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A Simple Macroeconometric Model of the Sierra Leone Economy

Ibrahim Abubakarr Bah¹

Abstract

Given the need to analyze how economies respond to economic shocks, it has become prudent for economic policymakers to design increasingly sophisticated and dynamic tools to predict economic performance in the presence of shocks. This study designs a simple macro-econometric model of the Sierra Leone economy based on the Keynesian national income identity. The econometric model contains five single equations, 6 endogenous variables, and 3 exogenous variables estimated using two-stage least squares (2SLS). The results of mean absolute percentage error (MAPE) and mean percentage error (MPE) largely validate the performance of our model. To test the performance of our model, the baseline simulations are tested against 3 policy shocks; a 15% increase in government spending, a 15% increase in money supply, and a 15% increase in both government spending and money supply. Unlike the fiscal policy shock, the monetary policy shock only affects the interest rate. The results from the exercise largely follow the actual performance of the Sierra Leone economy over the period of study.

Keywords: *Simultaneous-equations, two-stage least squares, national income identity, Sierra Leone*

1. Introduction

Modern economics increasingly rely on macroeconomic models to simulate the workings of an economy. Macroeconomic models provide researchers and policymakers the tool to be able to better understand how economies work and react to economic phenomena. The Sierra Leone economy is no different. This study builds a simple macro-econometric model of the Sierra Leone economy with the aim of analyzing the impact of monetary and fiscal policies on aggregate economic variables like output, investment, imports, exports, and the interest rates.

Sierra Leone is a small open economy on the west coast of Africa. It is bordered by Liberia, Guinea, and the Atlantic Ocean. With a population of just 7.5 million people, Sierra Leone is one of the tiniest countries in West Africa. Agriculture is the mainstay of the country's economy with around 60 percent of Gross Domestic Product (GDP) coming from the sector. Consequently, 86 percent of the labor force is engaged in agriculture. The country also heavily relies on mining of minerals including diamond, gold, iron-ore, and rutile (FAO, 2021). Furthermore, the country is heavily reliant on trade with the outside world and has a negative trade balance in recent years.

The Covid-19 outbreak has severely impacted on the economy and its short-term prospect. However, in the short to medium term, it is expected that the rise in commodity prices of minerals will boost the mining sector and that will drive the recovery of the economy. The non-mining sector is also expected to witness a 4.5 percent average growth in the medium term (IMF, 2021). The economy will continue to remain highly vulnerable to economic shocks from either

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disease outbreaks or slumps in the prices of minerals like iron-ore. Some key economic indicators are highlighted in Table 1. Among the indicators, GDP growth has averaged less than 5 percent between the years 2000 and 2020 while GDP per capita averages less than 700 constant 2015 United States dollars over the same period.

Table 1: Key Economic Indicators of Sierra Leone

Indicator	2001-2007 Avg.	2011-2017 Avg.	2020
GDP (constant Leones, Billions)	4969.831	9081.723	10007.75
GDP growth	3.4904	2.9022	-3.98
GDP per capita (constant Leones)	914285.904	1293499.65	1254577.6
GDP per capita (constant 2015 US\$)	454.6654	643.2446	623.89
Consumer price index (Base year, 2010 = 100)	76.0381	132.1389	265.65
Inflation, CPI (annual %)	11.6500	8.4767	13.45
Inflation, GDP deflator (annual %)	18.8051	10.4031	10.92
Foreign direct investment, net inflows (% of GDP)	2.8028	12.6274	8.58
Private consumption expenditure (% of GDP)	91.3355	98.9514	101.19
Private consumption expenditure (constant Leones, Billions)	4528.7136	8801.5346	9635.61
Gross capital formation (% of GDP)	10.7460	21.6012	12.10
Gross domestic savings (% of GDP)	-2.4450	-8.8477	-9.27
General government final consumption expenditure (% of GDP)	11.1095	9.8964	8.09
General government final consumption expenditure (constant Leones, Billions)	511.4311	757.7844	3230.88
Total reserves (% of total external debt)	11.7905	36.6631	33.48
Total reserves in months of imports	3.2830	2.7677	5.82
Short-term debt (% of total external debt)	1.0696	12.4678	8.66
External debt (% of Gross National Income)	98.1592	37.6351	53.03
Current account balance (% of GDP)	-6.6355	-24.4733	-6.78
Exports (constant Leones, Billions)	733.6354	3228.4871	2242.71
Imports (constant Leones, Billions)	1359.2737	5757.3439	5870.07
Domestic credit to private sector (% of GDP)	2.9996	5.6999	5.96
Official exchange rate (Leones/US\$)	2567.3013	5186.4765	9829.93
Real effective exchange rate index (Base year, 2010 = 100)	106.4691	123.2384	108.86
Broad money (current Leones, Billions)	603.5763	4613.5515	11790.9
Real interest rate (%)	12.6126	8.0903	6.33

