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# DETERMINANTS OF FINANCIAL SHORTFALLS IN STATE-OWNED RAILWAY SYSTEMS: AN ARDL APPROACH FOR SRI LANKA RAILWAYS

**Danthanarayana, C.T.,[1] Francis, S.J.[2] and Kumarage, A.S.[3]**

[1,2] *University of Colombo, Sri Lanka*
[3] *University of Moratuwa, Sri Lanka*

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## Abstract

*Sri Lanka Railways (SLR) has been experiencing a financial shortfall since the 1940s, characterised by operational expenditure exceeding total revenue. This study aimed to identify the critical determinants of the financial shortfall of Sri Lanka Railways (SLR) using an econometric approach. Employing a quantitative methodology, the study utilised secondary and manipulated data from 1977 to 2022 to examine the effects of four key variables: revenue shortfall from fare revisions (FRFR), subsidised season tickets (FRSS), freight transport volume (FTK), and total wage bill (WB), incorporating the general price level (CCPI) to account for inflation. The regression analysis, using the Auto Regressive Distributed Lag Model, identified a short-run relationship between the financial shortfall (LFS) and lagged variables, including the volume of rail freight transport (LFTK), total employee wage bill (LWB), and the general price level (LCCPI). A long-run relationship was found among revenue shortfall from fare revisions (LFRFR), LWB, LCCPI, and LFS. The findings highlight the significant impact of aligning railway fares with bus fares and managing employee expenses on SLR's financial shortfall. Additionally, the revenue shortfall from subsidised season tickets showed a significant relationship at a 10% significance level, both short-term and long-term. The study underscores the necessity of revising railway fares in line with bus fares to enhance revenue and ensure financial sustainability. Optimising employee-related costs through effective management and reviewing the subsidy structure for season tickets are also recommended. Furthermore, investment in capacity and facility development for freight transport is crucial for mitigating long-term financial shortfalls.*

**Keywords*:*** Auto Regressive Distributed Lag Model, Financial Shortfall, Sri Lanka Railways

**JEL Classification:** M37, G32, C52

Corresponding Author: joseph@econ.cmb.ac.lk/chamila@econ.cmb.ac.lk

# 1 Introduction

Sri Lanka Railways (SLR), formerly known as Ceylon Government Railways (CGR), was established in 1858 as a state-owned department with the objective of providing comprehensive rail transport services for both passengers and freight (Chanmugarajah, 1991). As a state monopoly, SLR has played a pivotal role in Sri Lanka's land passenger transportation sector. According to De Silva (1991), railway operations in Sri Lanka commenced in 1864, with the primary purpose of efficiently transporting coffee harvests from hilly regions. Over time, the railway network expanded to facilitate the transportation of diverse agricultural products, including tea, from plantations to Colombo Port for international trade. Presently, SLR boasts an extensive rail network spanning 1611 km, serving 182 railway stations and 163 sub-stations, supported by a workforce of over 12,541 employees (Sri Lanka Railways, 2022).

According to Danthanarayana & Kumarage (2021), Rail transport in Sri Lanka accounts for a relatively small market share of approximately 5% within the overall motorised transport sector. Nonetheless, SLR witnesses approximately 130 million passenger journeys each year, signifying a doubling of the figure from four decades ago. Notably, a considerable portion of passenger revenue is derived from approximately 50% of season ticket holders. Additionally, SLR handles roughly 2 million freight tons annually, accounting for nearly 2% of the country's total freight movements. Cement, minerals, and oil products constitute the primary sources of freight revenue. Recognising the growing demand for transport services and the need to optimise modal distribution, the government aspires to increase the modal share of railway passenger and freight transport from 5% to 10% and 2% to 5% respectively (Ministry of Transport, 2009). Consequently, SLR is committed to enhancing its operations, strengthening human resources, and fostering efficient rail transport to facilitate this transition.

Rail transport in Sri Lanka offers significant socioeconomic benefits, including cost-effectiveness and fuel savings per passenger kilometer when compared to road transport. Allocating capital expenditure toward railway development projects can yield maximum benefits due to several inherent advantages of rail transport. According to Dissanayake (2010), these advantages include higher speeds compared to roads, reduced traffic congestion, enhanced safety, lower crew costs, the capacity to efficiently transport large volumes of passengers between densely populated areas, cost-effectiveness with comparatively lower fares, reduced fuel consumption, and curbing rural-to-urban migration trends. However, SLR necessitates advanced infrastructure facilities through railway reforms, which entail substantial fixed costs for operation and maintenance (Kumara & Bandara, 2021). By leveraging these factors, rail transport has the potential to offer an efficient and high-quality service, optimising output while minimising costs.

During its early stages, SLR thrived as a dominant mode of freight transport, generating substantial revenue and profitability. From its establishment in 1864 until 1935, the railway consistently operated at a profit, except for the initial two years (Chanmugarajah, 1991). However, the economic focus of Sri Lanka shifted from plantation agriculture to industrial and service sectors, leading to a decline in the movement of agricultural products such as coffee and tea, which contributed to the railway's profitability. Factors such as increased costs, including fuel and employee expenses, and reduced operational revenue further strained SLR's financial viability. The trade depression and road competition also contributed to a gradual loss of traffic, leading to a decrease in the profitability ratio (Chanmugarajah, 1991). According to Danthanarayana & Kumarage (2021), SLR has been experiencing a financial shortfall since the 1940s, characterised by operational expenditure exceeding total revenue. Over the years, this shortfall has intensified, with the percentage of loss to earnings increasing from 22.2% in 1941 to 94.0% in 2018. The operating ratio, which measures the proportion of working expenses to revenues, exceeds 100% in the case of ineffective financial performance, indicating the financial difficulties experienced by SLR. This reflects a significant decline in financial performance, transitioning from a profit-making to a loss-making state.

According to Kumarage (2012), the lack of administrative flexibility provided to a government department has been cited as the reason for the inability to implement changes required for the railway to be translated into a commercially viable institution. As a result, railways no longer commanded a monopoly over freight transportation, freight revenue continuously decreased, and the gap between revenue and expenditure expanded. Over the period from 1977 to 2018, despite an increase in total revenue at current prices, the decline in total revenue at constant prices resulted in an Average Annual Growth Rate (AAGR) of -0.35%, while the AAGR for total operational expenditure was 0.91%; moreover, the AAGR of financial shortfall in constant prices exhibited a substantial increase of 5.4%, indicating weak financial performance during the past four decades (Danthanarayana & Kumarage, 2021; Danthanarayana & Dunusinghe, 2023).

To address the financial shortfall of SLR, it is essential to devise strategies that aim to increase total revenue or reduce recurrent expenditure. However, limited research exists regarding the financial and operational performance of SLR, resulting in a lack of comprehensive understanding of the Sri Lankan rail context. Existing literature in Sri Lanka provides insufficient insights, and government publications and transportation reports offer limited knowledge of the relationships between underlying factors of railway performance. Moreover, there is a noticeable absence of research employing statistical analysis through econometric models to examine and identify the key determinants influencing the financial performance of rail transport. Therefore, it is imperative to bridge this research gap and gain a comprehensive understanding of the factors influencing the financial performance of SLR. This study aims to address this research gap by conducting an econometric analysis to identify the crucial determinants contributing to the continued financial shortfall of SLR. The outcomes of this study will provide valuable insights and viable solutions for policymakers and planners to minimise the revenue-expenditure gap and enhance the role of SLR as a significant public transportation mode in Sri Lanka.

## 2 Literature Review

A financial shortfall is a condition in which a company or individual cannot generate sufficient revenues or income, resulting in an inability to meet or pay its financial obligations (Hayes, 2020). This highlights that when a railway undertaking experiences a continual financial shortfall, it places an enormous burden on the economy. Therefore, it is imperative to enhance organisational performance in terms of operations and finance to achieve long-term financial sustainability. According to the Institutional and Organisational Assessment Model (IOA Model), financial viability plays a crucial role in reflecting organisational performance (Mitchell, 2002). The model demonstrates that organisational performance is influenced by motivation, capacity, and various external factors affecting the organisation. This underscores the importance of ensuring financial viability to enhance organisational performance.

