REFLECTIONS ON LABOUR PRODUCTIVITY OF THE SRI LANKA TRANSPORT BOARD: AN ANALYSIS OF PATTERNS AND EVOLUTION

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ABSTRACT

The predominant reliance on buses, particularly by low-income commuters, has made the bus transportation industry one of the most pivotal contributors to the domestic economy. Therefore, as the single largest public bus transportation service provider in Sri Lanka, SLTB's ability to generate higher volumes of output by employing fewer inputs is increasingly crucial. However, SLTB is a state-owned enterprise that has been criticised for its inefficient factor productivity for a long time. Such allegations against the leading transport service provider of the country would raise serious economic concerns. Thus, this study attempted to examine SLTB's labour productivity in its physical dimensions as reflected through the elasticity of output on labour inputs to determine the underlying causes for any inefficiency in the utilisation of labour in the organisation. The scale and evolution of elasticities of output of SLTB's operations on labour inputs between 2011 and 2019 were subject to econometric scrutiny in this study. The results of the study revealed that the SLTB's elasticity of output on labour inputs has been negative at the overall national level. However, a favourable evolution of the elasticity of output on labour could be observed over the years. The results also revealed the presence of significant differences in region-specific effects on the elasticity of output on labour inputs compared to the national level, indicating that different regions have different labour productivity levels.

Keywords: Labour Productivity, Sri Lanka Transport Board, Cobb-Douglas Mode, Bus Transportation, Elasticity of output on labour inputs

JEL Codes: J24, R15, C31, R41

1. INTRODUCTION

Factor productivity is a vital attribute of successful business entities, operating in competitive environments; output on labour and capital inputs being referred to as indicators of labour productivity and capital productivity, respectively. Greater output on a given quantity of factor input is synonymous with greater productivity on that particular factor, a reflection of higher levels of "efficiency" of organisational operations.

Labour as a factor of production, while being recognised as constituting the "organic composition" of inputs, which adds to the value creation of the economy while providing employment opportunities to people, also represents a significant share of costs of production in commercial business operations, thus impacting "profitability". Therefore, labour productivity is an important indicator of business operational viability and is endeavoured to attain at high levels by commercial ventures.

It is in this backdrop that the labour productivity of Sri Lanka Transport Board (SLTB) is examined. SLTB is the single largest public bus transportation service provider in Sri Lanka with over 7,000 bus fleet and around 30,000 employees and, being a State-owned enterprise, is often blamed for its "inefficiencies". SLTB was established in 1958 when passenger bus transportation was nationalised [1]. In 2018, it catered to approximately 6.8% of the total passenger transportation demand in Sri Lanka. SLTB is the ultimate travel choice, particularly of low-income commuters [2]. Therefore, SLTB carries out its operation not merely on profit seeking basis, but also with the intention of providing social benefits [3]. However, even for such governmental enterprises, it is vital to maintain high organisational and managerial efficiency to ensure the economic viability and sustainability of its operations.

The issue of poor factor productivity at SLTB has been often discussed on many platforms, citing managerial and operational inefficiencies, fruitless recruiting policies and mindless public policies as causal factors. Diandas [4], for instance; pointed out that financial problems and mismanagement issues and, particularly the unnecessary political interferences, had caused many undesirable outcomes; low productivity being one such most frequently cited problems associated with the SLTB. The negligence and inability of authorities to resolve these causal factors in time are believed to have paved the way towards this often-discussed low productivity levels in SLTB.

The hypothesis of low productivity levels at SLTB has not been tested by the authorities or academics through scientific effort. Thus, the presence and scale of the problem, as well as its causes, remain unknown. To fill this research gap, the present research was conducted to examine factor productivity levels of SLTB, focusing

mainly on its vital dimension of labour productivity, through an attempt to reflect quantitative estimates and their evolutions and trends.

More specifically, the study intended to focus on identifying the labour productivity evolution in SLTB by studying the elasticity of output on factor inputs. Therefore, the study aimed at estimating the impact of elasticity of output on labour inputs and its evolution over time.

2. LITERATURE REVIEW

2.1. Labour Productivity

Productivity is essentially an input-output relationship. It reflects the ability of an organisation, an economic sector, or an economy to generate higher income or output using limited inputs [5]. From the theoretical point of view, as Masky and Mishra [6] (p.02) stated, "… productivity is the relationship between the production output and what is required to produce it as inputs, which measures the rate at which it is performed". Productivity can be shown in the form of an equation as follows:

$$Productivity = {Output}/{Input} \text{ --- (1)}$$

Therefore, productivity analysis can be considered as an important policy-making and managerial tool [7] and a measurement for assessing different decisions and preventing wastage of resources [8]. Kamarudin et al. [5], observed that productivity measures are used to determine capital productivity, labour productivity, Total Factor Productivity (TFP), and profitability indices. According to Salehi and Shirouyehzad [9], there are four (04) main methods for measuring productivity; namely, the Production Function Method and Stochastic Method, which are parametric models, and the Total Factor Productivity (TFP) method, and the Data Development Analysis method, which are non-parametric models. However, there is yet to be an exact, unique method for measuring productivity.

