Optimal Proportion of Budgetary Sources to Fund Government Expenditures

Group ID: 2023-087

B.Sc. (Hons) in Information Technology

Specializing in Data Science

Department of Information Technology

Sri Lanka Institute of Information Technology

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Dissertation submitted in partial fulfilment of the requirements for the Bachelor of Science in Information Technology specializing in Data Science

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1. Introduction

1.1. Background Literature

Since gaining independence in 1948, the Sri Lankan economy has encountered numerous challenges. One of the most significant issues has been fiscal indiscipline, leading to a substantial gap between government revenue and expenditure, commonly referred to as the 'budget deficit.' Starting from 1990, this budget deficit has seen a significant increase. In fact, according to reports from the Central Bank, since 1990, a surplus in the primary account has only been achieved twice [1]. This suggests that the government's revenue is often insufficient to cover expenses, excluding interest payments, further exacerbating the budget deficit.

The challenge with the budget deficit lies in the differing perspectives of economists. Mainstream economists argue that it could harm the economy in both the short and long term. They express concerns about the methods used to finance the budget deficit, namely internal and external borrowing, which they believe pose threats to economic stability, commonly referred to as macroeconomic stability. In contrast, there are dissenting groups of economists who challenge this notion.

The ongoing economic crisis in Sri Lanka is also believed to stem from both the fiscal deficit and the current account deficit [2]. The persistent high budget deficit over the years has led to an unsustainable level of public debt, eroding the country's credibility in the international market. Consequently, the nation faces challenges in efficiently functioning and accessing the global market.

The Central Bank plays a significant role in this context. Under the provisions of the current Central Bank Act, the Central Bank of Sri Lanka is obligated to provide funds to the government upon its request [3]. The government utilizes this authority to finance its budget deficit by issuing securities to the Central Bank, thereby acquiring funds created by the Central Bank in return. This practice is colloquially referred to as 'money printing' and technically falls under domestic borrowings as well.

A persistently high budget deficit, according to mainstream economists, leads to fiscal instability, which can ultimately place the country's economy in a precarious

position. Financing the budget deficit through borrowings, including money printing, is believed by these economists to pose a significant threat to macroeconomic stability.

However, it is important to note that there are dissenting groups of economists who contend that a budget deficit, when managed appropriately, does not necessarily harm the economy as implied by mainstream economists. They argue that strict fiscal policies can hinder economic growth because the infusion of money into the economy through borrowing or money printing creates artificial demand. For example, if 100,000 people receive a Rs. 5,000 allowance, they are likely to spend it rather than saving it in their banks. This spending increases the demand for goods and services, subsequently encouraging production and boosting GDP growth. However, mainstream economists argue that this artificial growth is unsustainable and, in the long run, may lead to inflationary pressures on the economy.

In essence, this debate reflects a clash of two economic ideologies. One side argues against encouraging a budget deficit, emphasizing its potential to cause fiscal instability and hinder sustainable growth. The other side contends that strict fiscal policies can impede economic growth. In reality, most countries around the world maintain a budget deficit, and Sri Lanka is no exception. Regardless of the ideological stance, it is widely agreed that preserving macroeconomic stability is crucial for fostering a growing and consistently performing economy. The following studies provide insights into the importance of preserving macroeconomic stability from various perspectives.

Tatiana Vasylieva, Sergij Lyeonov, Oleksii Lyulyov, and Kostiantyn Kyrychenko conducted a comprehensive study on the role and impact of macroeconomic stability on economic growth in European countries for the period spanning from 2000 to 2016 [4]. Utilizing a modified Cobb–Douglas production function, their research findings concluded that a 1% improvement in macroeconomic stability has a more positive influence on GDP growth compared to foreign direct investments. This underscores the importance of implementing

appropriate macroeconomic policies by governments to foster economic growth in the studied countries.

Several studies have been undertaken to explore solutions for preserving macroeconomic stability, with a primary focus on understanding the influence of budgetary sources and budget deficits on macroeconomic variables like inflation and economic growth. Uncovering the effects of various economic attributes on the overall economy plays a crucial role in mitigating adverse consequences and optimizing favorable outcomes, representing one approach to sustaining macroeconomic stability. Numerous studies conducted in different regions across the globe have aimed to ascertain the correlation between fiscal deficits and macroeconomic variables, including economic growth and inflation. The majority of these studies tend to indicate a negative impact of fiscal deficits on macroeconomic variables. However, there exist studies with contrasting results, suggesting a positive or non-significant effect of fiscal deficits on these variables.

For instance, Nguyen Tung (2020) [5] investigated the effects of fiscal deficits on economic growth in an emerging economy using data from Vietnam. The study employed an Error Correlation model to assess the impact of fiscal deficits on economic growth, revealing a negative and significant influence in both the short and long run. Cebula (1995) [6] explored the impact of budget deficits on the U.S. economy's growth using quarterly data from 1955 to 1992 and found that budget deficits led to a reduction in the economic growth rate. The study also confirmed that income tax had detrimental effects on economic growth. This implies that an increase in the budget deficit leads to a higher tax ratio, generating additional revenue to offset previous deficits, thereby restraining economic growth.

Ghura and Dhaneshwar (1995) [7] investigated the effects of macroeconomic policies on nominal income growth, inflation, and output growth using data from 33 countries in Sub-Saharan Africa spanning from 1970 to 1987. The results suggested that an increase in the budget deficit ratio adversely affected output growth in those countries during that period.

Contrary to the aforementioned studies, some research has yielded contrasting results, indicating a positive or insignificant relationship between fiscal deficits and economic growth. Velnampy and Achchuthan (2013) [8] similarly found no significant relationship between fiscal deficits and economic growth in Sri Lanka in their study, which utilized data from 1970 to 2010. Ahmad (2013) [9] analyzed data from Pakistan for the period 1971-2007 and found a positive, albeit statistically insignificant, relationship between fiscal deficits and Gross Domestic Product (GDP). Pelagidis and Desli (2014) [10] discussed the potential of fiscal policy to support economic growth in Europe, suggesting that a budget deficit might lead to higher business profits, ultimately supporting economic growth. Their findings indicated a positive relationship between fiscal deficits and capital profitability, challenging the notion of a dogmatic aversion to budget deficits as inherently harmful. According to Eminer (2015) [11] the impact of a budget deficit on economic growth depends on whether it is geared toward productive or non-productive spending. In either case, the interpretation of 'productive spending' is relative and contingent upon the discretion of policymakers. Moreover, the full realization of the impact of budget deficits is dependent on the policy's duration, whether in the short or long run.

Numerous studies have been conducted to establish the relationship between various budgetary sources, including taxation, borrowing (both foreign and domestic), monetary financing, and macroeconomic variables. For instance, Mario Situm (2009) [12] conducted research titled 'The Effects of Money Printing on Inflation Accounting,' concluding that money printing leads to moderate inflation in the short term and rapid inflation in the long run. Thomas I. Palley (2015) [13] critically analyzed Modern Monetary Theory, which posits that excessive money supply through printing does not exert inflationary pressure on the economy. The paper Tax and Budget Policy, explains the economical influence of tax revenue in government spending. Moreover, it has been well evidently proved that tax revenue plays a huge part in fiscal stimulus as well as fiscal contraction [ref].

In the article ‘How do taxes affect the economy in the long run?’ [ref], This paper provides a detailed overview of the long-run effects of taxation on the economy, including its impact on budgetary resources. The authors find that taxation can have a significant impact on economic growth in the long-run, both directly and indirectly.

Discussion of the "Understanding the Economic Issues in Sri Lanka's Current Debacle" paper by Soumya Bhowmick [14] discusses Sri Lanka's increased vulnerability to economic shocks as a result of its high levels of external debt. The debt issue has also had an adverse impact on the economy's stability, making it challenging for the government to borrow funds at affordable rates and invest in crucial public services. ‘A Policy Perspective Analysis from Quantile Regression’ by Md. Shahinuzzaman et al. (2021) [15] investigates this link, highlighting the influence of foreign debt. Their findings suggest that the impact of external debt on South Asia's economic growth is nonlinear. It has a beneficial and considerable impact on growth at lower levels, mostly through funding important expenditures like infrastructure and human resources. Higher levels of debt, however, have a negative and severe impact because of possible problems such difficulties paying off the debt, a decline in the value of the currency, and the crowding out of private investment. The authors advise using external debt sparingly, avoiding excessive accumulation, and making sure it finances profitable investments for the best possible economic growth.