According to the theoretical framework, a business organisation's financial excess or shortfall is influenced by various factors that arise over time, including societal dynamics, innovations, risks, and uncertainties (Boianovsky, 2008; Clark, 1899; Knight, 1921; Schumpeter, 1934). Moreover, different firms pursue objectives such as profit maximisation, revenue growth, and other goals, which significantly shape their financial performance (Hilton & Baumol, 1962; Blaug, 1968; Cyert & March, 1963; Marris, 1964; Williamson, 1964). Theories also suggest that politicians, driven by self-interest and the desire to secure future votes, directly influence policy decisions related to pricing and investments in public enterprises (Stuart & Black, 1959; Downs, 1957.). Within the context of SLR, as a government department, policy decisions are specifically aimed at ensuring social welfare, overall growth, revenue generation, and other developmental objectives. These policy decisions have a direct impact on the financial performance of SLR.

Since the financial performance of railways, whether in excess or shortfall, is closely tied to operational efficiency, effectiveness, service quality, productivity, and other factors, this study focuses on examining past empirical studies that shed light on these performance aspects. According to Duranton et al. (2015), the performance of a railway system can be assessed based on three dimensions: the intensity of use (passenger and freight volume), quality of service (punctuality, availability, and fare level), and safety (accidents and fatalities). This reflects that the volume and fares of both passenger and freight transport have a direct impact on railway performance. Beck et al. (2013) illustrate the main cost and revenue drivers of railway efficiency in train operations and infrastructure. According to their findings, the primary cost drivers are vehicle and asset investments, maintenance, and renewals. Furthermore, the main revenue drivers are passenger revenue, government subsidies, and track access charges. This indicates that fare levels and government subsidies have an impact on the financial performance of railway undertakings.

Tahir (2013) researched the efficiency of the Pakistan Railway compared with China and India. The study highlights a decline in the efficiency of Pakistan Railway in comparison to Chinese and Indian counterparts, attributing it to inefficiencies related to capacity, volume, and fares. Additionally, the study concludes that prioritising the enhancement of production efficiency is essential for improving the financial efficiency of railway operations. Gallagher et al. (2019) conducted research on the operating ratio as a measure of railway operating and financial efficiency. Their findings indicate that railway freight rate increases and fluctuations in fuel prices have a significant impact on the operational ratio of rail transport in Canada.

George and Rangaraj (2008) conducted a performance benchmarking study on Indian Railway zones to assess operational efficiency. The study examined critical parameters, such as operating expenses, tractive effort, equated track kilometers, number of employees, passenger kilometers, and ton (freight) kilometers, which were identified as significant factors influencing the operational and financial performance of zonal railways. Murugaiah and Kumar (2017) conducted a study on the performance indicators of the Indian Railways. The findings of the study revealed that the performance of capital assets, rolling stock, employees, transport output (train km, wagon km), the volume of traffic, revenue, expenditure, and accidents all have a significant impact on the low operating ratio. Couto and Graham (2009) conducted a study on the determinants of efficiency and productivity in European railways, analysing the cost structure of the industry from 1972 to 1999. Their findings indicate that the cost of European railways increased significantly due to inefficiencies resulting from excess capacity supply and over-employment of labour inputs, while technological advancements positively influenced productivity levels.

Shaoul (2004) researched the financial realities of operating Britain's National Railways. He showed that British railways suffered huge financial losses during the 1970s with the reduction of freight transport due to the structural changes in the industrial sector and development of road transport, ineffective fares policy, and lack of infrastructure for railway developments. SLR has experienced a continuous financial deficit since the 1940s, primarily caused by operational expenses surpassing total revenue. According to the Ministry of Transport (2009), in parallel with advancements in road transportation, SLR has encountered various obstacles, such as insufficient investment, a deficiency in progressive management and regulatory measures, misallocated rail subsidies, impediments posed by robust trade unions, and the absence of a comprehensive fare policy. Consequently, these challenges have resulted in a significant deterioration of SLR's operational and financial performance over the course of several decades.

According to de Silva (1991), rail passenger fares and freight rates in Sri Lanka have undergone periodic revisions. However, these revisions have failed to keep pace with the significant increase in operational expenditure or consider the prices of comparable transportation modes. According to Jayasundara (1991), after 1977, railway passenger fares were revised twice in 1983 in response to a fuel price hike and subsequently multiple times, but these revisions did not adequately reflect the increase in expenditure. The monopolistic nature of government-owned railways in countries like India, Bangladesh, and EU nations led to regulatory pricing aimed at maximising social welfare, resulting in growing operating deficits during the 1970s and 1980s (ESCAP, 2003). Consequently, governments were compelled to increase subsidisation. For instance, the Indian Railways' inadequate pricing policies and low passenger fares in comparison to cost structures and alternative modes of transportation have contributed to financial shortfalls in passenger transportation (ESCAP, 2003).

In Sri Lanka, the government's policy aimed to prioritise rail passenger transport, with a focus on improving the capacity and volume of rail passenger services (De Silva, 1991; Kumara, 2011; Storm, 2001). Concurrently, the road freight market experienced significant growth as freight transportation by trucking services increased. Consequently, the rail freight market witnessed a substantial decline in market share starting from the 1970s. This decline in railway market share, accompanied by the expansion of road transportation, is a global phenomenon observed in various countries, including Thailand, Poland, Czech Republic, and other EU countries, resulting in adverse financial consequences due to a decline in passenger and freight transport volumes (International Transport Forum, 2019; ESCAP, 2003).

There is a notable increase in salaries and wages of staff of SLR determined by the government policy, including overtime, holiday pay, and other allowances (Chanmugarajah, 1991). Railway organisations are labour-intensive, and employee expenditure is the most crucial component of working expenditure (Directorate of Information Technology, Pakistan Railways, 2015; Directorate of Statistics and Economics, Ministry of Railways, 2018; Asian Development Bank, 2018). This reveals employee expenditure is a major contributory factor to the performance of railway undertakings. According to Danthanarayana and Kumarage (2021), the financial losses in SLR can be attributed to several major revenue and cost drivers, such as the diminishing market for freight transport, insufficient fare revisions, rapid escalation of fuel expenses, and increasing salaries and wages. In a related study, Danthanarayana and Dunusinghe (2023) highlighted the impact of controlling railway fares on SLR's financial shortfall, identifying two key factors as primary contributors to the long-term shortfall: SLR's relatively lower passenger fares compared to public bus transport and the lack of fare adjustments in line with price changes in the bus transport sector. Danthanarayana and Kumarage (2024) revealed a range of internal and external factors and diverse institutional-level and policy-level reforms to address the financial shortfall of Sri Lanka Railways. The institutional level reforms to minimise financial shortfall are: Reflection of foregone amount on season ticket subsidies in the financial statements, Strategies to improve revenue from land & assets, Improving marketing strategies, and New service developments. Moreover, the policy level reforms to minimise financial shortfall are: Improving infrastructure & facilities, Revision of rail passenger fares in line with bus fares, introducing new technology, and Improving the level of service, and Changes to the management structure. Based on the literature survey, the study revealed that the financial performance of a railway undertaking is impacted by different internal and external factors.