Production function can be used to reflect factor productivity levels based on changes in supply-side performance on simultaneous development in labour and capital inputs; the Cobb-Douglas (C-D) production function being one of such often used production functions to analyse the productive potential in the supply side performance. [10], . [11]. After reviewing several production function-based models, Ali et al. [12] have found that the C-D production function, which is a parametric productivity measuring model, would be the most suitable method to quantitatively examine productivity levels in a production process.

The functional form of the Cobb-Douglas production function is as follows;

$$Y = A.L^{\alpha}.K^{\beta}$$ --- (2)

Where Y represents the production output; L and K denote the quantity of labour and capital inputs, respectively; $\alpha = \dfrac{\partial Y / Y}{\partial L / L}$, $\beta = \dfrac{\partial Y / Y}{\partial K / K}$ representing elasticities of output on labour and capital respectively; and "A" (the Constant) represents Total Factor Productivity [13].

The present research thus opted to estimate the elasticities of output on factor inputs, corresponding to what changes to output would result upon a unitary change in factor input, thus reflecting factor productivity. It focused mainly on the elasticity of output on labour inputs, thus on "labour productivity"; the importance of which is best elaborated by the Nobel laureate Paul Krugman, who has claimed, as quoted by Rabnawaz et al., that "…*Productivity isn't everything, but in the long-run, it is almost everything. A country's ability to improve its standards of living over time depends almost entirely on its ability to raise output per worker*" [14]. A higher elasticity of output on labour inputs, reflecting greater labour productivity, would indicate more efficient use of labour inputs, opined by Salehi and Shirouyehzad [9].

There is no specific measurement as to how labour productivity could be estimated or what formula is to be used for the purpose [15]. Labour inputs could be measured both monetarily or physically; according to Abt and Ahn [16], working hours (man hours), wages paid to workers, number of workers' working time, or number of direct workers employed, could be used to measure labour inputs. Similarly, the output could also be measured in both physical and monetary terms. Therefore, the estimates of the elasticity of output on labour inputs, reflecting labour productivity, need to be perceived and compared with the understanding as to which measures have been used in arriving at such estimates.

2.2. Labour Productivity in Bus Transportation

Despite the fast-growing private motor vehicle ownership and usage worldwide, public transportation (both public bus and public railway transportation services), as underlined by Badami and Haider, continues to account for a significant share of total trips [17]. Having studied the bus transportation industry, Borger and Kerstens have found that it is a reasonably heterogeneous mixture of companies with different ownership and status that provide passenger services in a highly regulated environment [18]. Yet, the commuters who use public bus transportation face many inconveniences, such as lack of coverage, unsafe driving, rude behaviour of bus crew, harassment, etc. Despite such quality-related issues, public bus transportation still holds a significantly larger share in passenger transportation due mainly to the

unavailability of viable alternatives. For instance, the percentage of trips by public transportation in Mumbai city was 88% in 2006, as found by Tiwari, indicating that public bus transportation was still a predominant mobility service provider in Indian cities [19].

This quasi-captive market environment, where low-income commuters have no choice but to use the public bus transportation service, has made the performance of public bus transport service provision very important. Perceiving the levels and evolution of bus transport service provision through appropriate measures would yield vital information on the efficiency of using scarce resources in delivering services to passengers. According to Fouad and Karim, such information could possibly indicate the areas where performance improvements are required and also possible directions for decision-making authorities to envisage improvements of the service quality [20]. Moreover, having examined the patterns and sources of growth regarding the labour productivity in public transportation across 13 industrial countries between 2000-2015, Vu et al., pointed out that the total factor productivity growth, digital transformation and sub sector level labour productivity improvements would play a crucial role in driving up the labour productivity in public transportation industry [21].

Over the years, numerous studies have been undertaken to identify the key indicators of public transportation service performance. In bus transportation, there are various types of inputs and outputs, and, as opined by Basu et al [22], an assessment of bus transport supply performance usually should start with identifying such operational inputs and outputs. Kumarage [23], for instance, identified two primary inputs in bus transportation, namely, the human resources (representing labour) and the capital (represented by the bus fleet-runner), while recognising two major types of output as well, namely, the qualitative outputs measured in terms of travel speed, comfort, cleanliness, convenience, etc., and quantitative outputs measured using such parameters as operated-kilometres per day. Borger et al. [24] used the total number of employees, including operators, maintenance staff, and administration staff, as labour inputs and the total number of vehicles operated by the system as capital inputs. Also, they used vehicle-kilometres as output in their study on public bus transportation. Sanchez [25] evaluated the bus service performance of the Spanish transport system, while selecting the total number of employees as input and vehicle-kilometres as output.

According to Basu et al., it is challenging to aggregate all these performance measurements into one formula to model the productivity levels in bus transportation [22]. Therefore, the selection of input and output variables to determine labour productivity depends on the researcher and the research objectives. In India, the

Central Institute of Road Transport (CIRT), for instance, has measured labour productivity as the total number of staff per bus on the road and the total effective kilometres per man day paid for. This measurement appears to have been identified as a better indicator of labour productivity in bus transportation from the bus operator's perspective. However, passenger-kilometres per employee would be a better choice from a social point of view, Badami and Haider [17] opined.

2.3. Labour Productivity in Sri Lanka's Bus Transportation

Even though the land transportation sector in Sri Lanka comprises of a number of transport modes like busses, railways, private vehicles, three wheels, trucks, and water transportation, bus transportation, according to Kumarage, is the predominant mode of passenger travel [23]. In Sri Lanka, bus transportation consists of private and State-owned bus transport providers, while 25% to 30% of passenger transportation is provided by the State-owned (government) bus transport service.

