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Analysis of the Settlement of Revenue Pooling in the *Sahasara* Bus Reforms Project

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1. Introduction

The *Sahasara* bus reforms project was initiated focusing on Central Province Passenger Transport Services Authority (CPPTSA) with the collaboration of Strategic Enterprise Management Agency (SEMA) under the technical consultancy of Department of Transport and Logistics Management, University of Moratuwa. Faced with traffic congestion, uncontrollable competition among buses and deficiencies in regulations for monitoring buses, *Sahasara* was introduced with the intention of enhancing the quality of public transportation. *Sahasara* bus reforms project amalgamates time tabling, scheduling, revenue settlement via revenue pooling, monitoring the operation of buses and strategic decision making into one framework. The study focuses on one of the main aspects of *Sahasara*: revenue settlement via revenue pooling. All revenue collected by buses operated flow into one common account which is then distributed among operated buses by considering cost index, operated distance (km's), route type etc. Under the *Sahasara* project, four settlement systems were introduced for the distribution of pooled revenue.

2. Methodology

The analysis was based on four 'settlement methods' formulated by the technical consultancy team of Department of Transport and Logistics Management, University of Moratuwa to distribute pooled revenue among operated buses, as described below:

2.1. Settlement System 1 (SS1)

This is based on the premise that the distribution proportion should be based on the proportion of the total cost of providing transport services by all buses for all trips on all routes in the corridor.

$$S_i = \left(R_T * \left(\frac{b_{ij} k_{ij}}{\sum_1^m \sum_1^n b_{ij}\, k_{ij}} \right) \right)$$

Where on a given day,

S_i; Settled amount for the bus owner, i^{th} bus (Rs)

R_T; Total collected revenue from n buses on m routes on the corridor

b_{ij}; Estimated operating cost of i^{th} bus calculated on the basis of 12 factors in the NTC Bus Operating Cost Index for operating route j [1] (Rs per Km's)

k_{ij}; Operated km's by i^{th} bus on j^{th} route

m; Total number of buses operated on the corridor

n; Total number of routes operated on the corridor

2.2. Settlement System 2 (SS2)

This was introduced in order to address the distributional differences between routes. It was observed that while some routes were consistently getting more than what was collected, other routes were getting less. As a result, routes with similar earnings were clustered together.

$$R_c = \sum_1^m \sum_1^n ((x/100) * R_{ijc})$$

$$R_T = \sum_1^m \sum_1^n ((y/100) * R_{ij})$$

$$ClR_i = R_c * \left(\frac{k_{ijc}}{\sum_1^m \sum_1^n k_{ijc}} \right)$$

$$CoR_i = \left(R_T * \left(\frac{b_{ij} k_{ij}}{\sum_1^m \sum_1^n b_{ij}\, k_{ij}} \right) \right)$$

$$S_i = ClR_i + CoR_i$$

Where on a given day,

R_T; y% of total revenue collected by n buses on m routes on the corridor (Rs)

R_c; x% of total revenue collected by n buses on m routes on the cluster c (Rs)

ClR_i; Computed cluster based revenue to be allocated to owner of i^{th} bus (Rs)

CoR_i; Computed corridor based revenue to be allocated to owner of i^{th} bus (Rs)

R_{ijc}; Revenue of i^{th} bus on j^{th} route in c^{th} cluster

k_{ijc}; Operated km's by i^{th} bus on j^{th} route in c^{th} cluster

2.3. Settlement System 3 (SS3)

The tier based approach was introduced to address distributional differences within clusters. It was seen that some buses were consistently earning lower than others and thus the higher earning owners were still complaining.

There is a minimum target revenue determined for buses on each route, R_{min}.

If $R_i < R_{min}$,$S_i = R_i$
If $R_i \geq R_{min}$, $RpKm_i = R_i/k_i$

$d_c = RpKm_{\max\_c} - RpKm_{\min\_c}$

No of tiers $g_c = \frac{d_c}{10}$ where max $g_c = 4$

1st tier:$RpKm_{\min\_c} \leq RpKm_{ic} < (RpKm_{\min\_c} + \left(\frac{d_c}{g_c}\right))$

2nd tier:$(RpKm_{\min\_c} + \left(\frac{d_c}{g_c}\right)) \leq RpKm_{ic} < (RpKm_{\min\_c} + 2\left(\frac{d_c}{g_c}\right))$