The past literature in rail transport shows the various determinants of railway performance and the policy priorities to develop rail transport based on the research findings. However, the existing body of railway research lacks a comprehensive analysis of the determinants of financial or operational performance using time series data, particularly in the context of Sri Lanka. This study aims to bridge this research gap by employing the Autoregressive Distributed Lag (ARDL) model to thoroughly examine the key determinants of Sri Lanka Railways' (SLR) financial shortfall. The present study finds the impact on financial shortfall by focusing on government policy on rail passenger fare revisions, compensatory payments on season subsidies, declined volume of rail transport, and high employee expenditure. The existing literature provides evidence that these factors are closely interconnected with the financial shortfall of SLR. By utilising this rigorous statistical analysis, the study aims to ascertain the relationships between critical variables and provide valuable insights into the magnitude, direction, and significance of these relationships. The novelty of this research lies in the application of modern econometric approaches, such as ARDL cointegration and error correction models, which have not been widely used in analysing the performance of rail transport. The findings of this study hold significant value for transport policymakers and planners, as they will gain a deeper understanding of the underlying determinants and be able to minimise SLR's financial shortfall while alleviating the burden on the government treasury.

# 3 Methods

## 3.1 Conceptual Framework

As per the knowledge grasped through the literature survey and the discussions with railway experts, the study finds the impact of four (04) key variables on the financial shortfall of SLR as depicted in Figure 1. The study used a quantitative research approach using secondary and manipulated data to find the relationship between these variables.

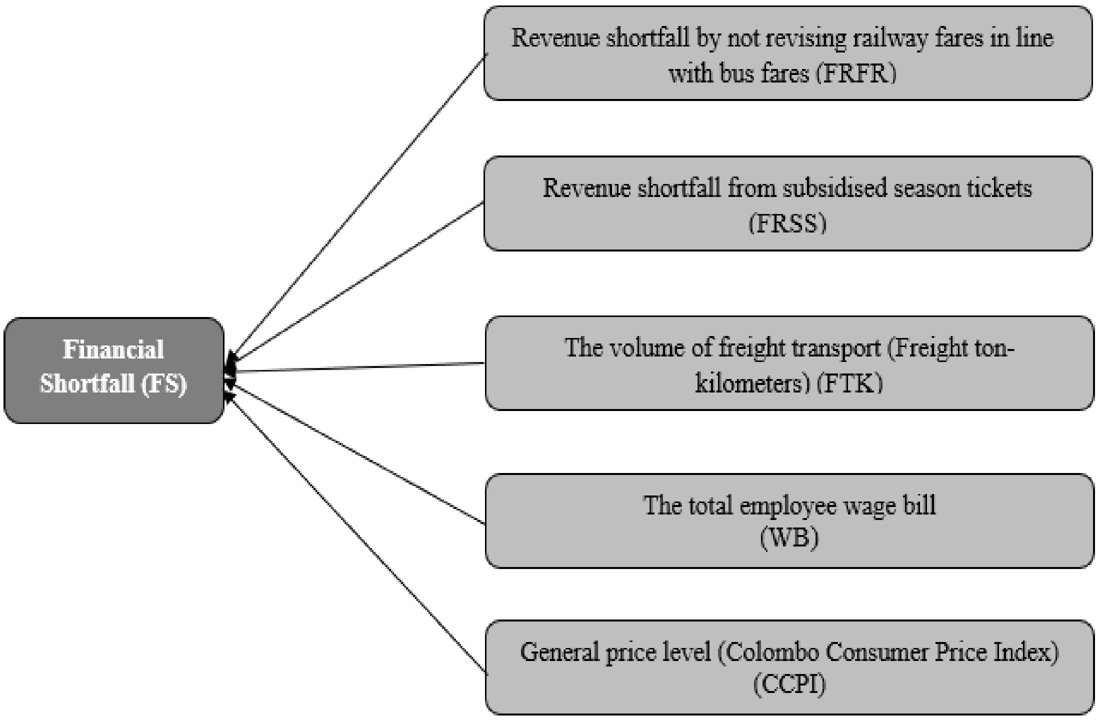


**Figure 1: Conceptual Framework**

## 3.2 Specification of Variables

### *3.2.1 Financial Shortfall (FS)*

The study considered the absolute value of the 'financial shortfall' of SLR depicted in the financial statements as the dependent variable. Financial shortfall refers to the gap between total revenue and recurrent expenditure. The total revenue of Sri Lanka Railways (SLR) is composed of operational revenue and non-operational revenue. Operational revenue, which accounts for approximately 85% of the total revenue, comprises passenger revenue and freight revenue, while non-operating revenue includes parcel revenue, miscellaneous revenue (such as advertisements, train reservations, transport income, rents from stalls and shops, railway station canteens, and stores), among others. The recurrent expenditure primarily comprises personal employee emoluments (Wage bill), traveling, supplies, maintenance, contractual services, and transfers, with fuel expenditure and wage bill being the predominant components accounting for 92% of the total recurrent expenditure. In the calculation of the financial shortfall by SLR, the influence of capital expenditure and depreciation is not considered.

### *3.2.2 Revenue Shortfall by not Revising Railway Fares in Line with Bus Fares (FRFR)*

The railway ordinance states that "No rule regarding charges for the conveyance of passengers and goods shall be made without the concurrence of the Minister of Finance" (Sri Lanka Railways, 1991). Accordingly, passenger fares are determined by the government, and it is beyond the control of SLR's management. The existing fare structure for rail passenger transport is comparatively lesser than bus transport and rail passenger fares have been revised from time to time but not compared to the upsurge of operational expenditure or prices of other substituted modes (De Silva, 1991). Thus, the study finds the impact of government policy on fare revisions on financial shortfall by analysing the effect of the foregone revenue (FRFR) due to the absence of fare revisions in line with bus fares.

The study initially calculated the price elasticity of rail passenger demand to find FRFR (Annexure 1). As per Button (2010), price changes in public transport have minimal impact on the quantity of travel or demand for transport services. Oum et al. (2008) indicate that the absolute value of the elasticity of demand for rail passenger transport ranges from 0.11 to 1.54. The estimated price elasticity of demand for this study is -0.14, indicating an inelastic passenger demand for rail transport, which aligns with previous literature findings. The study determined the revenue shortfall that would occur if railway fares were not revised in accordance with bus fare revisions (rate of change). Estimating the fare per passenger kilometer in bus transportation is challenging due to the lack of revenue data in private bus operations. Therefore, the study relied on the rate of change in the revision of step-on bus fare (bus fare within the first two kilometers) to estimate the foregone revenue.

### *3.2.3 Revenue Shortfall from Subsidised Season Tickets (FRSS)*

SLR (Sri Lanka Railways) offers various concessionary rates for different passenger categories, including private sector employees and individuals (40%), government employees (15%), students over 12 years (10%), students under 12 years (5%) and railway employees (3%). The maximum charge for season ticket holders is 40% of the monthly value of the journey. On average, SLR earns around 15% of total revenue and 20% of total passenger revenue from season ticket passengers. Among the season ticket revenue, approximately 78% represents normal and zonal season tickets, while 20% represents government employees on average (Sri Lanka Railways, 2018). As per the literature review, since sate-owned railways (Eg: India, Bangladesh, and EU countries) were monopolies, regulatory prices on maximising social welfare resulted in growing operating deficits during the 1970s and 1980s, and the result was that most governments were forced increasing subsidisation (ESCAP, 2003). In Sri Lanka, the government does not provide any compensatory payment to SLR for season ticket subsidies. Due to the high foregone revenue (revenue shortfall) from subsidised season tickets, SLR faces a heavy financial shortfall every year. The study calculated the revenue from different season ticket categories if they were charged the full ticket price (100%) with the maximum concessionary rate, which is 40% for all season ticket holders. The revenue shortfall (foregone revenue) represents the gap between the estimated total ticket revenue and the season ticket revenue from season ticket holders that the treasury has not compensated.