Kumarage [26] also has found that the capital productivity of bus service operations in Sri Lanka has recorded a steady improvement since its nationalisation in 1958 to establish the Ceylon Transport Board (CTB), the predecessor of SLTB. However, according to him, the capital productivity of the industry also declined after the reintroduction of private bus transport services in 1978, possibly indicating that the State-owned bus operation in Sri Lanka would have been more capital productive than the private bus service supply.

Quite in contrast, Perera has found that the labour productivity levels in the private bus operations being twice that of the State sector [27], an indication of the low labour productivity levels prevalent in the SLTB. He suggested that there has been a clear over-staffing issue in the state-owned bus operator. Kumarage [23] pointed out that the output per employee in the CTB operations, an indicator of the organisation's labour productivity levels, had reduced from 10,000 bus kilometres in 1958 to just over 7,000 bus kilometres in 1978. He attributed this reduction to the fact that, by 1978, CTB had been under-bussed and over-staffed simultaneously. Using historical data relating to 1959-1996, Kumarage [23] also mentioned that the increase of the number of employees in CTB (now SLTB) "was found to be more related to the timing of General Elections than the proportional increase in the bus fleet" (p.08). Further commenting on the matter, he stated that it gave a strong impression that CTB had been used as an "expedient ground for employment of political supporters" (p.09). His analysis of resource productivity has shown that over-staffing appeared to be an endemic problem in public sector (State Sector) bus transportation in Sri Lanka. These findings suggest that the problem of persistently low labour productivity levels that appeared to be prevailing in SLTB could have been a result of political

interference in its recruitment policies. Labour laws also could have been a crucial obstacle to improving labour productivity in bus transportation.

In this conjuncture, addressing the labour productivity issues in bus service provision becomes important. Gaining control over the labour productivity and its related factors, as pointed out by Micallef, could yield a potentially significant impact towards increasing overall productivity [15]. Borger [28] also suggested that the productivity issues in public transport services have to be duly addressed. According to Ittyerah et al., a carefully designed, implemented and adequately regulated bus transportation policy could help achieve the productivity objectives in bus service supply [29]. However, not much interest in this matter has been shown by scholars concerning the Sri Lanka's bus transport industry, even though its importance has been amply recognised in literature.

The present study was conceived with a view to focusing on SLTB's labour productivity aspects and approaching it through an examination of its elasticity of output on labour inputs. The elasticity of operational output on labour inputs illustrates the increase or decrease in total output due to changes in one unit of labour input; thus, reflects the labour productivity. Productivity indicators at the national level and their pattern of evolution over the years, and the regional differences as against the national average, were thus attempted to be estimated in view of producing valuable results which could lead to policy-relevant inferences.

3. METHODOLOGY

3.1. Analytical Techniques and Models Used

The general methodology of this study was divided into two stages. In the first stage, the Input-Output relationship, adopting from Equation (1), was constructed as presented in Equation (3) to measure the SLTB's labour productivity evolution from 2011 to 2019.

$$Labour\ Productivity = {}^{Total\ output}/_{Labor\ input} \text{------------------------(3)}$$

To calculate the labour productivity in physical terms, operated kilometres per month was deployed as the total output measure. The number of employees in service during the corresponding month was used to proxy labour inputs. Thus, as depicted in Equation (3) above, the labour productivity was represented in terms of operated kilometres per employee per month, both being physical measures.

In the second phase of the study, the impact on operational output due to the changes in labour inputs was investigated; thus, estimating the elasticity of output on labour inputs, adopting the Cobb-Douglas production function described by Equation (3), as

the theoretical model for the study. The model was converted to log-linear form, as presented below, to develop the expression in Equation (4):

$Y = A.\ L^{\alpha}\ K^{\beta}$

Natural logarithm form: $lnY = lnA + \alpha.lnL + \beta.lnK$ ------------------------(4)

Where, Y = Operated km per month [Total output],

A = Total Factor Productivity [TFP],

L = Number of employees in service in a given month [Labour input],

K = Number of fleet-runner[1] (buses that are maintainable in running condition) as at month-end [Capital input].

In this model, α and β denote elasticity of output on labour inputs and elasticity of output on capital inputs, respectively, which indicate the impact on the total output level when a given input increases by 1%, shedding light on factor productivity of SLTB operations. These coefficients were thereafter estimated using the Ordinary Least Square (OLS) methodology.

As in the case of the first phase of the study, the physical perspective of SLTB's factor productivity at the "national level operation of SLTB was thus examined in this phase, too. Operated kilometres per month was considered the total output measure, while the number of employees in the service during each month and number of fleet runner at the end of the month were used as labour and capital inputs, respectively.

As the third phase of the study, a model was constructed to examine the evolution of elasticities over time. A new variable, "t", representing "time", was introduced to the original Cobb-Douglas production function, as presented in Equations (5) and (6), to examine the dynamics of elasticity of output on labour over time.

$Y = B.\ L^{(\alpha + \xi t)}.\ K^{(\beta + \phi t)}$ ---(5)

Log linear form: $lnY = lnB + \alpha.lnL + \xi.(t*lnL) + \beta.lnK + \phi.(t*lnK)$ -------(6)

In this relationship, the evolution of the elasticity of output on labour over time would be reflected by the coefficient 'ξ' that would correspond to the variable t*lnL, while the sign of the coefficients would indicate the direction of the respective impacts on elasticities.