3rd tier:$(RpKm_{\min\_c} + 2\left(\frac{d_c}{g_c}\right)) \leq RpKm_{ic} < (RpKm_{\min\_c} + 3\left(\frac{d_c}{g_c}\right))$

4th tier:$(RpKm_{\min\_c} + 3\left(\frac{d_c}{g_c}\right)) \leq RpKm_{ic}$

$S_i = RpKm_{avg\_gc} * k_i$

Where on a given day,

R_i;	Revenue collected by bus I (Rs)
k_i;	Km operated by i^{th} bus (Rs)
$RpKm_i$;	Average revenue of i^{th} bus (Rs)
$RpKm_{max\_c}$;	Maximum average revenue of c^{th} cluster (Rs)
$RpKm_{min\_c}$;	Minimum average revenue of c^{th} cluster (Rs)
$RpKm_{avg\_gc}$;	Average revenue for each group (Rs)

2.4. Settlement System 4 (SS4)

This was allowed on a temporary basis for routes that wanted each bus to be settled equally to the revenue they earned.

$$S_i = R_i$$

3. Results

The study period is from 2nd August 2016 to 20th February 2017 that was also marked with several protests and strikes from bus owners which affected the operational performance. The notable incidents were in early October 2016 and in early December 2016. According to Figure 1, there is no significant increase in September 2016 pooled revenue due to the increase in traffic with the reopening of schools because of the problems that cropped up during the inaugural month of August. The introduction of the SS2 while relaxing time table control saw an increase in the supply

level as operators attempted higher individual revenues. The bus operations averaging 160,000 km per week in August & September 2016 increased to 170,000 km per week due to relaxation of time table control. However, this tapered down very quickly back to 160,000 km level as 170,000 km was not sustainable. A period of operational instability followed again in early December 2016 followed by the introduction of SS3 and SS4 settlement systems. The next 10 weeks since then has seen pooled revenue increasing gradually while the km operated remained at around 160,000 km per week. Weekly pooled revenue has increased from an average of Rs 12 million in August 2016 to Rs 13 million in Feb 2017. The highest weekly pooled revenue was Rs 13.5 million in mid-February 2017 while the lowest was a strike week in early December 2016 where it was Rs 9 million. However, the supply level appeared to gain stability at around 160,000 km per week with slight variations due to mid-week holidays etc.

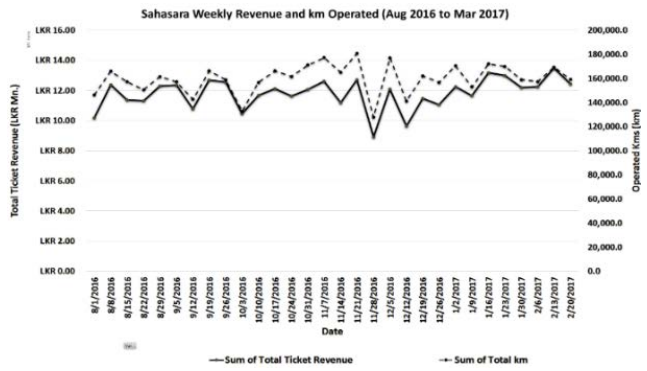

Figure 8: Sahasara weekly revenue and operated Kms

3.1. Analysis of Revenue per km (RpKm) by different Settlement Systems

The resulting performance of the earnings measured as Revenue per km (RpKm) is given in Figure 2. This indicates that the RpKm was maintained between Rs 75 to Rs 80 up until the 1st week of October 2016. The fall in earnings which happened during the week of strikes in early October 2016 could not be recovered since higher km were operated due to relaxation of time table controls as part of the compromise made during discussions with operators. The recovery began only after the second wave of protests in early December 2016 when SS3 and SS4 were introduced from 16th December 2016 onwards. It is evident that after this date, recovery in RpKm has been made in all three systems including SS2 which did not