1.2. Research Gap

The current literature, as discussed, primarily focuses on identifying the impact of fiscal deficits or budgetary sources on macroeconomic variables such as inflation and economic growth. Its goal is to comprehend the causes of macroeconomic instability and determine whether these factors have a negative or positive effect on the economy. While the results of these studies do indicate whether fiscal deficits, money printing, or taxation are detrimental or beneficial to the economy, they often lack a systematic approach to mitigate harm or maximize benefits. Hence, it can be argued that the current literature falls short in providing systematic solutions to maintain macroeconomic stability. Therefore, there is a gap in the existing literature that needs to be filled with systematic approaches to ensure and enhance macroeconomic stability. Furthermore, as we found, there are not many studies done in the Sri Lankan context when it comes to identifying the impact of budgetary sources on the economy, hence there is a gap in the existing literature to come up with a study to identify the impact of budgetary sources on the economy in the Sri Lankan context.

1.3. Research Problem

The prevailing economic crisis in Sri Lanka is believed to be caused by the balance of payment issue and the macroeconomic instability resulting from the substantial fiscal deficit [2]. Consequently, in response to this crisis, the current authorities of the country have decided to negotiate a staff-level agreement with the International Monetary Fund (IMF). This agreement entails a fiscal consolidation program aimed at achieving and maintaining macroeconomic stability in the short and long term. It involves reducing the fiscal deficit over time and restructuring public debt [16]. Within this program, the fiscal deficit is acknowledged as the primary contributor to macroeconomic instability. It's important to note that the new Central Bank Act, proposed as part of this agreement, strictly prohibits monetary financing for budgetary needs, effectively closing the door on the Sri Lankan Government's ability to finance the fiscal deficit [17], [18]. However, as discussed in the literature review, there are dissenting voices among economists who argue that

the fiscal deficit may not be as detrimental as implied. Some studies in the existing literature even conclude that the fiscal deficit can have a positive impact on economic growth. Additionally, it's worth noting that a majority of countries worldwide operate with fiscal deficits.

Given these considerations, could there be an alternative systematic solution to achieve and sustain macroeconomic stability by approaching this crisis from a different perspective? One could argue that rather than treating the fiscal deficit as an inherently negative factor, it could be considered the 'new norm.' This alternative viewpoint could lead to the encouragement of borrowing, including monetary financing for budgetary purposes, rather than their exclusion.

In this alternative approach, efforts could be made to minimize the potential risks associated with the fiscal deficit, monetary financing, borrowing, or taxation, as outlined in the existing literature, while maximizing the potential benefits highlighted by dissenting economists and select studies within the literature.

1.4. Research Objective

1.4.1. Main Objective

This study focuses on preserving macroeconomic stability by using a systematic solution to optimize budgetary source amounts to finance government expenditure in order to minimize the risk associated with it while maximizing the benefit associated with it. Hence, the identification of the optimum budgetary source amount for a given expenditure amount is the main objective of the study.

1.4.2. Sub Objective

The budgetary source amounts have to be predicted for the following years to be optimized later. Predictive models will have to be used for this purpose. In order to optimize the budgetary sources, the relationship between those and the considered macroeconomic variables has to be identified. Using the relationship, the budgetary sources such as monetary financing can be optimized based on given targets. A web application has to be developed to provide a user interface to input defined targets based on which the budgetary sources are optimized.

2. Methodology

2.1. Methodology

This study focuses on generating optimized ratios of budgetary sources for a given expenditure amount. While finding the optimum amount, the feasibility factor is taken into consideration, therefore upper and lower thresholds need to be defined in this study. As a general scenario, in this study, the upper threshold is taken as 150% of the previous year's amount and the lower threshold is 50% of the previous year's amount. This can be changed accordingly. Because of this feasibility constraint, without assigning random values of budgetary sources to the optimization algorithm the study focuses on assigning predicted amounts based on the historical data using time series models. As this study only focuses on finding the optimum monetary financing amount, the documentation explains the methodology of predicting the monetary financing amount for the following years.

2.1.1. Time Series Models

Four time series modes including three statistical models and a neural network model, are used to predict the monetary financing for the following years and the model with the best accuracy is selected for predictions. The dataset for the models was acquired from the Central Bank of Sri Lanka (CBSL) [19].

Monetary financing is technically referred to as borrowings from the Central Bank. When a government needs money to cover its budget deficit (i.e., when its expenses exceed its revenues), it may issue government securities like bonds or bills to the financial market. These securities are essentially IOUs from the government, and investors can purchase them. IOU stands for "I Owe You." It is a written acknowledgment of a debt or a promise to pay a specified amount of money to another party. In the case of monetary financing, the central bank steps in and buys these government securities directly from the government using newly created money. This is different from a regular bond market transaction where the securities are sold to private investors [20]. Therefore, from the dataset, the 'Net Credit

granted to the Government by Central Bank' column is taken as the monetary financing amount used to finance the government's expenditure over the years.

The monetary financing dataset consists of monthly data hence there is no requirement to expand the dataset by dividing it quarterly. However, the data format of the 'Month' column is not consistent, hence it is pre-processed. The 'Net Credit granted to the Government by Central Bank' column is standardized in order to make it easy to compare the Mean Squared Error (MSE) values of the models later. Standardization of data is used as a data pre-processing action to improve the performance of machine learning models because it helps to take all the variables into a single scale removing different scales. However, in univariate time series modelling where a single column of data exists this does not make a difference [21]. After pre-processing the data, it is checked to understand its behaviour and it is understood that it has a seasonality and trend.

2.1.1.1 SARIMA Model

A Seasonal Autoregressive Integrated Moving Average (SARIMA) model is a sophisticated time series forecasting method that builds upon the concepts of Autoregressive Integrated Moving Average (ARIMA) models. SARIMA models are particularly useful when dealing with time series data that exhibit seasonality, trends, and other complex patterns. When ARIMA is used and the data is non-stationary, it has to be differentiated to make it stationary whereas SARIMA is believed to be dealing with non-stationary data by itself. However, at times it might not be the case. In this study, it is proven that the SARIMA is not dealing with it by itself. Hence, the time series is differentiated first and utilizes ACF, PACF plots, and the Autoarima function to derive (p, d, q) (P, D, Q) m values. The Autoarima function appears to be giving better values when MSE values are checked. When the SARIMA model is trained with standardized data, the MSE value is high compared to the value when it is trained without standardized data. Hence, for the SARIMA model, the data is not standardized.

2.1.1.2. LSTM model

Long Short-Term Memory (LSTM) is a type of recurrent neural network (RNN) designed for time-series predictions. It excels at capturing long-term dependencies and patterns in sequential data, making it effective for tasks like stock price forecasting, natural language processing, and more. LSTMs use memory cell and gating mechanisms to control the flow of information, making them capable of learning and remembering patterns over extended sequences, which is challenging for traditional RNNs. The benefit of using LSTMs for time series forecasting is that they can capture complex patterns, including seasonality, trends, and irregularities, without relying on simplifying assumptions. Standardized data was utilized for the LSTM model unlike in SARIMA model. The model appears to be functioning very well with a good MSE value.

2.1.1.3. FB Prophet model

Prophet is a forecasting tool developed by Facebook for time series predictions. It is designed to handle daily observations that display patterns on different time scales, including holidays and special events. Prophet is user-friendly and requires minimal data pre-processing, making it a valuable tool for quick and accurate time series forecasting in various domains. It is believed to handle seasonality automatically, however, in this study, it appears that it does not handle the seasonality by itself. Hence, the seasonality is given manually as 12 since it is visible that the time series has seasonality 12 months apart. Standardized data was utilized for this model.