In the fourth phase of the analysis, an examination of the regional differences in the elasticity of output on labour inputs was attempted. For this purpose, an innovative model was constructed by using the functional form of the Cobb-Douglas production

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[1] The term "fleet-runner" is used in the SLTB to categorise the group of busses in the fleet that could be maintained in running condition. It does not necessarily mean, however, that the totality of fleet-runners is actually operated in a given month, due to various reasons.

function. The regional outputs ($\hat{Y}_R$) were thus modelled using the regional labour and capital inputs, but using national-level elasticity estimates (A, α and β), and the actual regional labour and capital inputs, as expressed by the equation (7).

$$\hat{Y}_R = A. \, L_R{}^{\alpha} . \, K_R{}^{\beta} \text{--(7)}$$

where,

$\hat{Y}_R$ = Estimated regional output in region R, using national-level elasticities

L_R = Number of employees in the service during the month in region R

K_R = Number of fleet runner at the end of the month in the region R

α = Elasticity of output on labour inputs at the national level

β = Elasticity of output on capital inputs at the national level

A = Total Factor Productivity at the national level

As described by the equation (7), the estimated regional output levels would be different from the actual regional output levels because in the process of deriving estimated regional output, the national average productivity estimate, namely, A, α and β, were used.

The ratios between the actual outputs and the outputs estimated using the national level elasticities based on equation (7) corresponding to each region could be defined as depicted in equation (8).

$$d_R = Y_R / \hat{Y}_R \text{ --(8)}$$

where,

d_R = The proportion of the actual regional output to the regional output estimated based on national-level elasticities, pertaining to region R

Y_R = Actual regional output in region R

$\hat{Y}_R$ = Estimated regional output in region R, using national-level elasticities

This derived variable "d_R" was thereafter modelled using the Cobb-Douglas formulation, in which the "proportions" were expressed in terms of regional labour and capital inputs, as depicted in equation (9); the logarithmic form of which is expressed in equation (10).

$$d_R = C. \, L_R{}^{\gamma}. \, K_R{}^{\delta} \text{--(9)}$$

$$ln \, (d_R) = ln(C_R) + \gamma.ln(L_R) + \delta.ln(K_R) \text{ --(10)}$$

where,

d_R = Ratio between the actual regional output and the estimated output based on national-level elasticities, corresponding to region R

L_R = Number of employees in the service during the month in the region R

K_R = Number of fleet-runner at the end of the month in region R

γ = Region-specific impact on the national-level elasticity of output on labour inputs

δ = Region-specific impact on the national-level elasticity of output on capital inputs

In the relationship described by the equation (9), γ and δ would be the coefficients for $\ln(L_R)$ and $\ln(K_R)$, respectively.

Next, a model to represent the regional output (Y_R) of any given region "R" could be developed, as explained below, using the relationship for $\hat{Y}_R$ as described in the equation (7), the definition of "d_R" provided in the equation (8), and the functional relationship developed for "d_R" as depicted in the equation (9), resulting in a Cobb-Douglas type expression for regional outputs, expressed by the equation (11).

$$Y_R = \hat{Y}_R * d_R = (A.\, L_R^{\ \alpha}.\, K_R^{\ \beta}) * (C.\, L_R^{\ \gamma}.\, K_R^{\ \delta})$$

$$Y_R = (AC).\, L_R^{\ (\alpha+\gamma).}\, K_R^{\ (\beta+\delta)} \text{---(11)}$$

Thus, $(\alpha+\gamma)$ and $(\beta+\delta)$ in equation (11) amount to be the regional elasticities of output on labour and capital inputs, respectively, as per Cobb-Douglas formulation; γ and δ thereby emerging as the "differences of the corresponding regional elasticities from the respective national elasticities", wherever those are "significant" when estimated using the model depicted in equation (10). In case any of the "differences" emerge as "insignificant", it implies that there would be no difference between the corresponding regional and national elasticities of the relevant inputs (γ and $\delta \rightarrow 0$) and that the national elasticity averages would prevail, or, in other words, $(\alpha+\gamma) \rightarrow \alpha$, and $(\beta+\delta) \rightarrow \beta$.

To estimate the relationship expressed in equation (10) in a single OLD analysis for all the 12 transport regions of the SLTB, the generic model expressed by equation (12) could be evolved by differentiating regions using twelve dummy variables (D_i =1 for the region "i", and 0 otherwise)

$$ln(d_i) = ln(T) + \Sigma\gamma_i.D_i\, ln(L_i) + \Sigma\delta_i.D_i\, ln(K_i) \text{----------------------------------(12)}$$

where,

L_i = Labour inputs in the ith region of the SLTB

K_i = Capital inputs in the ith region of the SLTB

D_i = Dummy for i^{th} region (value 1 for i^{th} region, and 0 for other regions)

γ_i = Region-specific impact on the national level elasticity of output on labour input, corresponding to the ith region

δ_i = Region-specific impact on the national level elasticity of output on capital input, corresponding to the ith region

T = The constant value, a combined effect of TFP for all regions

3.2. Sources of data

The analysis was conducted using secondary data. The required cross-sectional data were sourced from the Profit and Loss statements of the SLTB, facilitated through its ERP (Enterprise Resource Planning) Reporting System[2]. SLTB database contains island-wide, region-based and depot-wise statistics in both monetary and physical terms. In this particular study, the focus was on quantitatively analysing the physical dimensions of SLTB's labour productivity, for which island-wide statistics and region-specific data corresponding to the period between 2011 and 2019 were sourced.