Source: Author's computation; data from the World Bank

Korsu and Daboh (2010) estimated a macroeconomic model for Sierra Leone and examined how fiscal and monetary policies affect the economy. Their study used data from 1971 to 2009 to estimate five single equations including money supply, price level, private investment, output, and trade balance using Vector Auto-Regression (VAR) method. They find that increasing the provision of bank loans (expansionary monetary policy) to the private sector has a positive effect

on private investment, real GDP, and the trade balance while the price level increased. Similarly, maintaining the budget deficit at 4 percent of GDP negatively impacts money supply while the price level declined. However, this increases real GDP, private investment and the trade balance. Nkoro and Uko (2018) estimated a macroeconomic model for the Nigerian economy using data between 1981 and 2012. They find that increasing the monetary policy rate reduced investment, nominal interest rate, the price level and GDP. In addition, they find that increasing crude oil prices has positive effects on GDP and government revenue. Khan (2014) developed a macroeconomic model to forecast the demand and supply of food in India. Using two-stage least squares and 3 structural equations, the study predicts an increase in the demand and supply of food by 2030. Gurara (2013) built a macroeconomic model for the Rwandan economy using the Auto-regressive Distributed Lag framework. The study finds that increasing spending on fixed assets raises the price level.

The aim of this study is to provide a simple macro-econometric model for Sierra Leone that broadly estimates the behavior of key macroeconomic indicators including GDP, Investment, Consumption, Imports, Exports, and the Interest rate. In addition, the study estimates the effect of both fiscal and monetary policies on these indicators. Lastly, the study also uses econometric techniques to forecast the behavior of the economy in the short to medium term.

2. Description of Data and Sources

The data for this study is from the World Bank's World Development Indicators database. The sample data consists of 20 annual observations on consumption, gross capital formation (Investment), Imports, exports, real interest rates, GDP, broad money (money supply), and government consumption expenditure. In addition, data of the United States (US) GDP is also used. The data covers the period from 2001 to 2020.

Consumption is in constant Sierra Leone Leones (SLL) and measures the market value of final goods and services including licensing and permit fees, durable goods, imputed rent and non-profit institutions serving households in Sierra Leone within a year. However, this measure of consumption excludes purchases of houses. Gross Domestic Product measures the market value addition in the production of goods and services and is measured annually. It only includes the value addition by residents within a country and is in constant local currency. It includes taxes on products less subsidies not included in the value of the goods/services. This GDP measure does not exclude depreciation of assets or natural resources. Gross Capital Formation consists of value additions to fixed assets and net change in total inventory of an economy. Any expenditure that increases the fixed assets of an economy including the construction of roads, plants, purchases of equipment and machinery can be considered as value additions to the fixed assets of an economy. An increase in inventories which includes stock of finished goods awaiting sales and work-in-progress also increases gross capital formation. Gross capital formation is measured in constant Sierra Leone Leones. For this study, gross capital formation is the proxy for investment. Exports of goods and services is the market value of all goods and services provided to the outside world. It includes costs of transportation, royalties, merchandise, insurance, freight, communication, and government services among others. However, it does not include transfer payments, payment for use of factors of production (factor payments), and compensation of employees. It is denominated in constant Sierra Leone Leones. Imports of goods and services is the market value of all goods and services received from the outside world. It includes costs of transportation, royalties, merchandise, insurance, freight, communication, and government

services among others. However, it does not include transfer payments, payment for use of factors of production (factor payments), and compensation of employees. It is measured in constant Sierra Leone Leones. The real interest rate is the official lending rate that is adjusted for inflation and is in percentage. Broad Money is the total currency units that is held in cash plus time and saving deposits including those held in foreign currency units and checking accounts. It is denoted in constant Leones. Government consumption expenditure, the proxy for government spending, refers to current government outlays, denoted in constant Leones. It does not include outlays on fixed assets. Table 2 below provides a summary of the sample data.