1.1.1.4. Exponential Smoothing (Holt-Winters)

The Holt-Winters Exponential Smoothing model is another popular method for time series forecasting. It considers three components in the data: level (average), trend (directional movement), and seasonality (repeating patterns). By exponentially weighting past observations, it adapts to changes in these components over time. This model is effective for capturing and predicting data with consistent patterns and trends, making it valuable for forecasting in business and economics. Standardized data was used for this model.

Table 1 is a summary of the performance of all the time series models used to predict budgetary source amounts for the following years. Root Mean Squared Error is used as the performance metric.

1.1.1.5. ARIMA

ARIMA, or AutoRegressive Integrated Moving Average, is a powerful time series modeling technique, especially valued in economics. It combines three key components: AutoRegression (AR) - which considers past values to predict future ones, Moving Average (MA) - which analyzes past prediction errors, and Integration (I) - a differencing process to make a series stationary. What makes ARIMA special is its ability to capture complex temporal patterns, trends, and seasonality in economic data. This versatility enables economists to model and forecast a wide range of economic phenomena, from stock prices to GDP trends, making it a fundamental tool for understanding and predicting economic fluctuations and trends [22].

1.1.1.6. GARCH

GARCH, or Generalized Autoregressive Conditional Heteroskedasticity, is a specialized time series model widely used in economics for modeling and forecasting financial volatility. What makes GARCH special is its ability to capture the dynamic nature of volatility in financial markets, where the level of risk changes over time. Unlike traditional models that assume constant volatility, GARCH recognizes that volatility clusters during turbulent periods and subsides during calm ones. This feature is crucial in economics because it allows analysts to better understand and predict the risk associated with financial assets, aiding in risk management, option pricing, and portfolio optimization. In essence, GARCH is a powerful tool for modeling the complex and changing nature of uncertainty in economic and financial data [23].

Table 1 is a summary of the models utilized to predict budgetary source amounts.

Models	**Budgetary Sources**			
	Monetary Financing	**Tax Revenue**	**Domestic Borrowings**	**Foreign Borrowings**
ARIMA		2.85		2.33
SARIMA	**117452.81** **(Not standardized)**		**4.706**	
Triple Exponential Smoothing	0.0156			
Exponential Smoothing		**0.03**	5.26	2.24
FB Prophet	0.0557		65.4	

GARCH		1.60		2.22
LSTM	0.0077	0.38	70.2	**1.548**

Table 1: Summary of model performance

Using the best model for budgetary source amounts are predicted for the following years. Subsequently, the predicted budgetary source amounts have to be optimized. In this study, a simulation and an optimization algorithm are used to do the optimization. In the simulation random set of budgetary source amounts and relevant macroeconomic variable values are generated according to given relationships and constraints. Considering the feasibility factor, in this study, the budgetary source amount of the following year cannot be lower or greater than a certain threshold of the previous year's amount of that respective source. The upper threshold is taken as 150% of the previous year's amount and the lower threshold is 50% of that amount. This threshold can be changed accordingly. Random source amounts are generated using the simulation according to this constraint.

The focus of this study is to optimize the predicted source amounts such that Inflation and Debt- GDP ratio targets are met. Only inflation and Debt to GDP ratio are considered when optimizing the budgetary sources because by taking other macroeconomic indicators such as Interest Rates, Unemployment Rate, and Exchange Rate the study will have to consider broader concepts and define equations that could increase the uncertainty of the results. Most importantly this will take time consequently the research will not be able to be completed within the given period. If a certain amount of monetary financing, tax, foreign borrowing, and domestic borrowing meet the predefined inflation and debt-to-GDP ratio targets, that is taken as the optimum set of amounts to finance a given expenditure amount. To do this the relationship between budgetary sources and two macroeconomic indicators have to be identified and included in the simulation. Subsequently, using the identified relationships Inflation and Debt-GDP values have to be calculated through each iteration for given budgetary source amounts.

2.1.2. Debt Sustainability Formula

$$\frac{\textit{Current Government Debt + Domestic Debt + Foreign Debt + Monetary Financing}}{\textit{Gross Domestic Product (GDP)}}$$

The Debt-GDP ratio formula is defined as above. Debt-GDP ratio formula includes two additional variables apart from the predicted amounts: Current Aggregate Public Debt and GDP. Since the behavior of GDP and Current Aggregate Public Debt for the following years is unknown to us, they have to be predicted. Hence, separate SARIMA models for Current Aggregate Public Debt and GDP are built. The reason behind the decision to choose the SARIMA model is that SARIMA is better at identifying trends based on seasonality which is showcased during the pre-processing stage of the data. It was visible that the time series has a seasonality component, hence the SARIMA is selected for its prediction.

2.1.3. Relationship of Inflation and Budgetary Sources

During the investigation, there was no formula that defined the relationship between inflation and budgetary sources. Yet, defining Inflation and Budgetary sources through a formula is an important aspect of the research since it is one of the targets that is used to optimize the amounts, therefore a statistical formula is defined considering the association between inflation and budgetary sources. Following regression models are built and the model with the best accuracy is taken to derive the formula. Only linear regression models are used because otherwise coefficients cannot be derived from non-linear regression models.

The methodology of building an equation using Regression Analysis was discussed by Gerhard Tintner in the article "SOME APPLICATIONS OF

MULTIVARIATE ANALYSIS TO ECONOMIC DATA". As the author concludes "the choice of whether to use a deterministic or stochastic model depends on the specific problem being studied." In some cases, a deterministic model may be sufficient. However, in other cases, a statistical model may be necessary to capture the complexity of the economic system". Statistical linear models were used to construct weights or coefficients in order to create an association equation between budgetary sources and inflation. Four regression models were created in accordance with the specification, and the final model was obtained by comparing them to MSE values. Ridge, Linear Regression, Support Vector Regression (SVR), and Elastic Net. These algorithms were chosen after consideration of their linearity and their propensity to respond to time series data.

2.1.3.1. Support Vector Regression Model

According to the research financial time series forecasting using independent component analysis and support vector regression SVR is considered a novel neural network algorithm on top of statistical learning theory and the paper states that this algorithm is getting a lot of attention to solve nonlinear estimation problems. One huge barrier to making this model a win is to make the data well pre-processed as the algorithm is highly vulnerable to noisy data. Also, some other researchers and journals strongly believe that Support Vector family algorithms could be widely used in the future by providing its capabilities [2][3].

2.1.3.2. The Ridge Regression Model

The Ridge regression model is used to analyze data that suffer from multicollinearity. It performs L2 regulation and reduces the impact of correlated features on the coefficients [5]. As experiment research to identify the relationships of budgetary sources with inflation, this algorithm is modeled and compared for the economic data.

2.1.3.3. Linear Regression Model

The linear Regression model is a model that is widely used to explore the relationships between the dependent and the independent variables. Identifying the weights(coefficients) is the primary goal of this part of the research so that this model could be a feasible approach to use and compare with the available economic data [6].

2.1.3.4. The Elastic Net Model

In the Elastic Net model, in statistics, and the fitting of linear or logistic regression models, the elastic net is a regularized regression method that linearly combines the L1 and L2 penalties of the lasso and ridge methods [4].

2.1.3.5. The Ridge Model

The Ridge model is a model tuning method used to analyze data that suffers from multicollinearity. Also, the Ridge model is considered an extension of a Linear regression model. Also, it's a model that has been well used by wiser professionals to do correlation analysis for economic data [7].

Finally, the Support Vector Regression has proven to be the model with the best accuracy, hence the following formula is derived through Support Vector Regression:

Inflation =

(0.49161396* Domestic Borrowing) - (0.99352259 * Foreign Borrowing) - (1.003063746 * Taxation) - (0.65601281* Monetary Financing) + 7.13781158

2.1.4. Simulation

This study planned to find a way to optimize the budgetary source amounts through a single algorithm or simulate the target amounts and filter based on the targets defined. During the research study process, many pieces of literature mentioned a simulation named “Monte Carlo Simulation” [24] which had some publications on stock profile optimization, economic growth forecasting, and obtaining ratios using Monte Carlo Simulation. In further investigating simulation and optimization process algorithms another simulation method known as “Agent-Based Modelling” which has been used in economics-based research found [25].