3.3. Data Analysis

The data were analysed using the STATA Software package. The validity of the model was confirmed by the direction of the sign of the coefficient and significance of the model was indicated by the P value. The absence of the heteroscedasticity issue was tested and confirmed by using the Breusch-Pagan / Cook Weisberg Test.

4. ANALYSIS AND DISCUSSION

4.1. Labour Productivity Evolution in SLTB during 2011 - 2019

Over the years, the Sri Lanka Transport Board (SLTB) has been criticised for its inefficiency in labour management. Lack of proper recruitment policy, the invisible hand of political authority, and the lack of appropriate regulatory processes are believed to have created an overstaffing problem in the Sri Lanka Transport Board over the course of its existence, as discussed in the literature review.

However, having perused through the preliminary stage of the analysis, namely, the "overall labour productivity examination" using the ratio of total operational output to labour inputs, it was revealed that the SLTB's monthly bus kilometres operated per employee, a direct measure of labour productivity, has improved quite significantly from 2012 to 2018. This result is manifested in Figure 1, which graphically depicts the evolution of the overall labour productivity of SLTB, as well as the number of employees in service at each month-end between 2011 and 2019.

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[2] The authorisation granted by the Sri Lanka Transport Board to secure access to its ERP for this purpose is hereby thankfully acknowledged.
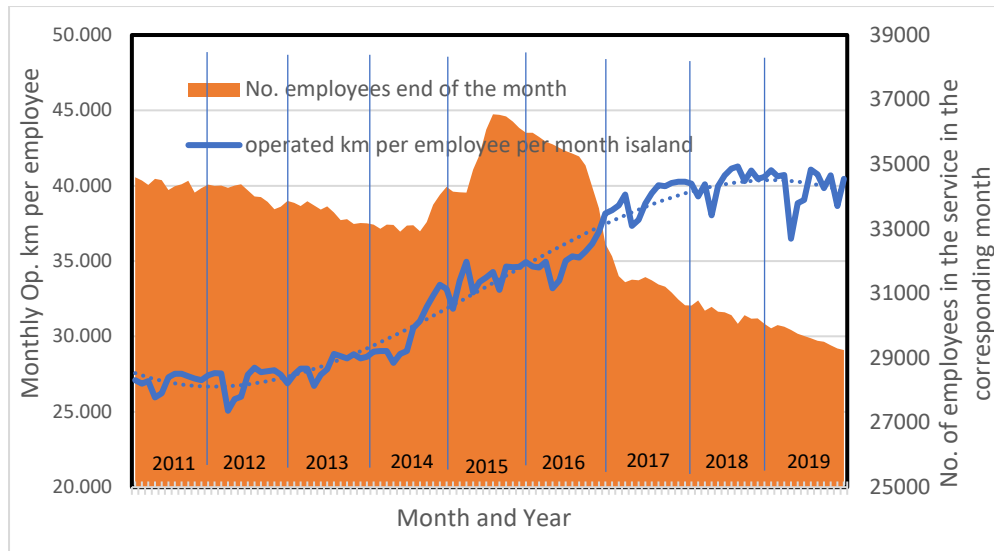
Source: Author's estimation using the data sourced from the SLTB database.

Figure 1: Evolution of the Labour Inputs and the Labour Productivity of the SLTB (2011-2019)

The results reveal that the SLTB's labour productivity has undergone three different patterns of evolution during this study period; a slight decline from early 2011 to approximately end of 2012, a consistent improvement from around beginning of 2013 till about the end of 2017, and a relative stagnation thereafter. The intermittent monthly ups and downs since early 2018 do not appear to indicate any stable pattern, except for a slight downward orientation observed in the aftermath of early 2019. On the other hand, the number of employees appears to have undergone a complete opposite movement compared to the labour productivity during the same period of time. The comparative patterns, observable in Figure 1, indicate that the labour productivity of the SLTB has deteriorated whenever the number of employees increased. Thus, the evidence suggests that the quantity of labour inputs would possibly have a pivotal influence on the labour productivity of the SLTB.

4.2. Reflection on SLTB's Labour Productivity through the Elasticity of Output on Labour Inputs

Analysis of the impact factor inputs on the operational output provides vital information regarding whether resources are utilised properly, and whether there are areas that might require improvements, which may help in making appropriate policy decisions [20]. Thus, this study went on to quantitatively investigate the dimensions of labour productivity of SLTB, particularly through estimating the elasticity of output on labour inputs; the regression results are summarised in Table 1.

Table 1: SLTB's elasticity of operational output on labour inputs

Model:	$lnY = lnA + \alpha.ln(L) + \beta.ln(K)$		
N = 108	Prob.> F= 0.000		$R^2 = 0.8985$

Determinant Variable	**Coefficient**	**Standard Error**	**p-Value**
ln (Emp)	-0.285*	0.065	0.000
ln (Fleet Runner)	1.205*	0.042	0.000
Constant	6.429*	0.831	0.000

Notes: * = P<0.01

Regression results and heteroscedasticity test results are provided in Annexure A.