Table 2: Descriptive Statistics of Sample Data

Variables	Obs	Mean	Median	Max	Min	Std Dev
GDP	20	7405.515	7130.997	10684.25	3479.977	2237.034
Investment	20	1204.826	783.905	3096.668	339.091	805.336
Exports	20	1884.076	1023.165	5760.584	338.375	1428.905
Imports	20	3637.914	3583.422	6640.707	1051.488	2223.709
USGDP	20	80782864	68501142	1.90E+08	27558621	49725435
Interest rate	20	7.568237	8.105397	27.14598	-28.51641	10.73734
Broad Money	20	3471.975	2450.293	11790.92	285.5392	3240.009
government spending	20	1004.424	635.0214	3230.876	411.327	922.6751
Consumption	20	6929.451	6817.852	1.02E+04	3414.135	2215.76

*Source: Author's computation; data from World Development Indicators, World Bank
Data on all variables except exchange rate and interest rate are in billions of constant Leones*

2.1. Test for Stationarity

This study examines the stationarity of the series by using the Augmented Dicky-Fuller (ADF) test and the Breakpoint unit root test. These tests allow for examining the stationarity of individual series. The Null hypothesis of non-stationarity (unit root) is tested at the 1 percent, 5 percent, and 10 percent levels. This study tests for stationarity of the sample data at level form and in differences form. The results are presented in Table 3 below.

Table 3: Augmented Dicky-Fuller and Breakpoint Stationarity Tests

Variables	None		Intercept		Intercept and Trend	
	t-statistics	p-value	t-statistics	p-value	t-statistics	p-value
Consumption	1.207	0.9354	-1.179	0.661	-2.681	0.254
Δ(Consumption)	-5.013***	0.000	-5.733***	0.000	-5.579***	0.002
Investment	-0.634	0.429	-2.121	0.239	-1.999	0.563
Δ(Investment)	-3.657***	0.001	-3.550**	0.019	-3.772**	0.045
Govt spending	1.568	0.964	1.241	0.997	-1.004	0.919
Δ(Govt spending)	0.104	0.7007	-0.433	0.880	-0.497	0.970
Exports	-0.744	0.381	-1.855	0.345	-2.312	0.408
Δ(Exports)	-5.366***	0.000	-5.271***	0.001	-5.187***	0.003
Imports	0.799682	0.877	-0.830	0.787	-1.553	0.7729

$\Delta(\text{Imports})$	-3.391***	0.002	-3.633**	0.016	-3.525*	0.0668
$\text{Log}(\text{Money supply})$	10.00691	1.0000	-1.594	0.4663	-1.344	0.8440
$\Delta[\text{Log}(\text{Money Supply})]$	-0.272	0.5728	-3.062**	0.0480	-2.967	0.1672
GDP	1.487457	0.9606	-1.401	0.5597	-2.206	0.4600
$\Delta(\text{GDP})$	-3.417***	0.0019	-3.779**	0.0117	-3.705**	0.0487
real interest rate	-1.249	0.1866	-10.696***	0.0000	-3.448*	0.0802
USGDP	7.137363	1.0000	3.112013	1.0000	2.057746	1.0000
$\Delta(\text{USGDP})$	1.784982	0.9755	-1.851	0.3458	-0.671	0.9540
Breakpoint Unit root test						
Govt spending			-0.585341	> 0.99	-26.5475***	< 0.01
USGDP			-1.767	> 0.99	-2.74725	0.9614
$\Delta(\text{USGDP})$			-4.583**	0.0346	-2.74725	0.9614

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Δ indicates first difference

From Table 3, all the model variables are stationary either at level or at first difference enabling us to specify Auto-regressive Distributed Lag Models for estimating the single equations. Hence the null hypothesis of unit root is rejected either at level or at first difference.

3. Model Specification

To construct the model, the study specifies single equations for the consumption, investment, imports, exports, and interest rate functions. The single equations along with a brief interpretation of the parameters are highlighted in Table 4.

Table 4: Single Equations

Equation	Meaning of Equation Terms
$PCE_t = \beta_0 + \beta_1 GDP_t + U_t$	β_0 is constant, β_1 is a slope parameter; and GDP is real gross domestic product
$INV_t = \beta_0 + \beta_1 GDP_t + U_t$	INV is gross capital formation (investment)
$EXP_t = \beta_0 + \beta_1 USGDP_t + V_t$	EXP is exports of goods and services; $USGDP$ is gross domestic product of the United States
$IMP_t = \beta_0 + \beta_1 GDP_t + \varepsilon_t$	IMP is imports of goods and services
$INT_t = \beta_0 + \beta_1 GDP_t + \beta_2 LOG(M2)_t + \varepsilon_t$	$LOG(M2)$ is natural logarithm of Broad Money (Money Supply)

Consumption Function

The study specifies an OLS and an ARDL model for all single equations but only the ARDL equation is estimated in the single-equations analysis.

$$PCE_t = \beta_0 + \beta_1 GDP_t + U_t$$

$$\Delta PCE_t = \beta_0 + \sum_{i=1}^m \beta_{1i} \Delta PCE_{t-i} + \sum_{i=0}^m \beta_{2i} \Delta GDP_{t-i} + \beta_3 PCE_{t-1} + \beta_4 GDP_{t-1} + U_t \quad (1)$$

Consumption is specified as a function of GDP. Higher incomes (GDP) should lead to increased consumption. Hence consumption is expected to be positively related to GDP.