Yet, by comparing these two methods, Monte Carlo Simulation is in many publications in the economic domain than Agent-Based Modelling although Agent-based modeling is emerging currently in the economics domain, while Monte Carlo Simulation is commonly discussed in the economics domain. This research started to focus on Monte Carlo Simulation to reach the research objective of this paper because Agent-Based Modelling depends on the agent and its interaction with the environment which is commonly used in gaming and environments that are solely based on the agent’s interaction, which is not the purpose of this study. In contrast, this study is more about the probabilistic approach where the Monte Carlo Simulation is more effective.

In the Mote Carlo Simulation, the set of predicted budgetary source amounts, formulas to produce Inflation and debt-to-GDP ratio values for a given set of budgetary sources, the Current Aggregate Public Debt and GDP values are extracted from SARIMA models and will be fixed during the entire simulation process.

Subsequently, the predicted budgetary source amounts are initialized to minimum and maximum; Minimum is considered as 50% of the predicted values, while Maximum is considered as 150% of the predicted budgetary source amount. This is the feasibility constraint explained before.

The simulation algorithm concept is defined as follows; Simulation is set to run for 100,000 iterations, and in each iteration, budgetary source amounts are initialized within the defined thresholds. Subsequently, the amounts are passed to

inflation and debt sustainability formulas and obtain the respective inflation and debt-to-GDP ratios. By the end of the iterations, there will be 100,000 records with inflation and debt-to-GDP ratios with respective budgetary source amounts.

2.1.5. Optimization

This section focuses on filtering the generated data frame based on the defined targets. In this study, the inflation rate and debt-GDP ratio are taken as inputs and subsequently, the result will be given. Just giving the inflation rate will not provide any results since there might not be inflation rates that are identical to that. Therefore, in the algorithm, the inflation target is taken as a range, where the lower bound is 0.01 less than the input ratio while the upper bound is 0.01 more than the input ratio. Based on that set of budgetary source amounts, inflation rates, and debt-GDP ratio will be generated and that will be further filtered by considering the minimum inflation and Debt-GDP ratio amounts. This helps to derive the optimum budgetary source amounts for that particular year. Using those amounts the proportion of budgetary sources can be derived and subsequently it can be used to identify the optimum budgetary source amounts including monetary financing amount for a given expenditure amount. Below is the summarized diagram of the entire optimization process.

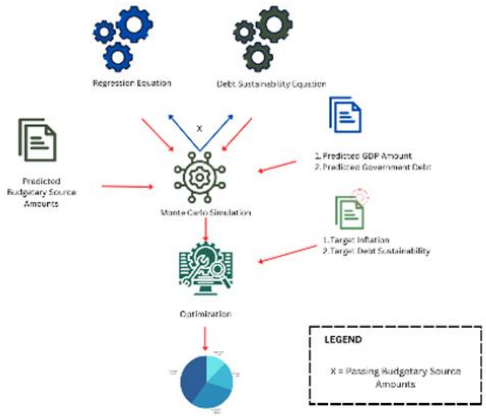

Figure 5: High-level structure of Optimization process

2.2. Commercialization

The goal of this research is to help economist of the government make their decision easily with a reliable and accurate system. Given that, our end users will be highly professional individuals who are also a part of governments' macroeconomic policymakers team, as well as professionals from the economic institutes who help governments with strategic reports and future predictions. The developed web application will be commercialized among the above-mentioned professionals by having physical meetings and presentations about the system and what it does.

Figure 6: The Central Bank of Sri Lanka

Figure 7: The Advocata Institute

And nowadays digital marketing has become a vital commercialization tool around the globe. Therefore, the importance and the benefits of this research will be commercialized through social media such as YouTube, Tok-tok, Facebook, and Instagram.

This system is built solely to help the policymakers in the government. It will be advertised as an open-source model that everyone related to econometrics, and economics with machine learning would enhance the models and logic to improve the accuracy of metrics and make the model more feasible and reliable. As mentioned, Google search optimizations and recommendation systems will be considered to make this research paper visible to everyone keen to help economics with the technical knowledge that they have.

As well as networking with expertise to request feasible testing of the system to make reliability high. Also, networking with the economic community and conducting webinars on this novel approach would make the system more popular and attract new researchers into this field of study.

2.3. Testing & Implementation

The main problem with this study is that the results given by the application cannot be validated if and only if the relevant authorities do not apply the same approach when they make policies and make decisions for the country. And also, it will take time to validate a result given for a particular year ahead of us since it must wait till the end of that year to compare the results. Hence, this approach is not the most effective way to validate this application.

However, the 'Optimizer' which is the algorithm used to optimize budgetary sources based on the given inflation and debt sustainability targets can be evaluated to check its accuracy in providing results. If the Optimizer is accurate, it is most likely that the application gives more accurate results. The following approach can be used to evaluate the Optimizer.

To evaluate the accuracy of the optimizer historical data can be used. For instance, the Optimizer can be given the inflation and the debt-GDP ratio of the year 2020 which is already known to the public. If and only if the Optimizer is accurate enough, it should give the tax, monetary financing, domestic borrowing, and foreign borrowing amounts that have been recorded for the year 2020. If the result is accurate, the Optimizer is trained with the right relationship between inflation and budgetary sources, and debt-to-GDP ratio and budgetary sources. This can be a good indicator that the statistical model used to find the relationship between inflation and budgetary sources is a success or a failure as the study made an experimental effort to derive a deterministic model from a statistical model.

Following are the test cases built in order to evaluate the Optimizer. The application is given the inflation, debt-to-GDP ratio, and total government expenditure amount (in millions) of the period 2014-2019 as inputs to check whether its output maches with the actual data. When giving the expenditure amount, the donations & revenue made by privatization of assets are reduced since they are not primary revenue sources of the government and this study does not consider it.