Source: Author's estimations derived from the regression analysis based on the data sourced from the SLTB Database.

The estimated coefficients (in Table 1) representing elasticities indicate a significant negative elasticity of SLTB's operational output to its labour inputs that appears to have prevailed during the study period. Accordingly, an increase of labour input by 1% would result in a 0.3% reduction of SLTB's monthly operated kilometres. This outcome could confirm the hypothesis of the presence of excess staffing in SLTB, compared to its available capital stock.

On the other hand, capital inputs and operational outputs appear to have had a strong, positively elastic relationship. According to the estimated model, when SLTB increases its capital input (i.e., number of fleet-runner) by 1%, it would increase the monthly operated kilometres by 1.2%. This implies that by introducing more buses to the fleet-runner, the SLTB could potentially increase its scale of bus operations.

However, this suggestive evidence would possibly require further verification through a dynamic analysis as the scenarios could evolve over time with changes taking place in regard to regarding both inputs and the output.

4.3. Changes to Elasticity of Output on Labour inputs over the years, reflecting the evolution of Labour Productivity

The evolutionary pattern over time, examined as the third stage of the analysis, yielded the results summarised in Table 2.

Table 2: Evolution over time of the elasticity of output on labour inputs

Model: $\ln Y = \ln B + \alpha.\ln L + \xi(t.\ln L) + \beta.\ln K + \phi(t.\ln K)$

N = 108	Prob.> F= 0.000	R^2 = 0.9592	
Determinant Variable	**Coefficient**	**Standard Error**	**p-Value**
ln (Emp)	-0.418**	0.194	0.033
t * ln(Emp)	0.008*	0.001	0.000
ln (Fleet Runner)	1.243*	0.126	0.000
t * ln(Fleet Runner)	-0.009*	0.001	0.000
Constant	7.410*	1.064	0.000

Notes: * = P<0.01, **p<0.05

Regression results and heteroscedasticity test results are provided in Annexure B.

Source: Author's estimations derived from the regression analysis based on the data sourced from the SLTB Database.

Though the initial "static model" yielded an overall negatively elastic relationship between labour inputs and the operational output, the above results indicate a favourable dynamism in the elasticity of output on labour inputs over the years, as reflected through the positively significant coefficient amounting to 0.008 associated with the combined "Time and Employment" variable. Though the negative elasticity of operational output on labour inputs was still persisting, this evolution indicates a gradually reducing scale of such negative bearing over the years, reflecting an improving trend in the overall national-level labour productivity in SLTB over the period of study. This effect also could have been behind the evolutionary pattern graphically observed in Figure 1. While the causal factors behind this favourable trend would have to be investigated through further research, it could possibly be a reflection, inter-alia, of the gradual change in the composition of employees in the SLTB, the older and less productive employees being replaced by more productive younger staff, and also more efficient labour-embedded technologies being infused over time. However, the pattern of evolution pertaining to capital inputs appeared to have been in the reverse direction, signifying a possible diminishing trend of capital productivity of SLTB over time despite the positive elasticity of operational output on the variable representing capital inputs. This is indicated by the negative coefficient (0.009) of the composite variable, the multiple of time and capital input

(t*ln Fleet Runner). The reasons behind such an unfavourable trend, indicated in the outcomes of this study, will have to be investigated through future research.

4.4. The patterns of regional labour productivity

The regional level analysis undertaken as the fourth stage of analysis revealed the presence of region-specific differences in the elasticity of output on inputs, as indicated by the significance of the parameter γ when estimating the equation (11) using OLS, revealing that the regional labour productivity levels would be significantly different from the national labour productivity pertaining to several regions of the SLTB.

Table 3 summarises the region-specific differences in elasticity of output on labour inputs (γ values) and their corresponding levels of significance, estimated through the log-linear model depicted in Equation (11).

Table 3: Region-specific differences in elasticities of output on labour inputs and their Significance

Model estimated: $\ln(d_i) = \ln(B) + \Sigma\gamma_i.D_i \ln(L_i) + \Sigma\delta_i.D_i \ln(K_i)$			
N = 1296	Prob. > F= 0.000		R^2 = 0.9989
Region	**Estimated γ_i**	**Region**	**Estimated γ_i**
Colombo	0.375*	Nuwara Eliya	0.383*
Gampaha	0.223*	Rajarata	0.504*
Kalutara	0.548*	Sabaragamuwa	0.448*
Mahanuwara	-0.158**	Southern	0.348*
New Eastern	-0.109	Uva	0.056
Northern	-0.142	Wayamba	0.472*

Notes: *: P<0.01, **: P<0.05

The detailed regression model is provided in the Annexure C.

Source: Authors' estimation derived from regression analysis using the data sourced from the SLTB Database.

The regional elasticities of output on labour inputs ($\alpha+\gamma$) for all twelve regions of the SLTB could, therefore be calculated by treating $\gamma \rightarrow 0$ for those regions with insignificant γ coefficients, and the results are summarised in Table 4.