Investment Function

$$INV_t = \beta_0 + \beta_1 GDP_t + U_t$$

$$\Delta INV_t = \beta_0 + \sum_{i=1}^m \beta_{1i} \Delta INV_{t-i} + \sum_{i=0}^m \beta_{2i} \Delta GDP_{t-i} + \beta_3 INV_{t-1} + \beta_4 GDP_{t-1} + U_t \quad (2)$$

Investment is specified as a function of GDP. Investment is expected to be positively influenced by GDP as higher incomes should induce more demand for goods and translate to higher investment.

Export Function

$$EXP_t = \beta_0 + \beta_1 USGDP_t + U_t$$

$$\Delta EXP_t = \beta_0 + \sum_{i=1}^m \beta_{1i} \Delta EXP_{t-i} + \sum_{i=0}^m \beta_{2i} \Delta USGDP_{t-i} + \beta_3 EXP_{t-1} + \beta_4 USGDP_{t-1} + U_t \quad (3)$$

Export is specified as a function of US GDP. The output of the US, a major trading partner to Sierra Leone is expected to have a positive influence on Sierra Leone's exports.

Import Function

$$IMP_t = \beta_0 + \beta_1 GDP_t + \varepsilon_t$$

$$\Delta IMP_t = \beta_0 + \sum_{i=1}^m \beta_{1i} \Delta IMP_{t-i} + \sum_{i=0}^m \beta_{2i} \Delta GDP_{t-i} + \beta_3 IMP_{t-1} + \beta_4 GDP_{t-1} + U_t \quad (4)$$

Imports is specified as a function of GDP. A higher GDP should induce an increase in demand for imported goods and services.

Interest rate Function

$$INT_t = \beta_0 + \beta_1 GDP_t + \beta_2 LOG(M2)_t + \varepsilon_t$$

$$\Delta INT_t = \beta_0 + \sum_{i=1}^m \beta_{1i} \Delta INT_{t-i} + \sum_{i=0}^m \beta_{2i} \Delta GDP_{t-i} + \sum_{i=1}^m \beta_{3i} \Delta LOG(M2)_{t-i} + \beta_4 INT_{t-1} + \beta_5 GDP_{t-1} + \beta_6 LOG(M2)_{t-1} + U_t \quad (5)$$

The real interest rate is specified as a function of GDP and the natural logarithm of money supply. The real interest rate and money supply on a priori basis are negatively related. On the other hand, as income rises, people demand more money holdings and the interest rate is then expected to rise.

4. Model Validation and Multiplier Analysis

To validate the use of the baseline simulations for policy analysis and forecasting, this study uses Mean Absolute Percentage Error (MAPE) and Mean Percentage Error (MPE) to measure the error associated with the baseline results. The results, computed using excel, are presented in Table 5 below. While all the results are not perfect, in general, our baseline simulations largely explain the actual values given the relatively lower MPE values. Since this is a simplified model of the Sierra Leone economy, with many excluded factors that can affect our endogenous variables, the relatively higher error values can be expected. The simulated values closely follow the same trend as the actual values in the baseline outcome.

Table 5: Model Validation using Baseline Simulation Results

Variables	MAPE	MPE
Investment	0.543978	0.337219
Consumption	0.172917	0.040006
Exports	0.624226	0.400694
Imports	0.503398	0.274186
Interest rate	1.51888	-0.14008
GDP	0.144068	0.034831

Source: Author's computation; data from baseline results and actuals

Table 6 presents results of multiplier analysis for the last 3 years; 2018, 2019, and 2020, compared with baseline values.

In scenario 1 of Table 6, an expansionary fiscal policy has a positive effect on GDP, consumption, imports, and the interest rate, and a negative impact on investment. An expansionary monetary policy in scenario 2 has a negative impact on the interest rate. The reasons why monetary policy seems to have no impact on GDP, consumption, imports, exports and Investment are not the subject of this study. However, the Sierra Leone economy is known to largely function outside the formal financial system, thus reducing the impact of monetary policy on macroeconomic indicators. In a mixed policy framework in scenario 3, the negative impact of monetary policy on the interest rate outweighs the positive impact of fiscal policy. This does indicate that monetary policy has a greater impact on the interest rate than does fiscal policy.