2.3.1. Test Case 1(2014)

Figure 8

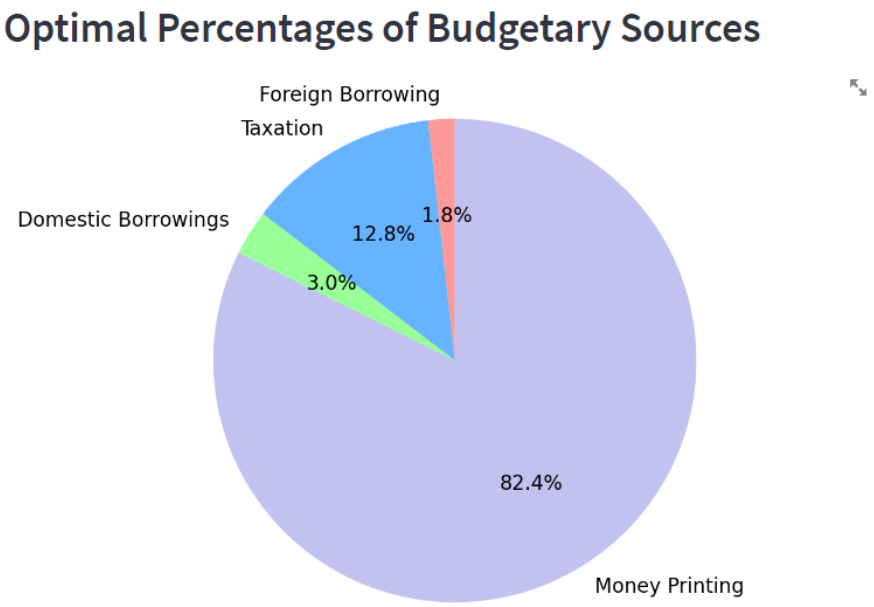

Figure 9

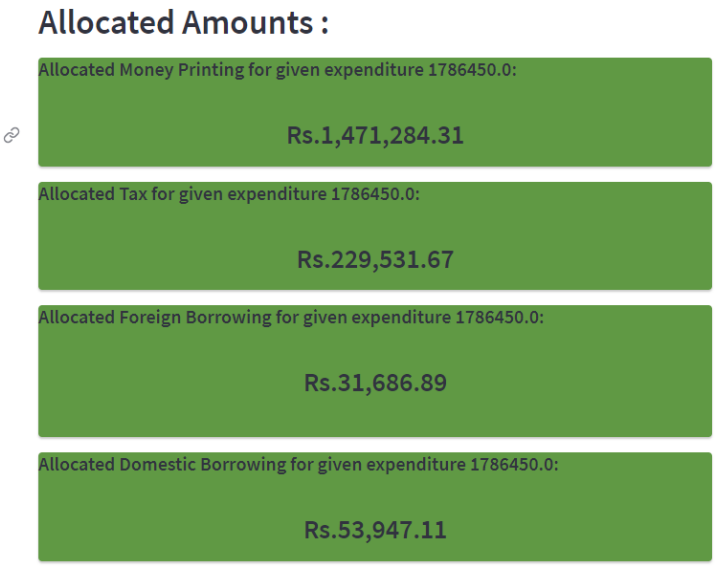

Figure 10

2.3.2. Test Case 2(2015)

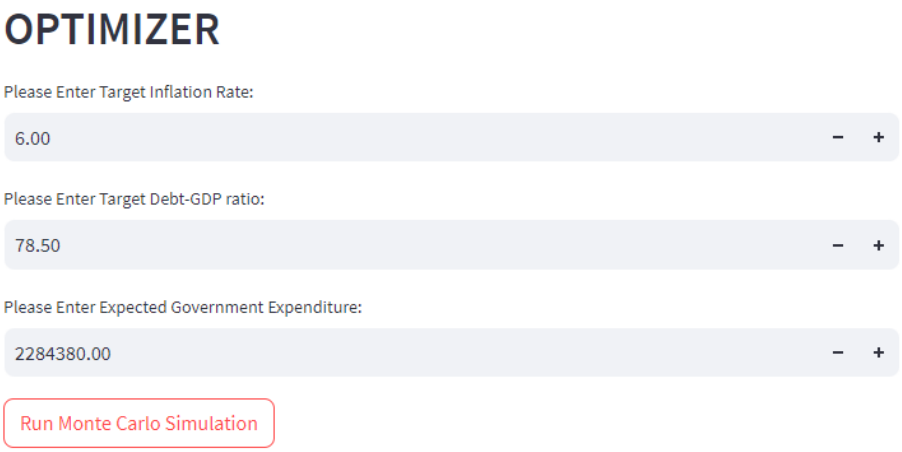

Figure 11

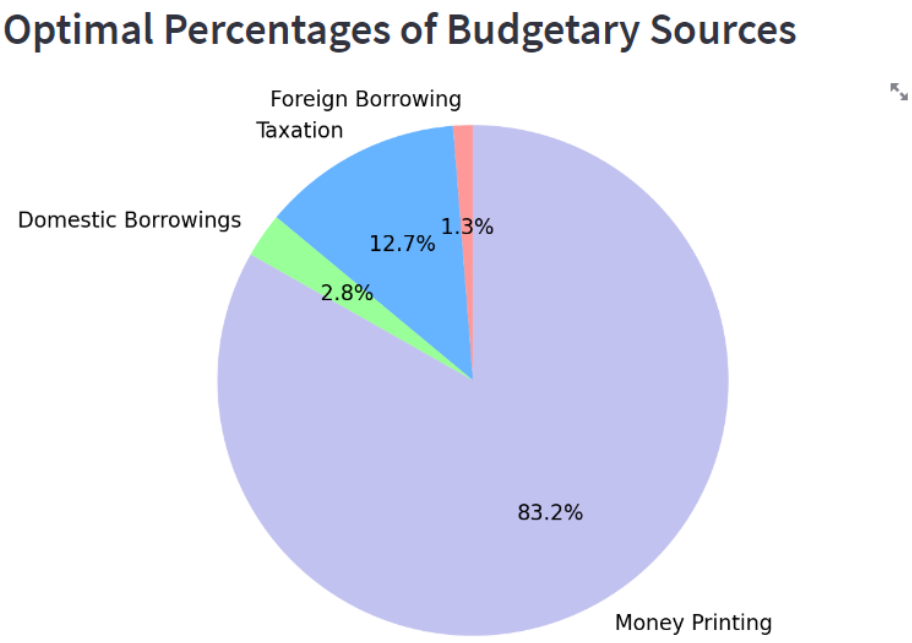

Figure 12

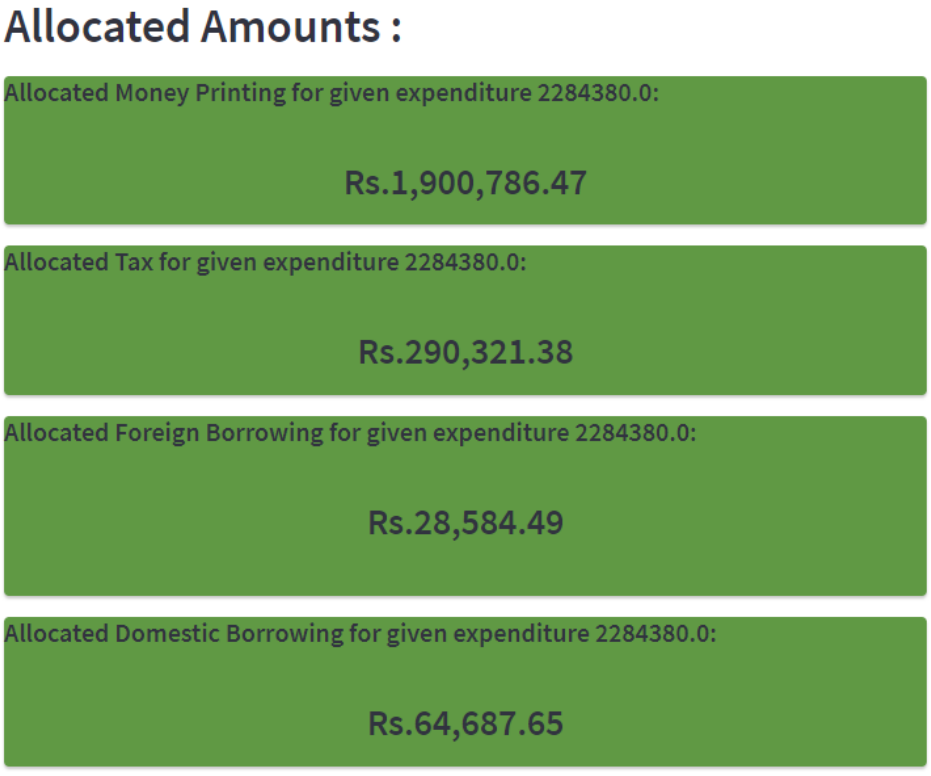

Figure 13

2.3.3. Test Case 3(2016)

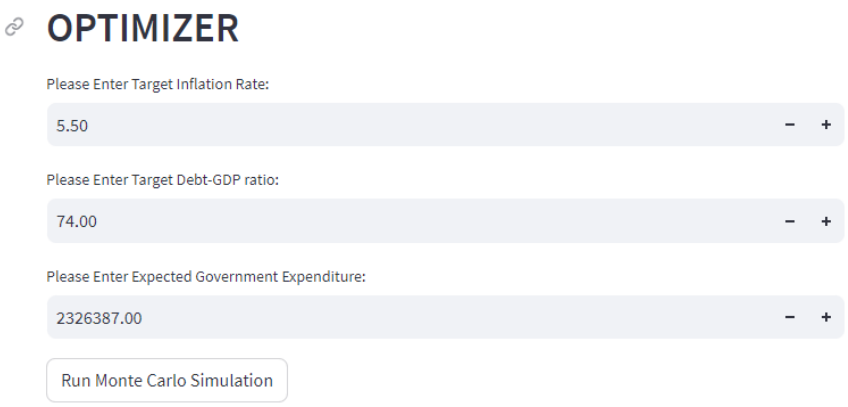