Table 4: Estimates of Regional elasticities of output on labour inputs

Elasticity of output on labour inputs at National level (α) = -0.285

Regional Elasticity of output on labour inputs = $\alpha+\gamma$

Region	γ_i	$\alpha+\gamma_i =$ -0.285+γ_i	Region	γ_i	$\alpha+\gamma_i =$ -0.285+γ_i
Colombo	0.375*	0.09	Nuwara Eliya	0.383*	0.098
Gampaha	0.223*	- 0.062	Rajarata	0.504*	0.219
Kalutara	0.548*	0.263	Sabaragamuwa	0.448*	0.163
Mahanuwara	-0.158**	-0.443	Southern	0.348*	0.063
New Eastern	Insignificant	-0.285	Uva	Insignificant	-0.285
Northern	Insignificant	-0.285	Wayamba	0.472*	0.187

Note: $\gamma_i = 0$, in computing $\alpha+\gamma$ values, in regions for which the estimates of γ_i emerged insignificant

Source: Authors' estimation derived from regression analysis using the data sourced from the SLTB Database.

According to the results summarised in Table 3 and Table 4, among the 12 regions of the SLTB, Colombo, Kalutara, Nuwara Eliya, Rajarata, Sabaragamuwa, Southern, and Wayamba regions emerged as having a positive region-specific effect on the elasticity of output on labour inputs at the national level, reflecting the possible significant difference of productivity of labour in those regions compared to the national average of the SLTB. Even though the Gampaha region has had a favourable regional effect, as reflected by its positive coefficient associated with the regional dummy, such regional impact appeared to have been "inadequate" to push the region to emerge as having an overall positive elasticity of output on labour inputs, and thus, remained "negative". The other regions, which emerged as having significantly positive region-specific effects, have managed to secure overall positive levels of elasticity of output on labour inputs. Mahanuwara region had produced negative region-specific labour elasticity of output. Hence, the overall impact of elasticity of output on labour in Mahanuwara region reflected at a much worse level than the overall average negative level estimated at the national level. For New Eastern, Northern, and Uva regions, the model did not yield significant region-specific effects (γ coefficients), thus leading to infer that the national average labour productivity would have prevailed in those regions.

With respect to the regional elasticities on capital inputs, the model resulted positive significant coefficients for regional capital input quantities for all the transport

regions except Mahanuwara, Northern and New Eastern regions. The model depicted insignificant coefficients for regional capital input quantities for those three regions. Thus, the national productivity average would be considered as the capital productivity of those regions. Therefore, all 12 regions had managed to possess overall positive impact of elasticity of output on capital inputs compared to the national capital productivity level.

5. CONCLUSIONS

The outcomes of this study led to several important findings. First, the results indicated the presence of a negative relationship between the elasticity of output on labour inputs in the SLTB, suggesting that the labour productivity at SLTB could possibly be weak and could potentially be improved. This could be a possible reflection of the existence of excess labour employed in the SLTB compared to its prevalent levels of capital stock. Second, the results also indicated that the elasticity of output on labour inputs had evolved favourably during the nine-year period up to 2019, reflecting a gradual improvement in labour productivity the SLTB would possibly have realised over the years, which could well be an outcome of the changes in recruitment and retirement policies adopted [30].

Third, the findings of the research unearthed the presence of regional differences in labour productivity, as revealed through the relative elasticities of output on labour inputs compared against the national level elasticity. Among the 12 regions of SLTB, Colombo, Kalutara, Nuwara Eliya, Rajarata, Sabaragamuwa, Southern and Wayamba regions appeared to have managed to realise significantly favourable regional elasticity effects, enabling those regions to record overall positive elasticities of output on labour inputs compared to the national level which was negative. In the Gampaha region, however, the significantly favourable region-specific effect observed compared to the national level appeared inadequate to sufficiently raise the regional elasticity of output on labour inputs to become positive. The New Eastern, Northern and Uva regions did not show any significant region-specific effect, and thus, it could be inferred that those regions were having similar levels of labour productivity that of the overall SLTB. Mahanuwara was the only region which indicated an overall negative region-specific effect compared to the national level of elasticity of output on labour, thereby ending up reflecting a much unfavourable labour productivity level compared to even the national level.

It is pertinent to observe, however, that there could be many other causal factors which could possibly have an influence over regional differences in elasticity of output on labour inputs: (a) hilly or geographically difficult terrains, (b) intensity of road traffic congestion potentially impacting on travel speeds, and (c) technological

conditions such as robustness and age of the bus fleet stemming from capital input differences, could be among such factors, even though the present study did not extend itself to examining their effects.

Even though not explicitly intended as an objective, the results of the study enabled shedding some light on the level of the SLTB's capital productivity as well. The elasticity of output on capital inputs showed a strong positive relationship with SLTB's operational output; possibly a reflection of a better and more productive deployment of capital compared to labour. But, over time, the evolving pattern of capital inputs seemed to have changed its direction, indicating a decreasing growth in capital elasticity of output, which may be a concern calling for managerial attention.

It is recommended that the finding of comparative productivity levels yielded from the present study be subject to closer and more careful scrutiny by the national and regional level management of SLTB and also be subject to further research with a view of examining the dimensions which were not covered through the present study. A strategic intervention to improve productivity formulated on this basis may yield substantial beneficial effects.