#### *3.2.4 The Volume of Freight Transport (FTK)*

The volume of rail freight transport is generally measured by freight ton-kilometers, which represent the freight transport demand (International Transport Forum, 2019) of railway undertakings. Freight ton-kilometers are usually measured based on the distance between the origin and destination (Freight train kilometers) multiplied by the number of freight tons carried between each origin and destination. The significant decline in rail freight market share from the 1970s in line with the development of road transportation is a global phenomenon. Adverse financial consequences for many state-owned railways (Eg: Thailand, Poland, Czech Republic, and other EU countries) resulted from the absolute decline in freight transport volume (International Transport Forum, 2019; ESCAP, 2003). In the Sri Lankan context, government policy endeavored to prioritise passenger transport and progressed freight market with the increase in freight movement by trucking services led to a drastic decline in the rail freight market share after the 1970s (De Silva, 1991; Kumara, 2011; Storm, 2001). Thus, the study finds the impact of declined volume of rail freight transport using freight ton-kilometers as an explanatory variable.

#### *3.2.5 The Total Employee Wage Bill (WB)*

Employee expenditure, known as ‘Personal Employee Emoluments’ (PEE) or total wage bill, is a major contributory factor of total recurrent expenditure, which consists of around 60 %. Employee expenditure is a product of the employee wage bill and the total number of employees of SLR. According to past literature, employee expenditure is identified as the most crucial component of operating expenditure, significantly impacting the financial performance of railway undertakings (Asian Development Bank, 2018; Couto and Graham, 2009; Directorate of Information Technology, Pakistan Railways, 2016; Directorate of Statistics and Economics, Ministry of Railways, 2018;). The total wage bill of SLR consists of basic salaries and wages, overtime and holiday pay, and other allowances. Chanmugarajah (1991) notes that there has been a significant increase in the wage bill of SLR staff, attributed to government policy and primarily driven by notable increases in overtime, holiday pay, and other allowances. Railway annual expenditure on overtime and holiday pay amounts of employees is not published or issued by SLR. Thus, the study finds the impact of overtime and holiday pay using the total wage bill as a proxy variable.

In addition to the above four variables, the Colombo Consumer Price Index (CCPI, 1977 =100) was included in the model specification as an explanatory variable to show the inflation effect of the general price level on financial shortfall during the study period. Moreover, CCPI was used to minimise the issues in adjusting financial variables (FRFR, FRSS, WB) into constant values.

## 3.3 Data Collection

Table 1 presents the variables along with the corresponding collected data for each variable, which were utilised in the regression analysis.

Table 1: Data Types of Data

| Variable | Data |
|---|---|
| FS | • Total revenue<br>• Recurrent expenditure |
| FRFR | • Passenger revenue<br>• Passenger kilometers<br>• Passenger train kilometers<br>• Total revenue<br>• Recurrent expenditure<br>• Financial shortfall |
| FRSS | • Season ticket revenue<br>• Ordinary (waybill) ticket revenue<br>• Total revenue<br>• Recurrent expenditure<br>• Financial shortfall |
| FTK | • Freight ton-kilometers |
| WB | • Total wage bill (Personal employee emoluments) |
| CCPI | • Colombo Consumer Price Index |

The analysis utilised an annual data series spanning from 1977 to 2022 consisting of 46 data points. The selection of this study period was motivated by the substantial transformations observed in the Rail transport sector due to the liberalisation of the economy. Moreover, the inclusion of data points covering over 30 years ensures a reliable foundation for conducting time series analysis. The required data for the regression analysis was obtained through a manual collection process from various published sources of the SLR, such as annual statistical and administrative reports, as well as unpublished data. In addition, inflation data were gathered from the Central Bank of Sri Lanka. To supplement the study's background information and literature survey, numerous external documentary sources were consulted, including journal articles, statistical and annual reports, and e-books. Furthermore, published books and statistical reports obtained from the Library of the University of Moratuwa, the Ministry of Transport, and the National Transport Commission aided in gathering statistical data and information on the history of rail transport. The regression analysis was conducted using Eviews software, a widely recognised tool in the field.

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## 3.4 Data Analysis

### *3.4.1 Log Transformation and Unit Root Testing*

After deriving the data series, the study initially transforms all variables into logarithmic form to facilitate data analysis. Accordingly, the original form (level data) of variables, i.e., Financial shortfall (FS), Revenue shortfall by not revising railway fares in line with bus fares (FRFR), Revenue shortfall on subsidised season tickets (FRSS), Volume of freight transport (FTK), Total employee wage bill (WB), and Colombo Consumer Price Index (CCPI) were transformed into log form (LFS, LFRFR, LFRSS, LFTK, LWB, and LCCPI) to linearise the data for the model specification. Subsequently, the study performed unit root tests to determine whether the data series were stationary. Among several unit root tests in the econometric literature, the most commonly used are the Dickey-Fuller (DF) test and the Augmented Dickey-Fuller (ADF) test (Francis & Vijayakumar, 2019). The Augmented Dickey-Fuller (ADF) test was used to perform the unit root test. Non-stationarity of the data series implies the existence of long-run equilibrium relationships among time series variables (Francis & Salahudeen, 2022).

As per the ADF test results, LFS, LFRSS, LFTK, and LWB are non-stationary at the level (with constant) and stationary in the first difference. The variables LFRFR and LCCPI are stationary at the level. This reveals the variables consist of a combination of I(0) and I(1) variables. ARDL (Autoregressive Distributed Lag Model) bounds testing co-integration procedure was used to find the long-run relationships and short-run dynamics between variables as the variables represent both I(0) and I(1) order of integration and the absence of I(2) or higher-order series (Francis et al. 2021). An ARDL process refers to a model with lags of both the dependent and explanatory variables, and it examines long-run and cointegrating relationships between variables (Pesaran & Shin, 1999). ARDL bounds testing procedure is suitable for small or finite sample sizes consisting of 30 to 80 observations (Pesaran et al., 2001). Therefore, conducting the ARDL cointegration model is appropriate for the present study.

### *3.4.2 Model Specification*

The generalised ARDL (p,q) model can be specified as shown in Equation 1.

$$Y_t = \gamma_0 + \sum_{i=1}^{p} \delta_i Y_{t-i} + \sum_{i=0}^{q} \beta_i X_{t-i} + \varepsilon_{it} \quad \text{.......... (1)}$$

$Y_t$ is the dependent variable of the ARDL model, which is explained by its lag values p and the current and lag values *q* of the repressor $X_t$. $Y_t$ is a vector, and the variables in $X_t$ are allowed to be purely I(0), I (1), or cointegrated. β and δ are coefficients, and γ is the constant. ε is a vector of error terms of the model.

The next step is selecting the order of the ARDL (*p, q1, q2, q3, q4, q5*) model in the five variables using appropriate lag order selection criteria. The study used Akaike Information Criteria (AIC) to select the lag length. The augmented ARDL (*p, q1, q2, q3, q4, q5*) model was estimated as shown in Equation 2.

$$\ln FS_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \ln FS_{t-i} + \sum_{i=1}^{q1} \beta_{2i} \ln FRFR_{t-i} + \sum_{i=1}^{q2} \beta_{3i} \ln FRSS_{t-i} + \sum_{i=1}^{q3} \beta_{4i} \ln FTK_{t-i} + \sum_{i=1}^{q4} \beta_{5i} \ln WB_{t-i} + \sum_{i=1}^{q5} \beta_{6i} \ln CCPI_{t-i} + \varepsilon_t \quad \text{.......... (2)}$$

Afterward, the following ARDL model (Equation 3) was estimated to test the cointegration relationship between the variables of the model.

$$\Delta \ln FS_t = \beta_0 + \propto_1 lnFS_{t-1} + \propto_2 lnFRFR_{t-1} + \propto_3 nFRSS_{t-1} + \propto_4 lnFTK_{t-1} + \propto_5 lnWB_{t-1} + \propto_6 lnCCPI_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta \ln FS_{t-i} + \sum_{i=0}^{q1} \beta_{2i} \Delta \ln FRFR_{t-i} + \sum_{i=0}^{q2} \beta_{3i} \Delta \ln FRSS_{t-i} + \sum_{i=0}^{q3} \beta_{4i} \Delta \ln FTK_{t-i} + \sum_{i=0}^{q4} \beta_{5i} \Delta \ln WB_{t-i} + \sum_{i=0}^{q5} \beta_{6i} \Delta \ln CCPI_{t-i} + \varepsilon_t \quad \ldots\ldots (3)$$

