantly drop (to LKR 3407 and LKR 5835, for car and A/C bus travel, respectively) when Vehicle Operating Costs, including fuel costs, and CO_2 emission costs were factored in. Thus, a mode shift to aviation, particularly from car travel, could be justified at much lesser VoT levels[1], compared to the foregone analysis with no consideration paid to such economic and externality costs. For instance, encouraging a car traveler having a VoT of more than LKR 1500 per hour (approximately 50 percent higher than the average VoT [2] in 2019, which would be well within the feasible levels for a car traveler), to move to aviation mode could be nationally advantageous when vehicle operating costs and emission costs are taken into consideration. However, when it comes to bus passengers, a minimum VoT of over LKR 1800 per hour (meaning USD 9 per hour, or USD 2580 per day) would be required for a shift to aviation to become justifiable, which level of threshold income

[1] Broadened conditionality for minimum VoT level once additional cost factors of Vehicle Operating Costs (VOC_A and VOC_R) and CO_2 Emission costs (CE_A and CE_R) of air and road travel, respectively, are factored in: $VoT > [(F_A * d_A) + E - (F_R * d_R) + (VOC_A - VOC_R) + CE_A - CE_R)] / H$

[2] Approximately Rs 1040 per hour in 2019, based on the GDP earned by an average working person in Sri Lanka.

would be rather unrealistic to be found among bus passengers, as such reflects a monthly income of around LKR 183,000.

CONCLUSIONS

This research attempted to examine the Generalized Cost of transport, and to comparatively estimate the VoT level of Sri Lankan passengers that would enable aviation to be economically beneficial, in view of examining any economic rationale to incentivize an otherwise commercially unviable air service operation through Viability Gap Financing (VGF). It considered the Colombo – Batticaloa segment as a case study.

It was revealed that, with the proposed airfare, it would be unlikely that many Sri Lankan Road transport users, except a few very high-income earning passengers having substantial VoT levels, would be attracted to aviation mode, given the required very high levels of VoT of around LKR 6400 and LKR 6700 that would be required for a car passenger and a bus passenger respectively, for such a modal shift. Yet, once the comparative benefits to the national economy were considered by factoring in Vehicle operating costs including fuel expenses and the CO_2 emission costs[3], it was found that encouraging car passengers to shift to aviation could become beneficial to the national economy when their VoT levels exceed Rs 1500 per hour. Concerning bus passengers, however, shifting to aviation appeared unlikely to be beneficial to the national economy given the relatively lower levels of their incomes which would be far behind the higher threshold VoT level of LKR 1800 per hour is required to justify such a modal shift.

Henceforth, the study enabled inference that bus transportation would inflict the lowest cost burden to the national economy among the three modes compared, and thus a modal shift towards it may be encouraged. Modal shift from car to aviation could become beneficial as car travelers would generally have higher VoT levels than an average working Sri Lankan; in such circumstances, a payment to a potential air transport operator through VGF, to be estimated based on a comprehensive benefit-cost assessment of investment proposal, could then become justifiable.

However, it is noteworthy that any national economic benefits of a modal shift are generated when passengers actually shift modes.

[3] The external costs such as congestion impacts on other road users, road accidents, etc, were not considered in this analysis.

Therefore, it is recommended that any VGF, if considered by the Government, could better be made proportionate to the number of local passengers carried, so that the payment to the operator from the State coffers could be defined as a "grant" per each local passenger transported, rather than paying for a minimum number of seats, making such payment directly reflecting the national economic and externality benefits generated by the corresponding mode shift.

It is further recommended that further research be conducted to factor-in other externalities involved, such as road congestion and accidents, when comprehensively estimating the comparative national economic net benefits of inter-modal shifts.

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