Table 6: Policy Analysis

Variable	Year	Scenario 1	Scenario 2	Scenario 3
GDP	2018	4.39	0	4.39
	2019	4.53	0	4.53
	2020	4.10	0	4.10
Consumption	2018	4.02	0	4.02
	2019	4.64	0	4.64
	2020	4.29	0	4.29
Investment	2018	-5.91	0	-5.91
	2019	-9.09	0	-9.09
	2020	-12.27	0	-12.27
Exports	2018	0	0	0
	2019	0	0	0
	2020	0	0	0
Imports	2018	5.16	0	5.16
	2019	5.74	0	5.74
	2020	5.64	0	5.64
Interest rates	2018	16.66	-76.94	-60.28
	2019	18.67	-105.25	-86.58
	2020	13.98	-87.08	-73.10

Source: Author's computation

Scenario 1: Expansionary fiscal policy; a 15% increase in government spending

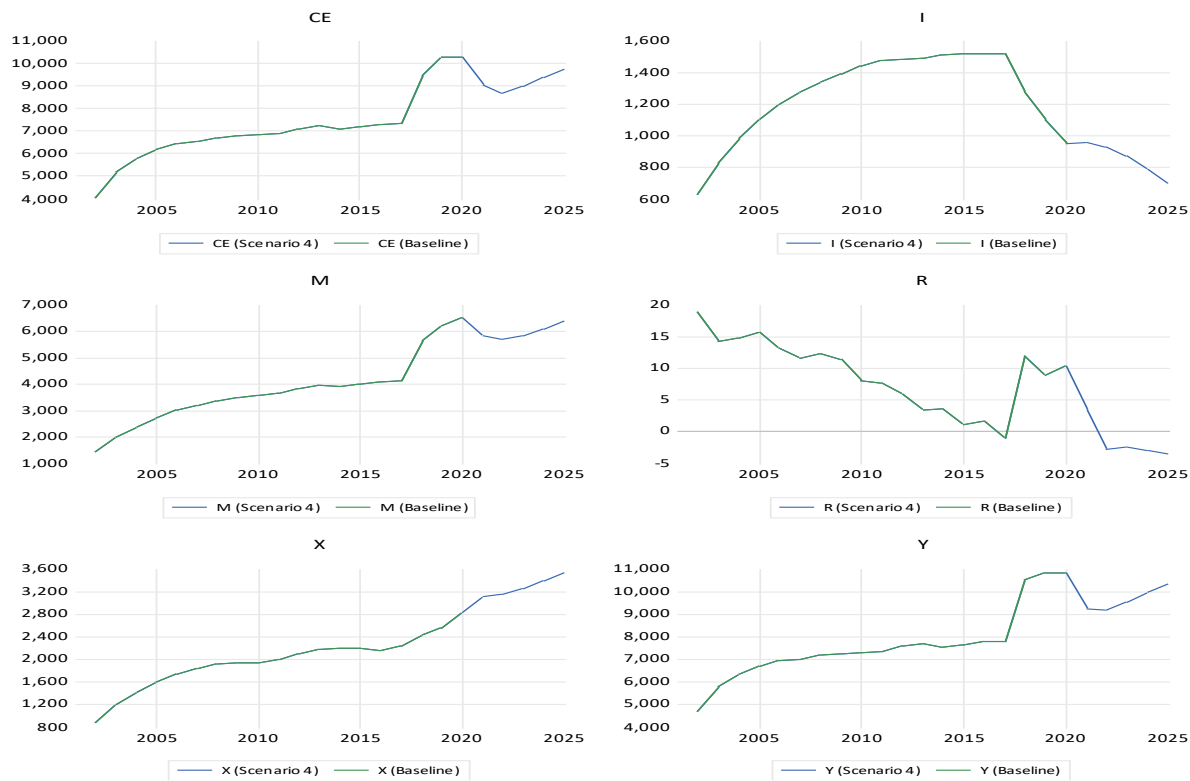
Scenario 2: Expansionary Monetary Policy; a 15% increase in Money Supply

Scenario 3: Policy Mix; Expansionary Fiscal and Monetary Policy; a 15% increase in both government spending and money supply

Values for scenarios 1, 2, and 3 are in terms of percentage change (%) from the baseline projections: Negative values indicate negative impact; positive values indicate positive impact; while zero values indicate no impact.

