
# Evaluating the economic effects of the Ebola virus disease in Liberia

## Using a Synthetic Control Method

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# Contents

# List of Tables



# List of Figures



# List of Maps

# List of Acronyms

| | |
|---|---|
| ANRDS | Adjusted Non-Restricted Donor Sample |
| CBL | Central Bank of Liberia |
| DID | Difference in Differences |
| ETU | Ebola treatment Unit |
| EVD | Ebola Virus Disease |
| GDP | Gross Domestic Product |
| GOL | Government of Liberia |
| HCW | Health Care Workers |
| IMF | International Monetary Fund |
| LEITI | Liberia Extractive Industries Transparency Initiative |
| MFDP | Ministry of Finance and Development Planning |
| OECD | Organization for Economic Cooperation and Development |
| SARS | Severe Acute Respiratory Syndrome |
| SCM | Synthetic Control Method |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNMIL | United Nations Mission in Liberia |
| WDI | World Development Indicators |
| WEO | World Economic Outlook |
| WHO | World Health Organization |

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## Abstract

Countries in the Global South are often vulnerable to the outbreak of infectious disease, which impedes economic growth and compromises the economy on an aggregate level. The 2014 Ebola epidemic in West Africa had an adverse correlation on the economies of the affected countries, leading to a scale down in Liberia productive sectors. There are many pieces of literature assessing the effect of the Ebola virus epidemic. Still, there is no general consensus of its effect on the macroeconomy, especially in Liberia. As such, most of these literature findings relied on descriptive characterization and predictions of the Ebola. Nevertheless, this research attempts to contribute to these existing studies by evaluating the macroeconomic effects of the Ebola epidemic on the Liberian economy. Hence, this research uses the synthetic control method (SCM) to assess the Ebola epidemic's impact on the selected macroeconomic outcome variables of interests. The SCM allows us to construct the synthetic counterfactuals by assigning a weight from a donor pool of thirty-nine (39) African countries within the treatment period from 2004-2018. These weighted average forms the synthetic control and compared it to Liberia, thus depicting each outcome variable's trends that reproduces similar characteristics to Liberia before the outbreak of the Ebola epidemic. For effect on each outcome variable, this study finds that the Ebola crisis led to an increase in the inflation rate by 18% and statistically significance at 5%. Due to the Ebola epidemic, Liberia's unemployment rate increased by 0.8%, while GDP declined by negative 0.9%, and GDP growth by negative 4% over time. The study finds that the estimated treatment effect of EVD compromised the fight against poverty as it contributed to a declined in per capita income between $40-$140 and statistically insignificant at 10%. As a result, it can be deduce that there is no economic convergence in per capita incomes because both the treated unit and control group are developing countries, and none could converge in per capita values. Hence, this research overall findings suggests that though the Ebola epidemic negatively impacted these macroeconomic variables, the impact was not substantial as it has been believed.


## Relevance to Development Studies

The economies of poor and vulnerable countries are often exacerbated by the outbreak of an epidemic, which leads to hunger and inequalities. As such, an empirical study involving impact and development intervention is one of the most cardinal cornerstones for rebuilding of the economies of fragile countries in the aftermath of an exogenous shock. Hence, this research is the first to evaluate the Ebola epidemic in Liberia with several macroeconomic outcomes. The findings herein inform policymakers in drafting economic reforms gear toward stabilizing the economy in case of any re-occurrences of the Ebola disaster, especially so because these shocks are most often observed in the short-term. Therefore, the significance of the Ebola epidemic on the economy cannot be overemphasized as such has a lot of policy relevance to development that needs to be researched.


### Keywords

Ebola, Epidemic, EVD, Synthetic Control Method, SCM, Counterfactual, Liberia.

# 1 Introduction

## 1.1 Overview and contextual background

The outbreak of natural disasters (health hazards) leads to some adverse consequences on developing countries' economies. The outbreak of the 2014 Ebola epidemic made an additional 170,000 people chronically food insecure in Liberia and rendered about half of the workforce to lose their job since its outbreak (World Bank, 2014a). Informal labourers in highly affected counties mainly felt the spillover effect of the EVD due to limited access to the market and mobility restrictions. This exogenous shock also led to an increase in the prices of essential commodities. It stressed the Liberian economy's vulnerability, which had an initial revised growth rate of 8.7% before the crisis. According to Huber et al. (2018), the estimated monetary effect of the EVD on the economies of the three affected African countries combine resulted in a loss of billions of dollars and specifically could amount to $US32.6 billion as a percentage of GDP in the worst-case scenario if a country with bigger economies in the region experienced an outbreak. For instance, the Liberian economy has performed poorly and has been unable to experience a significant boom in its productive sectors since the crisis ended in May 2015. Currently, it is believed that due to the Ebola epidemic, the inflation rate has gone record high of 26.96% and disrupted the country's demand and supply chain trajectories, as seen in *Table 1*.