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ANNEXURE - A

Regression Model and corresponding validity test

```
. regress lnoperatedKMperMonth lnNoemployeesendofthemonth lnFleetrunnerendofthemonth
```

Source	SS	df	MS			
Model	1.61310278	2	.806551392			
Residual	.182237091	105	.001735591			
Total	1.79533987	107	.016778877			

```
                                        Number of obs =    108
                                        F( 2,  105) = 464.71
                                        Prob > F    = 0.0000
                                        R-squared   = 0.8985
                                        Adj R-squared = 0.8966
                                        Root MSE    = .04166
```

lnoperatedKMperMonth	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lnNoemployeesendofthemonth	-.2846963	.0654361	-4.35	0.000	-.4144441	-.1549485
lnFleetrunnerendofthemonth	1.204827	.0419064	28.75	0.000	1.121734	1.287919
_cons	6.428546	.8314324	7.73	0.000	4.779969	8.077123

```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of lnoperatedKMperMonth

        chi2(1)    =     6.41
        Prob > chi2 =   0.0113
```

ANNEXURE B

Regression Model and corresponding validity test

```
. regress lnoperatedKMperMonth lnNoemployeesendofthemonth monthlnnoofemployeesendoft lnFleetrunnerendofthemonth monthlnFleetrunnerendofther
```

```
      Source |       SS       df       MS              Number of obs =     108
-------------+------------------------------           F(  4,   103) =  604.97
       Model | 1.72204314      4  .430510786           Prob > F      =  0.0000
    Residual | .073296731    103  .000711619           R-squared     =  0.9592
-------------+------------------------------           Adj R-squared =  0.9576
       Total | 1.79533987    107  .016778877           Root MSE      =  .02668
```

```
          lnoperatedKMperMonth |     Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------------
    lnNoemployeesendofthemonth | -.4186959   .1942828    -2.16   0.033    -.8040101   -.0333817
      monthlnnoofemployeesendoft |  .0083079   .0015992     5.19   0.000     .0051361    .0114796
    lnFleetrunnerendofthemonth |  1.243745   .1264401     9.84   0.000     .9929808    1.494509
    monthlnFleetrunnerendofthem | -.0097499   .0019364    -5.03   0.000    -.0135904   -.0059095
                          _cons |  7.410479   1.064634     6.96   0.000     5.299028     9.52193
```

```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of lnoperatedKMperMonth

        chi2(1)      =      1.23
        Prob > chi2  =    0.2667
```

ANNEXURE C

Regression Model and corresponding validity test

```
. reg lnd  D1lnL D1lnK D2lnL D2lnK D3lnL D3lnK D4lnL D4lnK D5lnL D5lnK D6lnL D6lnK D7lnL D7lnK D8lnL D8lnK D9lnL D9lnK D10lnL D10lnK D11lnL D
> 11lnK D12lnL D12lnK
```

Source	SS	df	MS			
Model	12671.6643	24	527.986011			
Residual	13.5941435	1271	.010695628			
Total	12685.2584	1295	9.79556634			

```
Number of obs =   1296
F( 24,  1271) =49364.66
Prob > F      = 0.0000
R-squared     = 0.9989
Adj R-squared = 0.9989
Root MSE      = .10342
```

lnd	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
D1lnL	.3754134	.0556372	6.75	0.000	.2662626	.4845641
D1lnK	-.5695084	.0578558	-9.84	0.000	-.6830117	-.456005
D2lnL	.2229434	.0685836	3.25	0.001	.0883939	.3574928
D2lnK	-.3654988	.0876744	-4.17	0.000	-.5375012	-.1934964
D3lnL	.547825	.0492086	11.13	0.000	.451286	.6443639
D3lnK	1.171661	.057114	20.51	0.000	1.059613	1.283709
D4lnL	-.1581017	.0679161	-2.33	0.020	-.2913417	-.0248617
D4lnK	.0766484	.0663894	1.15	0.249	-.0535964	.2068932
D5lnL	-.1086881	.0679778	-1.60	0.110	-.2420491	.024673
D5lnK	.0951406	.0666565	1.43	0.154	-.0356284	.2259096
D6lnL	-.1421097	.1002488	-1.42	0.157	-.338781	.0545617
D6lnK	.1156894	.1057787	1.09	0.274	-.0918307	.3232095
D7lnL	.3834382	.0634353	6.04	0.000	.2589887	.5078876
D7lnK	-.5809144	.0588103	-9.88	0.000	-.6962902	-.4655385
D8lnL	.5041402	.0604981	8.33	0.000	.385453	.6228274
D8lnK	-.6830965	.0594286	-11.49	0.000	-.7996853	-.5665076
D9lnL	.4482287	.0850599	5.27	0.000	.2813555	.6151019
D9lnK	-.6495479	.1028846	-6.31	0.000	-.8513903	-.4477055
D10lnL	.3477098	.0687936	5.05	0.000	.2127483	.4826713
D10lnK	-.4979368	.0779168	-6.39	0.000	-.6507964	-.3450772
D11lnL	.0562703	.0684367	0.82	0.411	-.0779911	.1905317
D11lnK	-.1319892	.067079	-1.97	0.049	-.2635869	-.0003915
D12lnL	.4717086	.0608854	7.75	0.000	.3522616	.5911556
D12lnK	-.6484368	.0637177	-10.18	0.000	-.7734401	-.5234334
_cons	.2738636	.3165651	0.87	0.387	-.3471839	.8949112

```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of lnd

        chi2(1)    =    1.24
        Prob > chi2 =   0.2654
```