This study uses the baseline values to simulate the performance of our model. The results are presented in Figure 1 below. Consumption, imports, and GDP will decline slightly after 2020 before taking an upward trend. Exports will rise throughout while investment and real interest rates are predicted to decline during this period.

Figure 1: Scenario 4 - Prediction Power of the Model



CE= Consumption Expenditure; I=Investment; M=Imports; R=Real Interest Rate; X=Exports; Y=Gross Domestic Product of Sierra Leone

5. Conclusion

A positive fiscal policy shock in our model expands output (GDP), imports, consumption, and the interest rate while it leads to a fall in investment. Fiscal policy shock is neutral in changing exports. A positive monetary policy shock is neutral in all but the interest rate. The interest rate declines due to positive monetary policy shock, just as economic theory predicts. This study recommends that policymakers focus more on using fiscal policy rather than monetary policy in expanding aggregate demand. However, in order to eliminate the negative impact of fiscal policy on investment, fiscal policymakers should focus on how not to crowd out private investment when increasing government spending.

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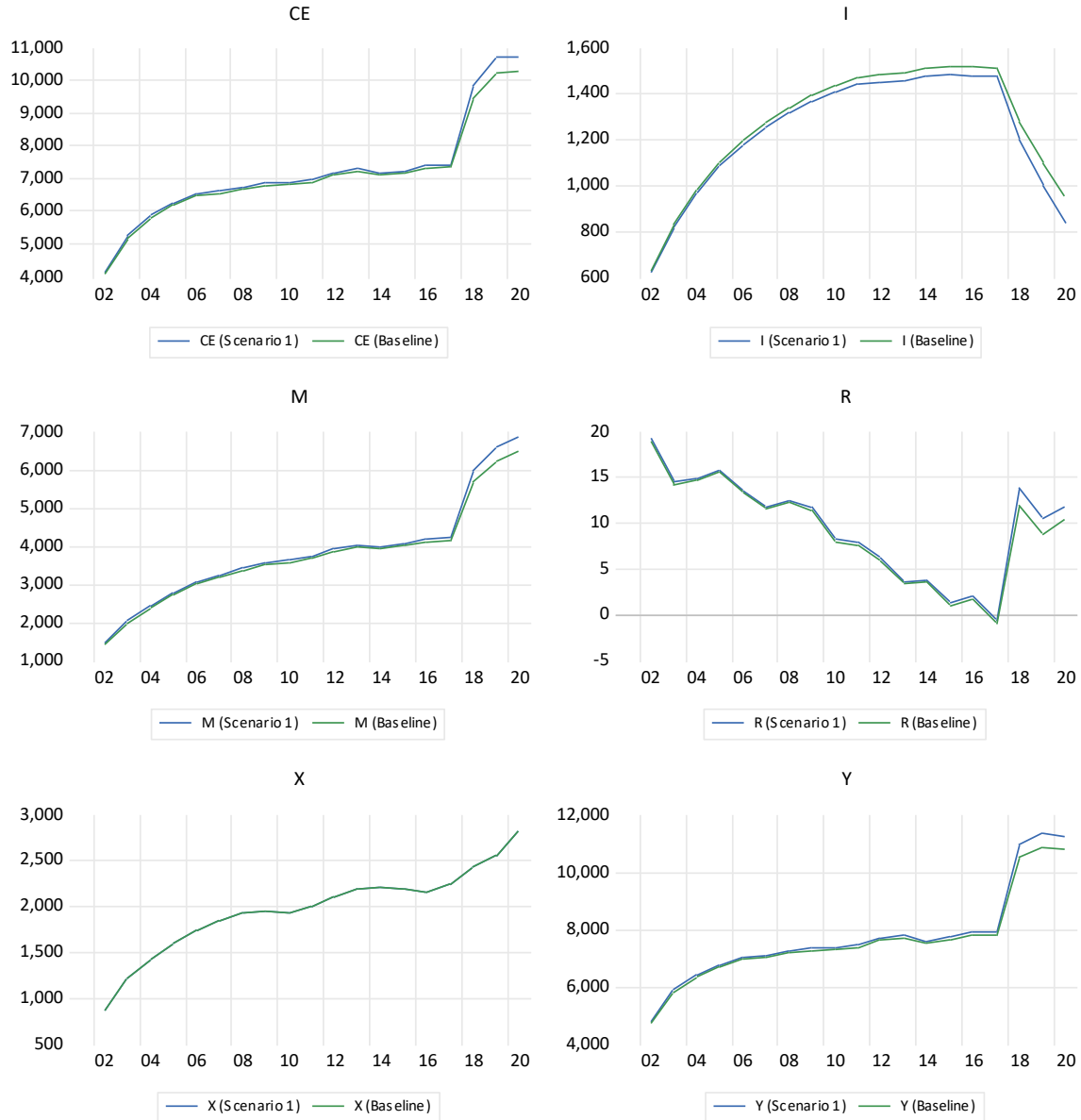
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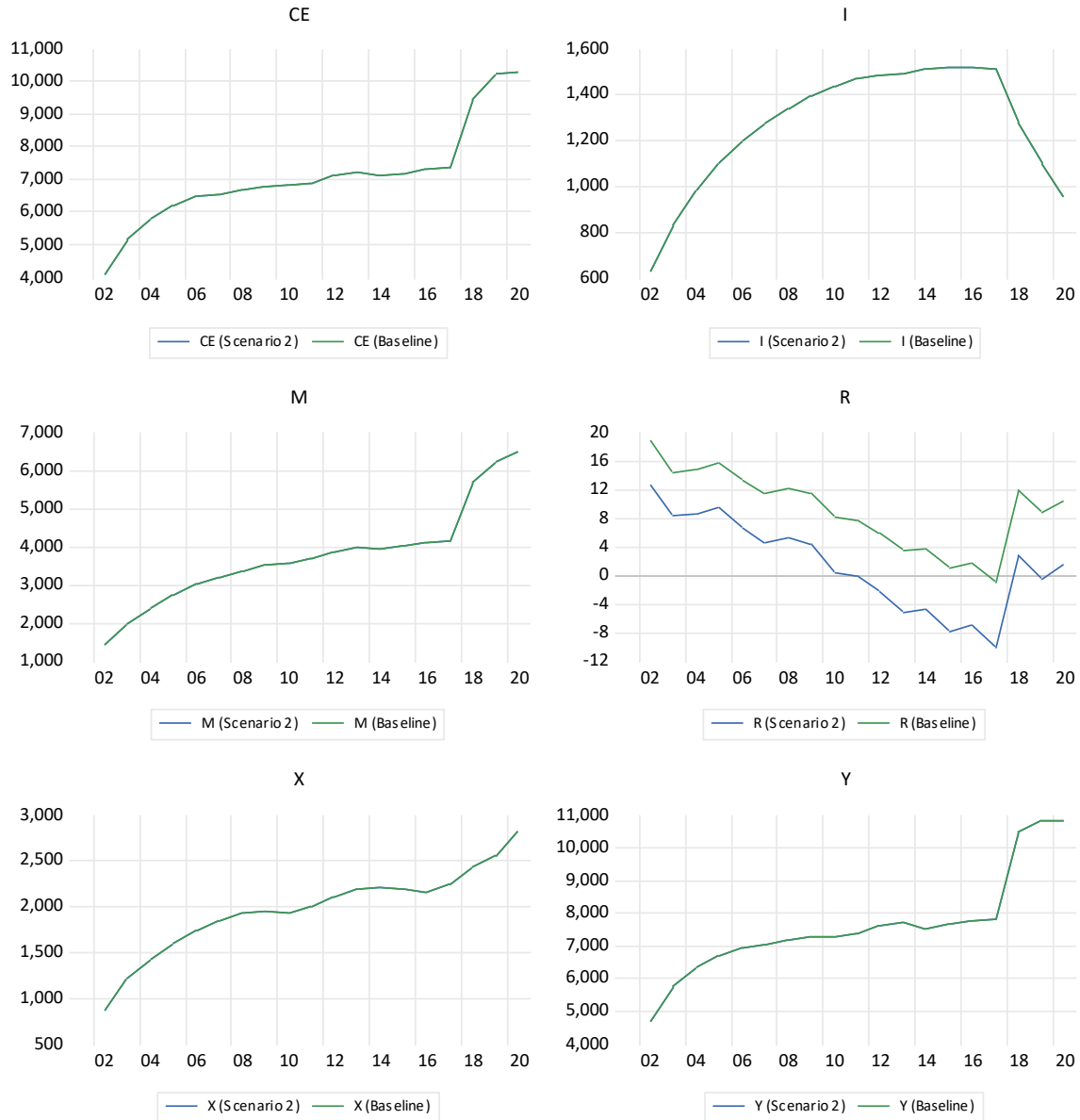
Appendices

Appendix A: Scenario 1 – Expansionary Fiscal Policy (15% increase in Government Spending)