Figure 14

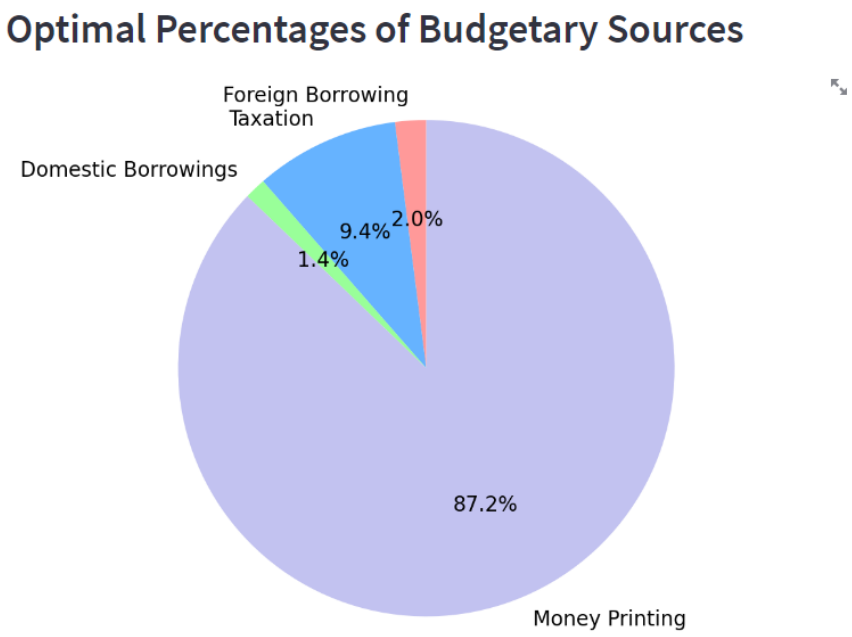

Figure 15

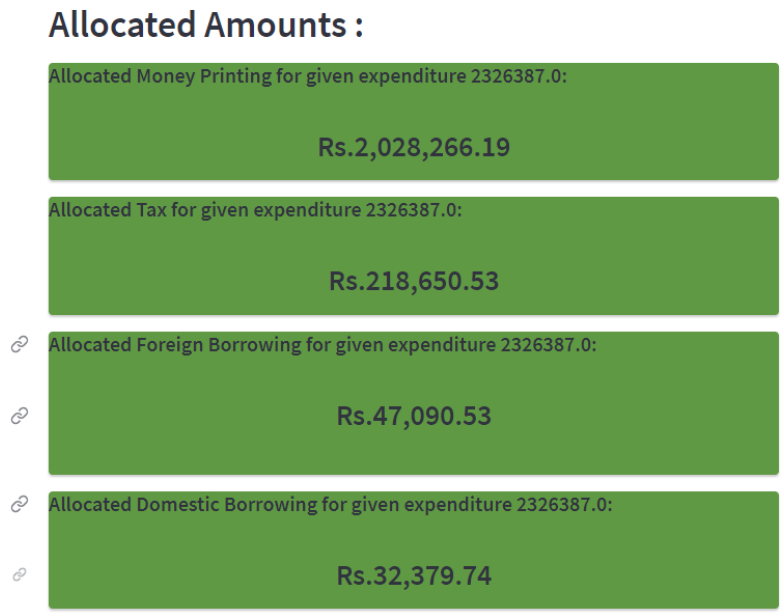

Figure 16

2.3.4. Test Case 4(2017)

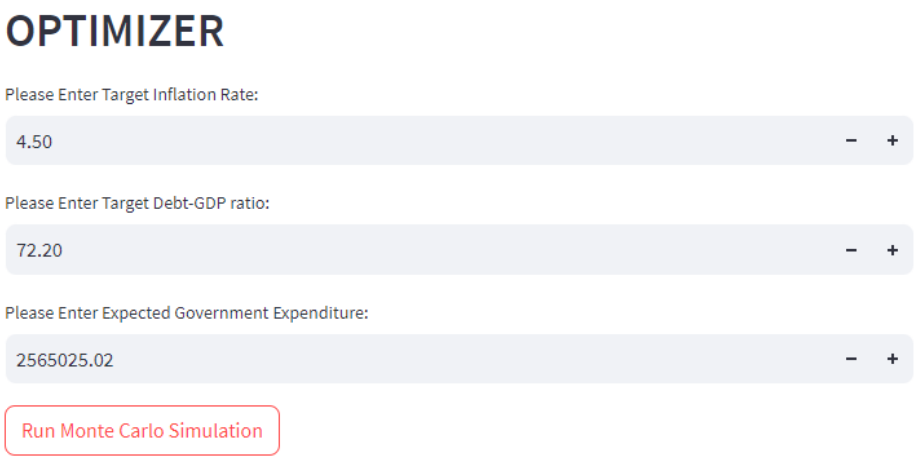

Figure 17

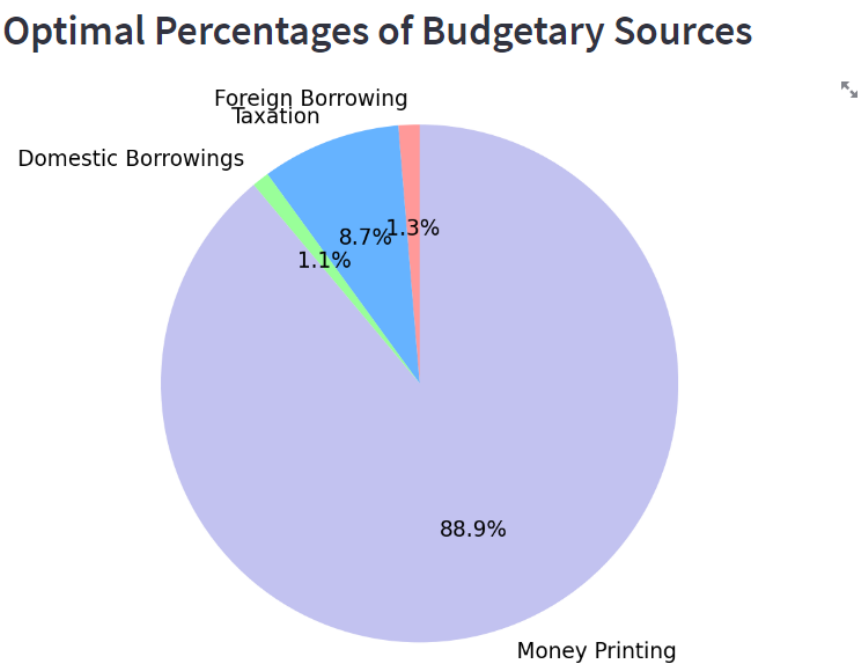
Optimal Percentages of Budgetary Sources
Foreign Borrowing
Taxation
Domestic Borrowings
8.7%
1.3%
1.1%
88.9%
Money Printing