Where,

*lnFS* - Financial shortfall,

lnFRFR - Revenue shortfall by not revising rail passenger fares in line with bus fares

lnFRSS - Revenue shortfall from subsidised season tickets

lnFTK - Freight ton kilometers

lnWB - Wage bill

lnCCPI - Colombo Consumer Price Index

$\beta_0$ - Intercept

$\propto_1$ - $\propto_6$ - Long run coefficients

$\beta_1$ to $\beta_6$ - Short run coefficients

$\varepsilon_t$ - Error term (white noise residuals)

Subsequently, the study performed the bound tests approach developed by Pesaran *et al.* (2001) to investigate the long-run relationship among the variables in the model. The study conducted an F-test to show the joint significance of the coefficients of the lagged variables as per the hypothesis below.

($H_o$: Null Hypothesis; $H_1$: Alternate Hypothesis)

$H_0$: $\alpha_1=\alpha_2=\alpha_3=\alpha_4=\alpha_5=\alpha_6=0$ (There is no cointegration between the variables)

$H_1$: At least one $\alpha_i \neq 0$ (Cointegration exists between the variables)

The study denotes the test which normalises FS by $F_{FS}$ (FS|FRFR, FRSS, FTK, WB, CCPI). Pesaran *et al*. (2001) provide two sets of critical values in which the lower critical bound assumes that all the variables in the ARDL model are I(0), and the upper critical bound assumes that all the variables are I(1). If the computed F-statistic is greater than the appropriate upper bound critical values, the null hypothesis is rejected, implying cointegration between variables. If F-statistics is below the lower bound, the null cannot be rejected, indicating there is no cointegration. In these two extremes, a conclusive decision could be drawn without knowing the order of integration of the variables. If, however, it lies within the lower and upper bounds, the result is inconclusive, and the ARDL cointegration test can be performed to find the long-run relationship between the variables by knowing the order of integration of the variables. In the final step, the study estimated the short-run dynamic parameters associated with the long-run estimates by performing the error correction model (ECM) based on the assumption made by Pesaran *et al.* (2001). The error correction version of the ARDL model can be specified as shown in equation (4).

$$\Delta \ln FS_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta \ln FS_{t-i} + \sum_{i=1}^{q1} \beta_{2i} \Delta \ln FRFR_{t-i} + \sum_{i=1}^{q2} \beta_{3i} \Delta \ln FRSS_{t-i} + \sum_{i=1}^{q3} \beta_{4i} \Delta \ln FTK_{t-i} + \sum_{i=1}^{q4} \beta_{5i} \Delta \ln WB_{t-i} + \sum_{i=1}^{q5} \beta_{6i} \Delta \ln CCPI_{t-i} + \lambda ECT_{t-1} + \varepsilon_t \quad \text{……} (4)$$

The coefficients of the lagged variables ($\beta_{1i}$ to $\beta_{6i}$) provide the short-run dynamics of the model's convergence to equilibrium. $ECT_{t-1}$ (error correction term), the residuals that are obtained from the estimated cointegration model of the equation, and λ, the speed of adjustment parameter, show the long-run relationship of the model.

The study examined the performance of the model and the reliability of the parameters using diagnostic tests such as the Breusch-Godfrey Lagrange multiplier test for serial correlation, the Breusch-Pagan-Godfrey test for heteroscedasticity based on the regression of squared residuals on squared fitted values and normality test based on skewness and kurtosis of residuals. The CUSUM and CUSUMSQ tests to the residuals of the equation were applied to test the model stability. The CUSUM test finds parameter instability if the cumulative sum goes outside the area between the two critical lines. For the stability of the long-run and short-run coefficients, the plot of the two statistics must stay within the 5 % significant level. As with the CUSUM test, movement outside the critical lines suggests parameter or variance instability.

## 4 Result and Discussion

### 4.1 Unit Root Test

First, the study tested the stationary status of the data series to determine their order of integration before proceeding to the ARDL bound test. The study performed Augmented Dickey-Fuller (ADF) test to find the unit root for all variables. The log-transformed variables, LFS, LFRFR, LFRSS, LFTK, LWB, and LCCPI, were tested, including intercept and intercept and trend for the test equations.

Table 2: ADF Test Results

| | Level | | First Difference | |
|---|---|---|---|---|
| Variable | Intercept | Intercept and Trend | Intercept | Intercept and Trend |
| LFS | -2.65 (0.09) | -2.59 (0.29) | -6.16 (0.00)** | -6.15 (0.00)** |
| LFRFR | -5.52 (0.00)** | -8.01 (0.00)** | -10.16 (0.00)** | -9.91 (0.00)** |
| LFRSS | -2.31 (0.17) | -2.54 (0.31) | -5.23 (0.00)** | -5.18 (0.00)** |
| LFTK | -1.63 (0.46) | -2.15 (0.50) | -7.16 (0.00)** | -7.17 (0.00)** |
| LWB | -2.50 (0.12) | -3.57 (0.04)* | -6.35 (0.00)** | -6.36 (0.00)** |
| LCCPI | -3.05 (0.04)* | -0.89 (0.95) | -4.59 (0.00)** | -5.42 (0.00)** |

Note: Values in parentheses are p-value. * and ** denote the statistical significance at the 5% and 1% levels, respectively.

Source: Author's compilation.

The results show that LFS, LFRSS, LFTK, and LWB data series in level with intercept are non-stationary variables I(1) as no evidence was found to reject the null hypotheses that data series have a unit root at a 5 % significant level. Thereafter, the first differences of non-stationary variables were tested for unit root, and the null hypothesis that the first difference of the data series has a unit root was rejected at a 1 % significant level. The data series LFRFR and LCCPI in level with intercept are stationary variables [I(0)] since the results show the null hypothesis that data series have a unit root at a 5 % significant level was rejected. Thus, all the variables are a combination of I(1) and I(0), as depicted in Table 2.

### 4.2 ARDL Model Estimation

For estimation of the ARDL Model, the study selected a maximum of 4 lags with the automatic selection option and opted for AIC (Akaike information criterion) as the model selection criteria as specified by the VAR lag order selection criteria. The chosen model, as indicated in Table 3, is the ARDL (4,1,2,2,4,0) model, incorporating the maximum specified lags for each variable.

Table 3: ARDL (4,1,2,2,4,0) Model Results

| *Dependent Variable: LFS* | | | |
|---|---|---|---|
| Variable | Coefficient | t-Statistic | Probability |
| LFS(-1) | 0.45** | 2.06 | 0.05 |
| LFS(-2) | -0.18 | -0.83 | 0.41 |
| LFS(-3) | 0.31 | 1.49 | 0.15 |
| LFS(-4) | -0.45** | -2.33 | 0.03 |
| LFRFR | 0.29 | 1.60 | 0.13 |
| LFRFR(-1) | 0.50*** | 2.95 | 0.01 |

| | | | | |
|---|---|---|---|---|
| LFRSS | | 0.18 | 0.49 | 0.63 |
| LFRSS(-1) | | -0.31 | -0.70 | 0.49 |
| LFRSS(-2) | | 0.81* | 1.94 | 0.07 |
| LFTK | | -1.19** | -2.53 | 0.02 |
| LFTK(-1) | | 0.64 | 1.42 | 0.17 |
| LFTK(-2) | | -0.53 | -1.35 | 0.19 |
| LWB | | 1.30*** | 2.98 | 0.01 |
| LWB(-1) | | -0.59 | -1.20 | 0.25 |
| LWB(-2) | | 0.02 | 0.05 | 0.96 |
| LWB(-3) | | -0.02 | -0.05 | 0.96 |
| LWB(-4) | | 1.33** | 2.48 | 0.02 |
| LCCPI | | -0.51*** | -3.03 | 0.01 |
| C | | -14.67 | -1.35 | 0.19 |
| R-squared | 0.83 | | | |
| Adjusted R-squared | 0.67 | | | |
| F-statistic | 5.25 | | | |
| Prob (F-statistic) | 0.00 | | | |
| Durbin Watson stat | 1.97 | | | |

Note: Values in parentheses are p-value. *, **, *** denotes the statistical significance at the 10%, 5% and 1% level respectively.
Source: Author's compilation.