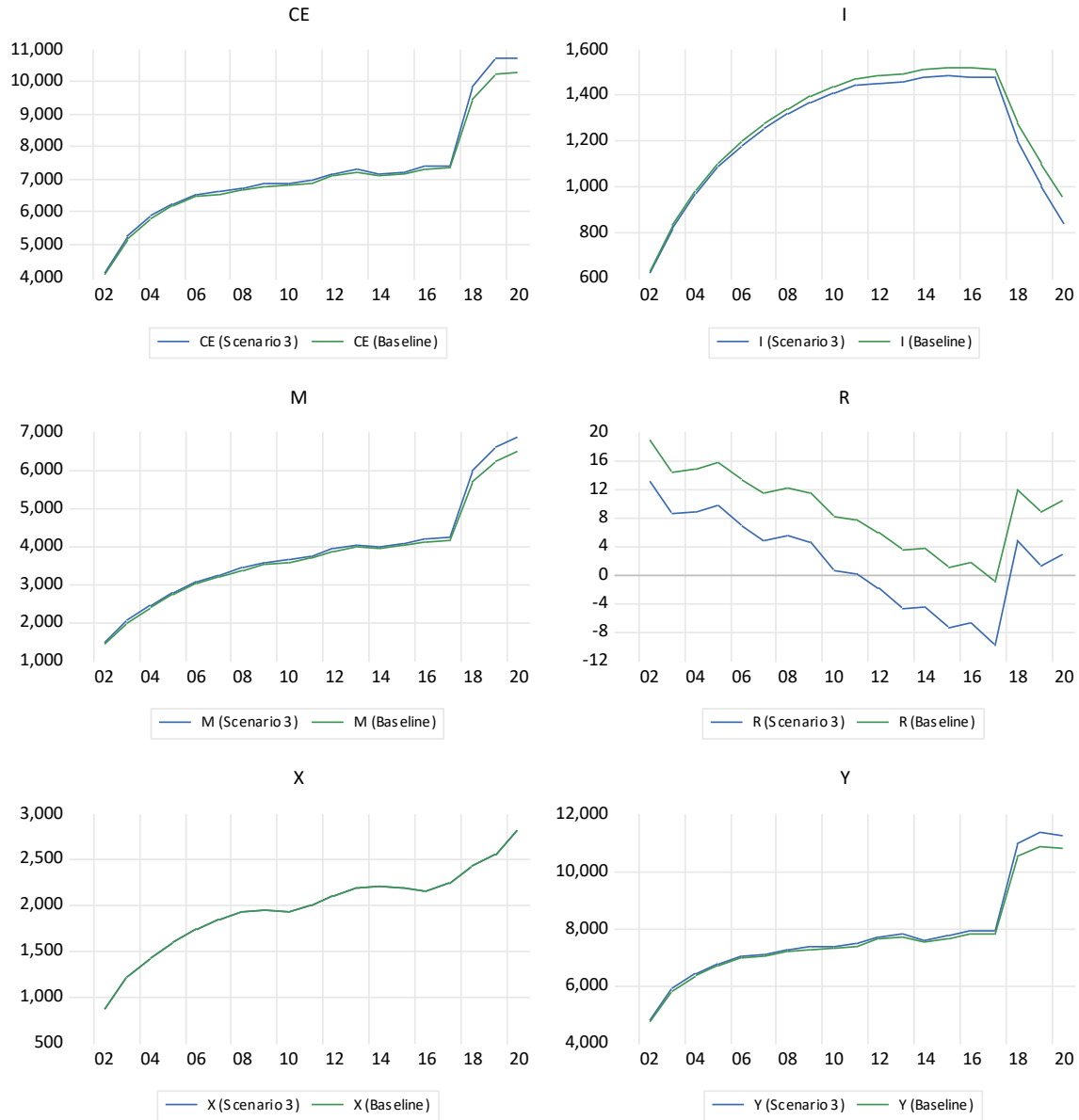
CE= Consumption Expenditure; I=Investment; M=Imports; R=Real Interest Rate; X=Exports; Y=Gross Domestic Product

Appendix B: Scenario 2 – Expansionary Monetary Policy (15% increase in Broad Money Supply)



CE= Consumption Expenditure; I=Investment; M=Imports; R=Real Interest Rate; X=Exports; Y=Gross Domestic Product

Appendix C: Scenario 3 (Mixed Policy) – Expansionary Fiscal and Monetary Policies (15% increase in Government Spending and 15% increase in Broad Money Supply)



CE= Consumption Expenditure; I=Investment; M=Imports; R=Real Interest Rate; X=Exports; Y=Gross Domestic Product