Figure 18

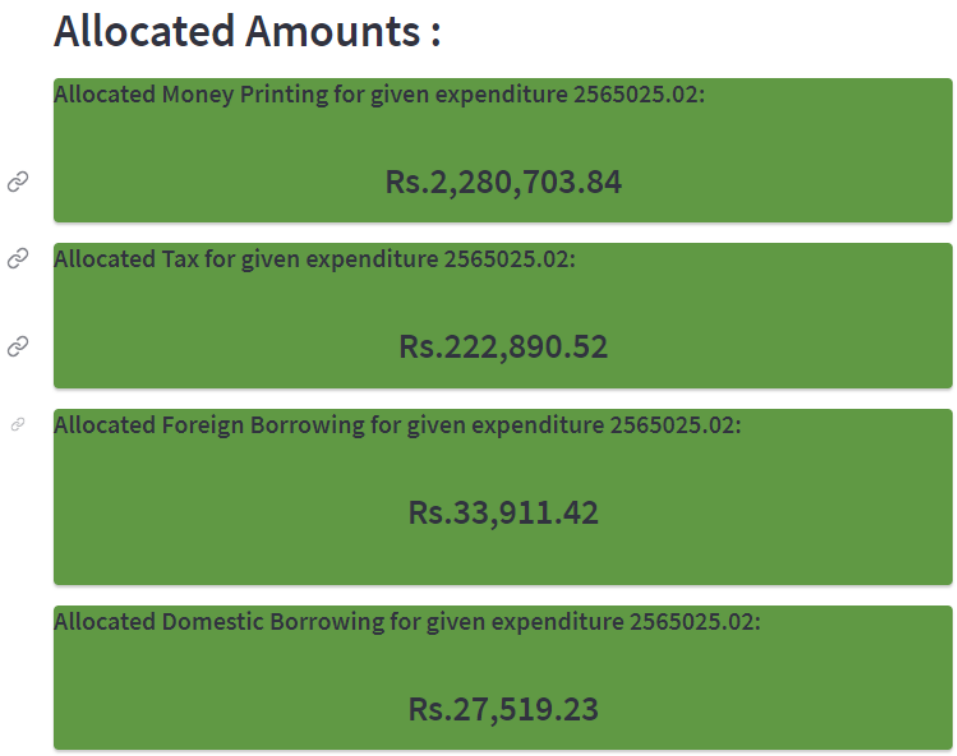

Figure 19

2.3.5. Test Case 5(2018)

Figure 20

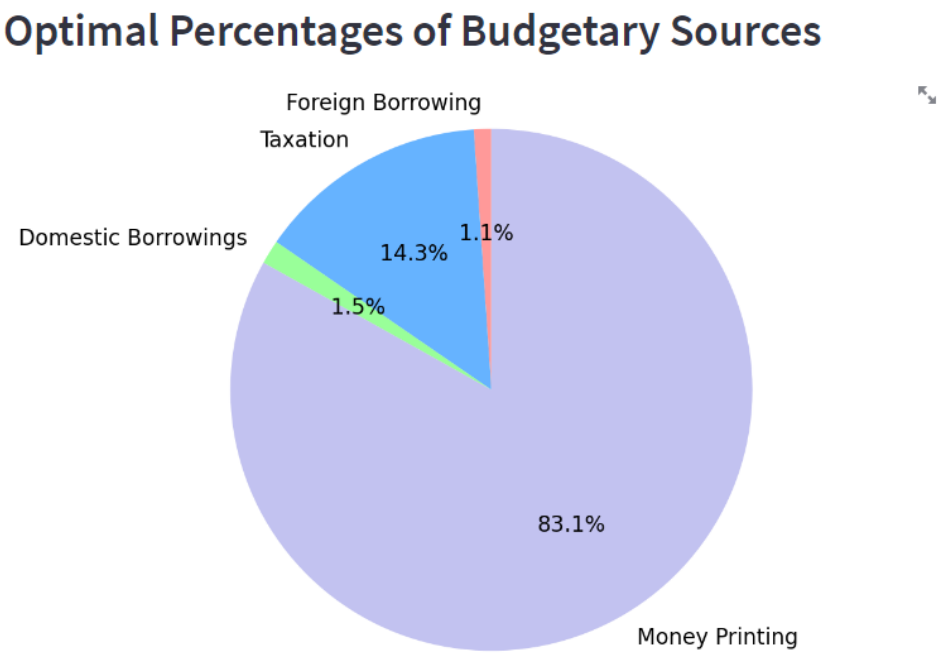

Figure 21

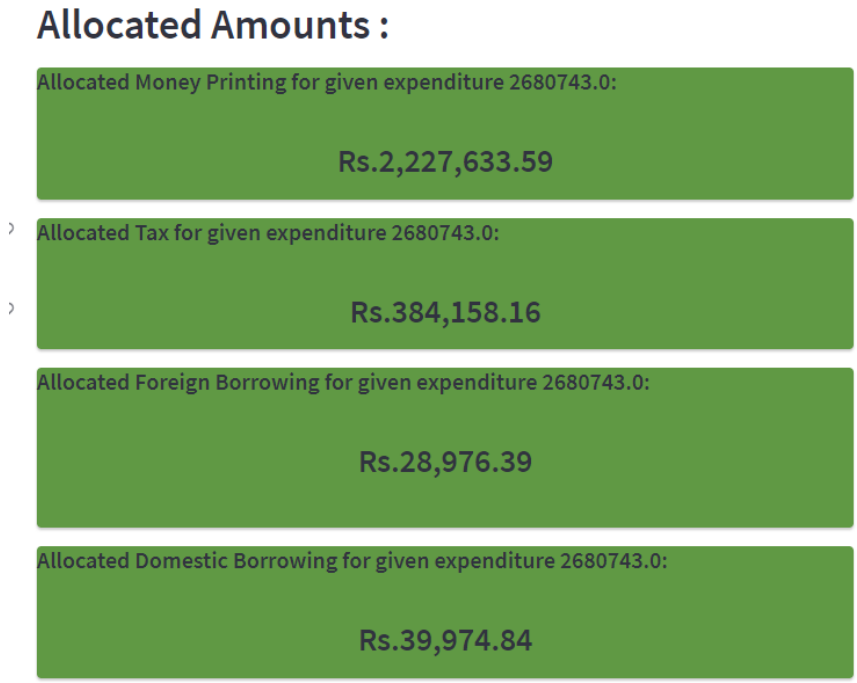

Figure 22

2.3.6. Test case 6 (2019)

Figure 23

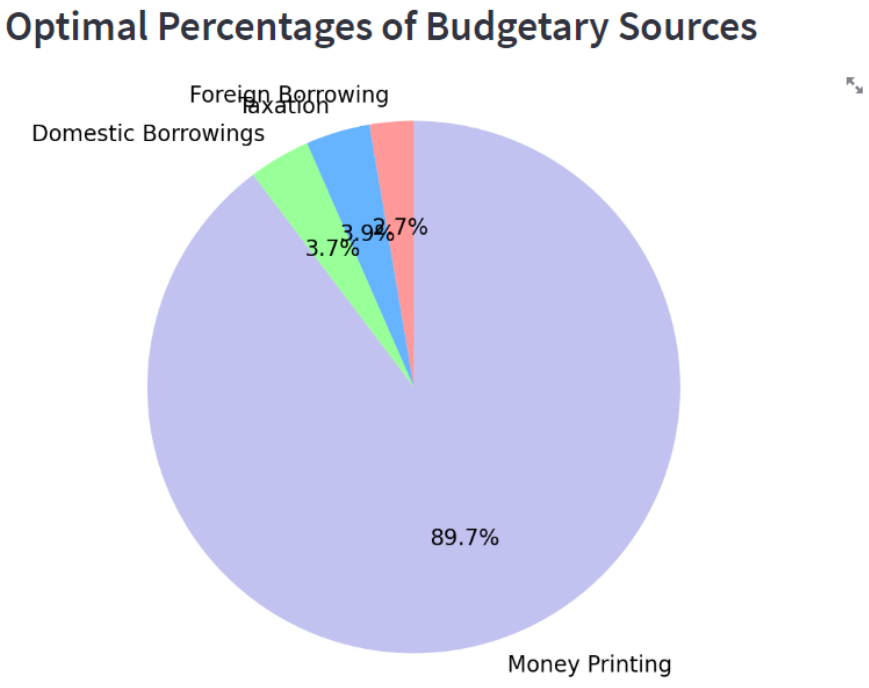

Figure 24

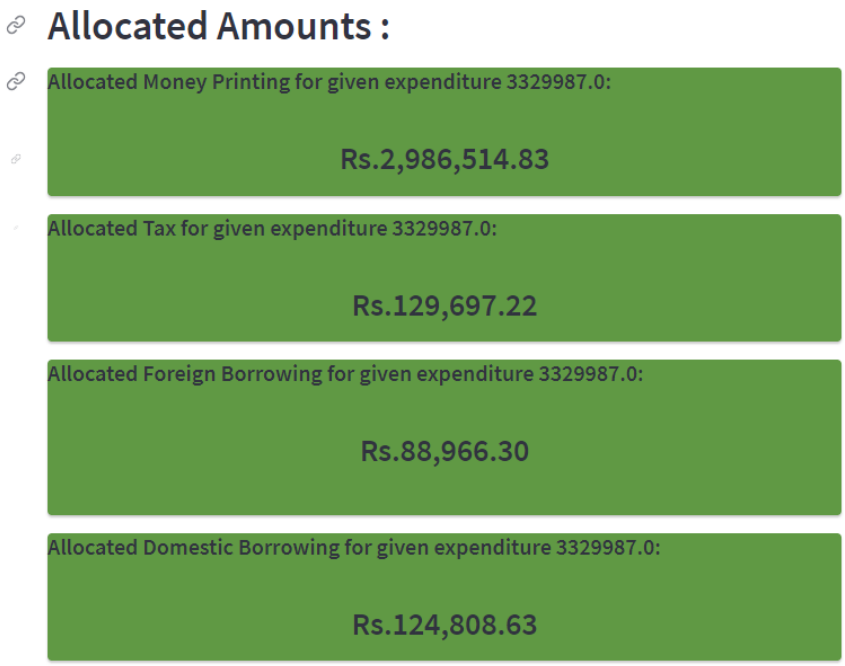

Figure 25

3. Results & Discussion

3.1. Results

Following is a summary of the test cases developed to evaluate the Optimizer. For the period of 2014-2019 the following set of inflation rate, debt-to-GDP ratio, and the expenditure amounts (in million) are given as inputs to the application.

Year	Inflation rates	Debt-GDP ratio	Expenditure (million)
2014	5.7	71.3	1,786,450
2015	6.0	78.5	2,284,380
2016	5.5	74	2,326,387
2017	4.5	72.2	2,565,025
2018	4.0	78.4	2,680,743

2019	3.5	81.9	3,329,987

Table 2: Application inputs

The following set of budgetary source amounts are given as outputs by the application. This can be compared with the actual

	Money Printing	Tax Revenue	Foreign Borrowing	Domestic Borrowing
2014	1,471,284.31	229,531.67	31,686.89	53,947.11
2015	1,900,786.47	290,321.38	28,584.49	64,687.65
2016	2,028,266.19	218,650.53	47,090.53	32,379.74
2017	2,280,703.84	222,890.52	33,911.42	27,519.23
2018	2,227,633.59	384,158.16	28,976.39	39,974.84
2019	2,986,514.83	129,697.22	88,966.30	124,808.63

Table 3: Application outputs

Following amounts are the actual budgetary source amounts taken from the Central Bank of Sri Lanka. Using them, the application outputs can be evaluated to get an understanding about the optimizer.

	Money Printing	Domestic Borrowing	Foreign Borrowing	Tax Revenue
2014	16,282,862.0	378,721.0	212,523.0	1,050,362.0
2015	19,710,115.88	592,699.12	236,802.61	1,355,779.48
2016	23,234,495.96	248,411.04	391,913.75	1,463,688.86
2017	26,168,173.01	294,250.99	439,243.49	1,670,178.21
2018	27,559,536.17	437,233.83	323,535.16	1,712,317.53
2019	31,282,003.0	896,448.0	542,641.0	1,734,925.0

Table 4: Actual budgetary source amounts

3.2. Research Findings

Table 5 contains the error rates of each budgetary source amount given by the apllication for each year during the period of 2014-2019.

	2014	2015	2016	2017	2018	2019
Money Printing	14,811,577.69	17,809,329.41	21,206,229.77	23,887,469.17	25,331,902.58	28,295,488.17
Tax	820,830.33	1,065,458.10	1,245,038.33	1,447,287.69	1,328,159.37	1,605,227.78
Foreign Borrowing	180,836.11	208,218.12	344,823.22	405,332.07	294,558.77	453,674.70
Domestic Borrowing	324,773.89	528,011.47	216,031.30	266,731.76	397,258.99	771,639.37

Table 5: Error values

According to the error rates in the Table 5, it is clear that the Optimizer is not giving the output the study expects. There is a significant difference between the application's output and the actual amount.

3.3. Discussion

Based on the test case results, it is evident that the application does not yield the intended outputs of the study, indicating potential issues with the methodology employed to achieve the desired results. Primarily, these results are derived through the use of time series model predictions, simulations, and an optimization algorithm which includes the relationship between budgetary sources and inflation that is defined using a statistical model as part of an experimental effort to establish a deterministic model.

It's worth noting that the accuracy of this result may be influenced by the performance of the time series models employed to predict future budgetary sources, which are subsequently optimized. As demonstrated in Table 1, the time series models, even after fine-tuning, are not perfect, even though exhibiting reasonable performance. One significant limiting factor is the insufficient historical data available for constructing robust time series models, a critical requirement for identifying patterns. Unfortunately, the limited data provided by institutions such as the CBSL and World Bank presents a constraint beyond the control of this study.