As per the ARDL Model (Table 3), lag 1 and lag 4 of the financial shortfall has a positive and negative impact on the current period of the financial shortfall with a 5 % significant level. The Wald test results show lag 1 and lag 4 of LFS can jointly influence the current period of LFS. The lag 1 of LFRFR has a positive and significant relationship with LFS. This reveals that revenue shortfall not revising railway fares in line with bus fares has positively contributed to increasing the financial shortfall in the short run. The Wald test results show that LFRFR at the level and lag 1 can jointly influence financial shortfall in the short run. The lag 2 of LFRSS has a positive relationship with LFS with a 10 % significant level in the short run. The Wald test results indicate that LFRSS at the level, lag 1 and lag 2 cannot jointly influence LFS. This reveals revenue shortfall on season ticket subsidies in the lagged period has no significant joint impact on LFS.

In the case of LFRTK, the current period of LFTK has a negative and significant impact on LFS. This reveals a decline in freight transport share in the current period has impacted to increase in the financial shortfall of SLR. As per the Wald test results, LFTK at the level, lag 1 and lag 2 can jointly influence LFS. LWB at the level and lag 4 positively and significantly impact LFS. The Wald test statistics reveal that LWB at the level, lag 1, lag 2, lag 3, and lag 4 can jointly impact LFS. This reveals an increase in the total employee wage bill has influenced the increase in financial shortfall. LCCPI at the current period has a negative and significant relationship with LFS. This reveals when the general price level increases, the real financial value of the financial shortfall decreases. The results of the Wald test statistics indicate that LCCI has a significant influence on LFS. Furthermore, the coefficients of the ARDL (4, 1, 2, 2, 4, 0) model show a significant relationship between the lagged dependent and independent variables.

The $R^2$ value indicates that 83% of the variability observed in the target variable can be explained by the regression model. This indicates a strong level of explanation and suggests that the model provides a good fit for the data. The F-statistic is significant (p=0.00), and Durbin Watson statistics (DW =1.97) show the model is free from serial correlation. The study found a short- and long-run relationship between the variables using the ARDL (4,1,2,2,4,0) model. The ARDL Bound Test was applied to find the cointegration relationship between the variables.

## 4.3. ARDL Bounds Test

ARDL bound test results show if there is a long-run relationship between the variables. Table 4 indicates that the calculated F-statistic is 2.90, and this falls between the upper [I(1)] and lower [I(0)] critical value bounds at a 5 % significant level. Theoretically, if the F-statistics is greater than the upper bound, there is a long-run relationship between the variables. If the F-statistic is below the lower bound, there is no long-run relationship between variables. As per the critical values given in Pesaran et al. (2001), if the F-statistic falls inside the upper and lower bound, the cointegration relationship is inconclusive.

Table 4: ARDL Bound Test Results

| F-statistic | Critical Value Bounds | | Significance Level |
|---|---|---|---|
| | Lower Bound | Upper Bound | |
| 2.90* | 2.26 | 3.35 | 10% |
| | 2.62 | 3.79 | 5% |
| | 3.41 | 4.68 | 1% |

Source: Author's compilation

An efficient alternative way of establishing cointegration is testing significant negative lagged error-correction term (Engle & Granger, 1987; Banerjee et al., 1998; Enders, 2010). Additionally, when the F-statistic falls within I(0) and I(1), the decision depends on the order of integration (whether the variables are I(0), I(1), or both). Based on the results of the

Augmented Dickey-Fuller (ADF) test on unit-roots of the variables, the present model indicates a combination of both the I(1) and I(0) order of integration. Therefore, the study conducted the ARDL cointegration test to determine the presence of a significant negative lagged error correction term and establish a long-run relationship between the variables.

## 4.4 ARDL Cointegrating Form

The long-run form of the corresponding ARDL (4, 1, 2, 2, 4, 0) and the pertaining relationship are shown in Table 5 and Equation 5.

Table 5: Estimated Long-run Coefficients using ARDL Model

Dependent variable: LFS

| Variable | Coefficient | t-Statistic | Probability |
|---|---|---|---|
| C | -16.77 | -1.53 | 0.14 |
| LFRFR | 0.91** | 2.43 | 0.02 |
| LFRSS | 0.78* | 1.76 | 0.09 |
| LFTK | -1.24* | -1.83 | 0.08 |
| LWB | 2.33*** | 4.06 | 0.00 |
| LCCPI | -0.59*** | -2.92 | 0.00 |

Note: *, **, and *** indicate significance at 10%, 5%, and 1% respectively.

Source: Author's compilation.

$$LFS_t = -16.77 + 0.91\ LFRFR_t + 0.78\ LFRSS_t - 1.24\ LFTK_t + 2.33\ LWB_t - 0.59\ LCCPI_t + \varepsilon_t \quad \text{.......(5)}$$

Based on the estimated long-run coefficients, it is observed that LFRFR (revenue shortfall by not revising railway fares) has a positive and statistically significant impact on LFS (financial shortfall) at a 5% significance level. The coefficient of LFRFR indicates that a one-unit increase in the revenue shortfall due to the failure to revise railway fares is associated with a 0.91 unit increase in the long-run level of the financial shortfall. This finding suggests that as the Sri Lanka Railways (SLR) does not revise its railway fares in line with bus fares, the revenue shortfall (LFRFR) increases, leading to a higher financial shortfall (LFS) for SLR in the long run. Consequently, it emphasises the importance of revising railway fares in accordance with bus fare revisions to mitigate the financial shortfall faced by SLR.

According to the estimated long-run coefficients, LFRSS (lagged revenue shortfall from subsidised season tickets) demonstrates a positive impact on LFS (financial shortfall), indicating that the revenue shortfall arising from subsidised season tickets has contributed to the increase in SLR's financial shortfall. The coefficient of LFRSS suggests that a one-unit increase in the lagged revenue shortfall from subsidised season tickets at a one-time lag is associated with a 0.78-unit increase in the long-run level of the financial shortfall. This finding suggests that receiving compensation payments for the foregone revenue from the government treasury would help mitigate SLR's financial shortfall. However, it is important to note that the coefficient of LFRSS is statistically insignificant at the 5% level, although it is significant at the 10% level. This indicates that receiving revenue shortfall from subsidised season tickets may not significantly reduce the overall financial shortfall in the long run. Additionally, the results further reveal that increasing monthly season ticket charges is crucial in the long run to minimise the financial shortfall, apart from relying on revenue shortfall compensation.

According to the analysis, LFTK (lagged freight ton-kilometers) has a negative impact on LFS (financial shortfall), indicating that an increase in the volume of freight transport would lead to a decrease in the financial shortfall of SLR. The coefficient of LFTK suggests that a one-unit increase in the lagged freight ton-kilometers corresponds to a 1.24-unit decrease in the long-run level of the financial shortfall. However, it is important to note that the sign of the coefficient is inconsistent, as higher freight volume generally results in increased freight revenue and can potentially minimise the financial shortfall. Nevertheless, it is worth mentioning that the coefficient of LFTK is statistically insignificant, indicating that an increase in freight transport does not show a substantial impact on strengthening the financial position of SLR in the long run. This lack of significance can be attributed to the fact that Sri Lanka is a geographically small country, where it may be challenging to generate sufficient revenue from long-distance freight movements. Hence, the findings suggest that although an increase in freight transport may have some positive effects, it may not significantly alleviate the financial shortfall of SLR in the long run.