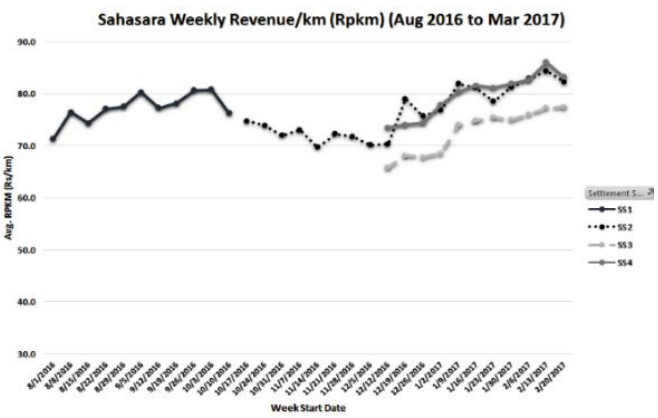

Figure 2: Sahasara Weekly RpKm by settlement method

show recovery between October & December 2016. While RpKm in SS2 has in fact maintained the lead after 16th December 2016, SS4 has now caught up at around Rs 82 per km. On the other hand, SS3 which was also introduced on 16th December 2016 started at around Rs 65 per km but steadily improved; though it is still around Rs 8 lower than SS2 and SS4.It can be observed that the change from SS1 to SS2 on 17th October 2016 did not lead to an increase in overall pooled revenue or RpKm. In retrospect, we can observe that this was because the operators also tried to increase supply and failed. This situation arose as there was a strong opinion among bus operators that given timetables were not conducive for earning higher revenues. However, the popular belief that revenue could be increased by operating outside the constraints of the timetables was proven to be false from this analysis. However, the changes brought about on 16th Dec 2016 have shown a remarkable improvement in all statistics and a recovery in all of the three Settlement Systems including SS2 that was in operation up until 16th December 2016. The best recovery has been in SS4, while the Tier Based Settlement System has shown the slowest recovery. SS2 has shown that it has recovered to the level enjoyed by SS1 in September 2016. However, the above shows that given time any of the Settlement Systems are capable of reaching the overall RpKm.

3.2. Operational Comparison between Settlement Systems

Initial information of on-board surveys indicated that on most routes where the individual settlement system (SS4) operated, travel times have increased and the benefit to passengers has deteriorated. Aggressive driving and competition among buses have returned.

3.3. Comparison of Travel Times

Figure 2 shows the travel time measurements done in March 2016 before *Sahasara* was implemented and in August 2016 just after implementation of *Sahasara*. It also shows the results from the March 2017 travel time survey. It can be seen that on most routes, travel time has decreased considerably soon after *Sahasara* was implemented under SS1, but now under different settlement systems, all of them indicate that travel times have deteriorated marginally from August 2016.

Table 2: Travel time analysis

		Before Sahasara	After Sahasara	Difference
Route Number	Start Location	Average Travel Time (hh:mm)	Average Travel Time (hh:mm)	Average Travel Time (hh:mm)
654/2	Kandy	1:02	0:40	0:21
	Digana	1:02	0:47	0:14
654	Kandy	1:20	1:03	0:16
	Karalliyadda	1:17	1:03	0:13
724	Kandy	0:58	0:46	0:11
	Pilimatalawa	0:50	0:43	0:06
690	Kandy	1:11	0:56	0:14
	Kadugannawa	1:13	0:58	0:14
TOTAL		**1:06**	**0:52**	**0:14**

According to the analysis, the more competitive routes such as Pilimatalawe (724) and Yakgahapitiya (655/4) appear to return reasonably short travel times even though they have the individual-based SS4 system which encourages slow operations as shown in the Hataraliyadde and Nitulemada Routes. The Digana Route is an exception which shows decent speeds possibly due to the higher speeds of the Karaliyadde and Medamahanuwara Routes which operate on SS3. The cluster-based SS2 routes have similar route lengths and thus it is difficult to project operations at higher longer route lengths. However, the limited data shows it to be better performing with increased distance.

4. Conclusion/Recommendation

The analysis of settlement of revenue pooling shows that at a given time, any of the discussed settlement systems are capable of achieving overall RpKm targets. With the implementation of these settlement systems, there is a control in aggressive driving, travel times, fraudulent activities such as not giving change to passengers while improving the quality of the public transportation. It is recommended to choose a suitable settlement system by considering the route type, revenue collection, operational Key Performance Indicators (KPIs) while encouraging the bus crew to provide quality service to passengers.

5. References

[1] A. S. Kumarage, “Criterion for a fares policy and fares index for bus transport in Sri Lanka,” International journal of regulation and governance, vol. 1, no. 2, pp. 53-73, 2002.

***Keywords**: Sahasara bus reform project, revenue pooling, settlement systems*