Furthermore, the attempt to define a deterministic model using a statistical model in the experimental process could significantly impact the application's outcomes, particularly as it contributes substantially to the optimization process. While this is not a proven fact, the utilization of the statistical model to establish a relationship between inflation and budgetary sources may have influenced the study's results. However, there is room for improvement in this aspect; enhancing the statistical model to better approximate the desired deterministic model could be explored in a separate study, potentially contributing to the existing literature.

Another factor to consider is the study's deliberately narrowed scope, which focuses on a manageable subset of variables. Specifically, the study examines the impact of budgetary sources solely on inflation rates and the debt-to-GDP ratio. The macroeconomic landscape, however, is considerably more intricate, with numerous interconnected variables such as exchange rates, interest rates, balance of payments, unemployment rates, and more, all influencing macroeconomic stability. Omitting

these variables from the study's purview could potentially have implications for the results.

Additionally, predicting economic behavior is inherently challenging due to the multifaceted nature of external influences. Political decisions, ideological shifts, pandemics, conflicts, and other factors play substantial roles in shaping economic outcomes, which are inherently difficult for machine learning models to capture. The unpredictability of these external factors makes it challenging to discern patterns and forecast economic futures.

Nevertheless, if these obstacles can be overcome in some manner, this study holds the potential for further refinement and enhancement to provide a systematic solution for preserving macroeconomic stability, not only in Sri Lanka but also in both affluent and economically challenged countries worldwide.

4. Conclusion

In conclusion, this research paper presents an innovative approach to address the prevailing economic crisis in Sri Lanka caused by the macroeconimic instability. By focusing on finding a solution for macroeconomic instability, the study identifies the optimal proportions of budgetary sources, including taxation, borrowing, and monetary financing, to minimize their negative effects on the economy. The research utilizes time series models and an algorithm to optimize budgetary source amounts, considering inflation and debt sustainability targets. The study contributes to macroeconomic stability by providing decision-makers with insights into maintaining macro stability. To enhance the study's scope and achieve more realistic results, consideration of other macroeconomic variables such as GDP growth, exchange rates, imports, exports, etc. can be beneficial in optimizing budgetary sources. Additionally, efforts can be made to improve the regression model built to establish the relationship between budgetary sources and inflation, aiming for a deterministic model that provides more accurate results. Regarding time series models predicting budgetary source amounts, the limited sample of available data

might affect prediction accuracy. A more comprehensive dataset would yield better predictions, though given the Sri Lankan context, this is the best available sample. However, external factors like politics, weather, conflicts, pandemics, etc., significantly influence economics, making it challenging to predict precise outcomes based solely on available data. Therefore, ample room exists to further enhance this study with innovative approaches in the future. In summary, this research paper contributes significantly to the economic discourse in Sri Lanka. It serves as a valuable reference for policymakers and economists working towards addressing macroeconomic instability. Through adopting the proposed approach, Sri Lanka can pave the way to overcome its economic crisis and establish a foundation for a more stable and prosperous future.

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