According to the analysis, LWB (lagged wage bill) has a positive and statistically significant impact on LFS (financial shortfall) at a 1% significance level. The coefficient of LWB suggests that a one-unit increase in the lagged wage bill is associated with a 2.33-unit increase in the long-run level of the financial shortfall. This finding aligns with the research by Danthanarayana and Kumarage (2021), which indicates that the rising cost of employees, despite a significant decrease in total employees, highlights the wage bill as a significant contributor to total recurrent expenditure. The current study further suggests that the incremental effect on wage bills, influenced by high overtime and holiday pay, has significantly contributed to the financial shortfall. Based on these findings, it becomes crucial to rationalise the payment structure for railway employees to minimise the financial shortfall in the long run. This rationalisation could involve addressing issues related to overtime and holiday pay and implementing measures to manage and optimise the wage bill. By doing so, the SLR can work towards reducing its financial shortfall and achieving greater financial stability in the long run.

According to the analysis, LCCPI (lagged consumer price index) has a negative and statistically significant impact on LFS (financial shortfall) at a 1% significance level. The coefficient of LCCPI indicates that a one-unit increase in the lagged consumer price index is associated with a 0.59 unit decrease in the long-run level of the financial shortfall. This indicates that an increase in the general price level has contributed to a decline in the financial shortfall of SLR (in real terms), which is a favorable condition.

## 4.5 Error Correction Model (ECM)

The long-run relationship and short-term dynamics of the model were examined by estimating an error correction model. Table 6 shows the error correction form of the ARDL (4, 1, 2, 2, 4, 0) model as per Equation 4. Error correction term (ECT(-1)) of the cointegration model indicates the speed of adjustment towards the long-run equilibrium in response to the disequilibrium caused by short-run shocks. Theoretically, the sign of the ECT(-1) must be negative and significant to ensure convergence of the dynamics to the long-run equilibrium. The coefficient value, which signifies the speed of convergence to the equilibrium process, usually ranges from -1 to 0.

The estimated value of the ECT(-1), -0.87, indicates the speed of adjustment towards long-run equilibrium in a disequilibrium situation, which is a reasonable adjustment rate. The absolute value of the coefficient of ETC(-1) further implies that about 87 % of the disequilibrium in the real financial shortfall is adjusted toward equilibrium annually. The coefficient of ECT(-1), which is negative and significant (p=0.00), indicates a long-run relationship between the variables.

Table 6: Error Correction Representation

| Dependent Variable: LFS | | | |
|---|---|---|---|
| Variable | Coefficient | t-Statistic | Probability |
| D(LFS(-1)) | 0.32 | 1.72 | 0.10 |
| D(LFS(-2)) | 0.14 | 0.77 | 0.45 |
| D(LFS(-3)) | 0.45** | 2.33 | 0.03 |
| D(LFRFR) | 0.29 | 1.60 | 0.13 |
| D(LFRSS) | 0.18 | 0.49 | 0.63 |

| | | | |
|---|---|---|---|
| D(LFRSS(-1)) | -0.81* | -1.94 | 0.07 |
| D(LFTK) | -1.19** | -2.53 | 0.02 |
| D(LFTK(-1)) | 0.53 | 1.35 | 0.19 |
| D(LWB) | 1.30** | 2.98 | 0.01 |
| D(LWB(-1)) | -0.02 | -0.05 | 0.96 |
| D(LWB(-2)) | 0.02 | 0.05 | 0.96 |
| D(LWB(-3)) | -1.33** | -2.48 | 0.02 |
| D(LCCPI) | -0.51** | -3.03 | 0.01 |
| **ECT(-1)** | **-0.87*****| **-3.39** | **0.00** |
| R-squared | 0.70 | | |
| Adjusted R-squared | 0.42 | | |
| F-statistic | 2.51 | | |
| Prob (F-statistic) | 0.03 | | |
| Durbin Watson stat | 2.00 | | |

Note: *, **, and *** indicate significance at 10%, 5%, and 1% respectively.
Source: Author's compilation.

The coefficients of the differenced variables in the error correction model (ECM) provide insights into the short-run impact on the financial shortfall of SLR. In the short run, deviations from the long-run equilibrium are observed due to shocks in the model's variables. The third lag period of LFS (financial shortfall) shows a positive and significant relationship with the current period of LFS, indicating persistence in the short-run impact. Conversely, the current period of LFTK (freight ton-kilometers) has a negative and significant impact on LFS. Furthermore, the current period and third lag of LWB (wage bill) exhibit a positive and negative significant effect on LFS in the short run. Similarly, LCCI (lagged consumer price index) shows a negative and significant impact on LFS, consistent with the long-run findings. Regarding the short-run effects, the study highlights significant relationships (at a 5% significance level) among the lagged variables LFS, LFTK, LWB, and LCCI. However, it is noteworthy that the failure of SLR to revise railway fares in line with bus fares does not seem to have an immediate impact on the financial shortfall in the short run, despite its substantial influence observed in the long run. Moreover, the revenue shortfall from subsidised season tickets exhibits a significant relationship at a 10% significance level, both in the short run and the long run.

According to the relationship between the variables in the short-run and long-run, the study highlights that although freight transport has an impact in the short-run, the development of freight transport does not help minimise the financial shortfall in the long-run, as described in section 4.4. However, transport policy should focus on improving freight revenue by increasing supply capacity and freight volume through increased facility development and operational efficiency in the short-run. Moreover, an increase in railway fares in line with bus fares has a significant impact in the long run, even though it does not show a relationship in the short-run. This indicates the importance of focusing more on improving passenger revenue through fare revisions to minimise the financial shortfall. A fare policy for rail transport should be formulated while focusing on quality improvement of service provision. The impact of the employee wage bill is significant in both the short-run and long-run, which underlines the importance of reducing employee expenditure in an efficient and effective manner while maintaining a focus on employee welfare and benefits. The findings emphasise that innovating new technology and developing infrastructure for railway operations and supporting services are imperative, along with rationalising employee expenditure. In the Sri Lankan context, new restructuring and railway reforms are crucial to face the challenges of the current economic crisis, in order to enhance additional revenue and minimise unnecessary costs, thereby reducing the burden on the government.

Reliability tests, including coefficient, residual, and stability diagnostics, indicate the absence of serial correlation and heteroskedasticity in the model. Although the data is not normally distributed, these tests suggest that the model remains robust. Furthermore, the R-squared value of 70% signifies a good model specification, exceeding the recommended threshold of 50%.

### 4.6 Diagnostic Tests

The diagnostic tests applied to the error correction model (Table 7) indicate no evidence of serial correlation and heteroskedasticity. In addition, the Jarque-Bera normality test shows that the residuals are not normally distributed.

Table 7: Diagnostic Testing Results

| Test Type | Test Name | F version | P-value | LM Version | P-value |
|---|---|---|---|---|---|
| Serial Correlation | Breusch-Godfrey LM Test | F(2, 24) = 2.46 | 0.11 | $\chi2(2) = 7.14$ | 0.03 |
| Heteroscedasticity | Breusch-Pagan-Godfrey Test | F(15, 26) = 1.03 | 0.45 | $\chi2(15) = 15.71$ | 0.40 |
| Normality | Histogram-Normality Test | NA | NA | Jarque-Bera =1.90 | 0.38 |

Source: Author’s compilation.

The study performed diagnostic tests on residuals and stability of the model: the Lagrange multiplier test of serial correlation of residuals, the heteroscedasticity test based on the regression of squared residuals on square fitted values, and the normality test based on a test of skewness and kurtosis of residuals. The diagnostic tests showed that the estimation of long-run coefficients and Error correction model of cointegrating form is free from serial correlation and heteroscedasticity and normality at a 5 % level of significance. The study also performed stability diagnostic testing for the constancy of long-run parameters, which is useful to incorporate the short-run dynamics of the model. The cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) were applied to check for the structural stability of the model as depicted in Figure 2.

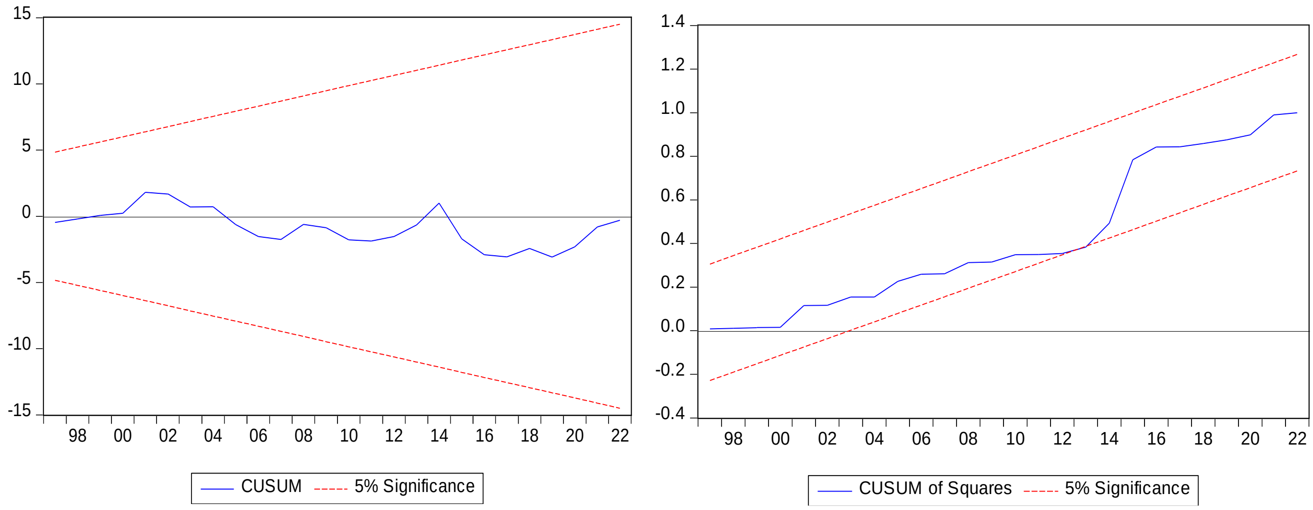

Figure 2: CUSUM Test and CUSUM of Squares Test Results

CUSUM statistics plotted against the critical bound of 5 % indicate the stability of the parameters remained within its critical bounds of parameter stability. CUSUMSQ, which is based on squared recursive residuals, is generally within the 5 % significance lines, suggesting that the residual variance is somewhat stable. In the CUSUMSQ test, deviations followed by a return to the critical lines indicate model stability and support the validity of the estimated parameters (Hendry & Mizon, 1978). Given that the plot of CUSUMSQ is converging back towards the critical bounds, it indicates that the observed deviation is merely temporary and not indicative of a sustained trend.

## 5 Conclusion

The aim of the study was to identify the crucial determinants contributing to the financial shortfall of Sri Lanka Railways (SLR) through an econometric approach. A quantitative methodology was employed, utilising secondary and manipulated data covering the period from 1977 to 2022. The study focused on examining the effects of four variables: revenue shortfall resulting from not revising railway fares in line with bus fares (FRFR), revenue shortfall from subsidised season tickets (FRSS), the volume of freight transport (FTK), and total wage bill (WB). Additionally, the study incorporated the general price level (CCPI) in the model specification to account for inflationary effects.

The regression analysis, utilising the Auto Regressive Distributed Lag Model, revealed a short-run relationship between the financial shortfall (dependent variable) and lagged independent variables. These independent variables included financial shortfall (LFS), the volume of rail freight transport (LFTK), total employee wage bill (LWB), and the general price level (LCCPI). Additionally, a long-run relationship was observed among the independent variables, namely revenue shortfall resulting from not revising railway fares in line with bus fares (LFRFR), LWB, LCCPI, and the dependent variable LFS. These findings confirmed the significant impact of fare revisions aligned with bus fare revisions and high employee expenditure, highlighting the influence of government policies on fare revisions and the substantial impact of overtime payments and other allowances on the financial shortfall. Moreover, the revenue shortfall from subsidised season tickets exhibits a significant relationship at a 10% significance level, both in the short run and the long run.

The study emphasises the importance of revising railway fares in line with bus fare revisions to mitigate the financial shortfall faced by SLR. Aligning fares with those of bus transportation can help generate additional revenue for SLR and improve its financial sustainability. The current rail passenger fares are much lower than those for bus transport, and the failure to raise rail fares to match the increase of bus fares is a contributing factor in both the increase in the overall financial shortfall and the drop in total revenue. As a result, while working to raise the quality and standard of service, transportation policy makers can concentrate on developing a railway fare policy that is consistent with the policy for modifications to bus fares in Sri Lanka.

The study further highlights the importance of rationalising the payment structure for railway employees to minimise the financial shortfall. Therefore, Sri Lanka Railways (SLR) should focus on optimising its employee-related costs, such as overtime payments and allowances, through efficient workforce management and cost control measures. Currently, the total wage bill of SLR exceeds its total revenue, with high overtime payments and other allowances contributing significantly to employee expenditure. Transport policymakers should prioritise rationalising the employee wage bill by analysing and adjusting overtime and holiday pay to reduce the financial shortfall. Additionally, SLR can evaluate the subsidy program for season tickets and ensure that it is structured in a way that minimises the negative impact on the railway's financial position. The results further reveal that increasing monthly season ticket charges is crucial in the long run to minimise the financial shortfall, in addition to relying on revenue shortfall compensation. Furthermore, it is imperative to invest in capacity and facility development for freight transport to mitigate the financial shortfall in the long run. The research findings further revealed and validated the statistical relationship of crucial variables impacting the financial shortfall of rail transport in Sri Lanka, by supporting the existing literature (Danthanarayana & Kumarage, 2021; Danthanarayana & Dunusinghe, 2023; Danthanarayana & Kumarage, 2024).

For future research, it would be valuable to explore the potential impact of other external factors on the financial shortfall of SLR, such as changes in government policies, economic conditions, and competition from alternative modes of transportation. These factors could be investigated through an econometric approach to provide a comprehensive understanding of the financial challenges of state-owned railways.

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## Annexure 1

Dependent Variable: LPKM
Method: Least Squares
Date: 01/01/22 Time: 11:44
Sample (adjusted): 1978 2018
Included observations: 41 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.006298 | 0.014640 | 0.430185 | 0.6695 |
| LRFPK | -0.138319 | 0.064506 | -2.144286 | 0.0385 |
| LPTRK | 0.795099 | 0.155195 | 5.123235 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.446146 | Mean dependent var | 0.023395 |
| Adjusted R-squared | 0.416996 | S.D. dependent var | 0.119657 |
| S.E. of regression | 0.091364 | Akaike info criterion | -1.877575 |
| Sum squared resid | 0.317201 | Schwarz criterion | -1.752191 |
| Log likelihood | 41.49028 | Hannan-Quinn criter. | -1.831917 |
| F-statistic | 15.30510 | Durbin-Watson stat | 1.694997 |
| Prob(F-statistic) | 0.000013 | | |

**Table: Price elasticity of rail passenger demand**

LPKM - Passenger Kilometers (Dependent Variable)

LRFPK - Passenger Fares (Passenger Revenue per Passenger Kilometer)

LPTRK - Passenger Train Kilometers