**Table 1**
The effect of EVD on Demand and Supply Chain in Liberia

| Demand | Supply | Intervention Mechanism | Magnitudes |
|---|---|---|---|
| The flow of Investment | Loss in confidence | Quarantine | Loss in revenues/ unemployment |
| Cross border Trade/businesses | Disruption of activities | Closure of borders and public places | Business failure, fall in revenues. |
| Education | No service | Closure of schools | Loss in human capital |
| Tourism | Travel restrictions | Travel banned | Loss in revenues. |
| Aviation | Drop-in services | Flights banned | Loss in revenues. |

*Source*: Author's construction.

Relying on the above information, the EVD disadvantaged the economy's demand side by reducing investment, trade, and other productive sectors. As a result of quarantine protocols, there was a decline in government revenues generation and an increase in unemployment. This is further corroborated by Cangul et al. (2017). Their findings suggested that the economy was affected by three percentage points of GDP drop in government revenues. Likewise, the supply side resulted in business failure due to cross border trade disruption and travel restriction.

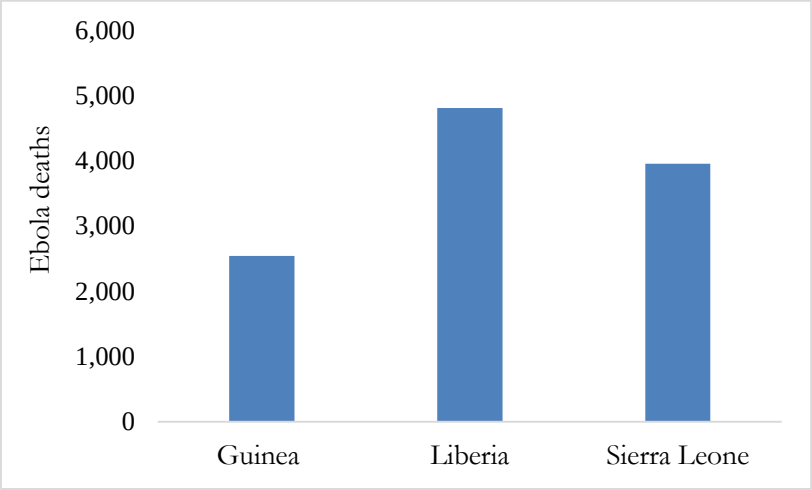
Nevertheless, the World Bank (2014a) study shows that the behavior change, fear of being infected by the EVD had an adverse effect on Liberia's labour force. For instance,

some companies closed their operations or lay-off employees due to their inability to pay basic incentives. This led to reducing the purchasing power of household income and had a negative bearing on household survival. Therefore, due to the magnitude of the Ebola epidemic, economic gains made to revitalize the economy after the prolonged civil disturbances were undermined. It remains the biggest public health threat to Liberia's fragile peace since the end of the war (Omoleke et al. 2016). For instance, the real GDP growth rate was robust, around 8% before the EVD (African Development Bank (AfDB) 2017). However, as the epidemic worsened, normal productive activities in key sectors were halted in complying with public health protocols. Hence, rendering economic growth to sharply declined downward (IMF, 2016a; Chuhan-Pole and Ferreira, 2014).

Additionally, due to the nature of the 2014 EVD, it has been characterized as the deadliest outbreak since the virus was first discovered in 1976. As such, the upsurge in the death toll, which surpasses all previous outbreaks, is due to inadequate surveillance procedures to detect early infections and the overall unpreparedness of these disadvantaged health systems in West Africa. The WHO (2020) concluded that the Ebola epidemic had a high mortality rate of 50%. As depicted in *Figure 1*, Liberia was the most affected country, as 45% of its total confirmed cases resulted in 4,810 people's deaths. Similarly, Guinea and Sierra Leone recorded 2,544 and 3,956 death tolls, respectively.

**Figure 0**

Total Ebola deaths per country




*Source*: Author's compilation.

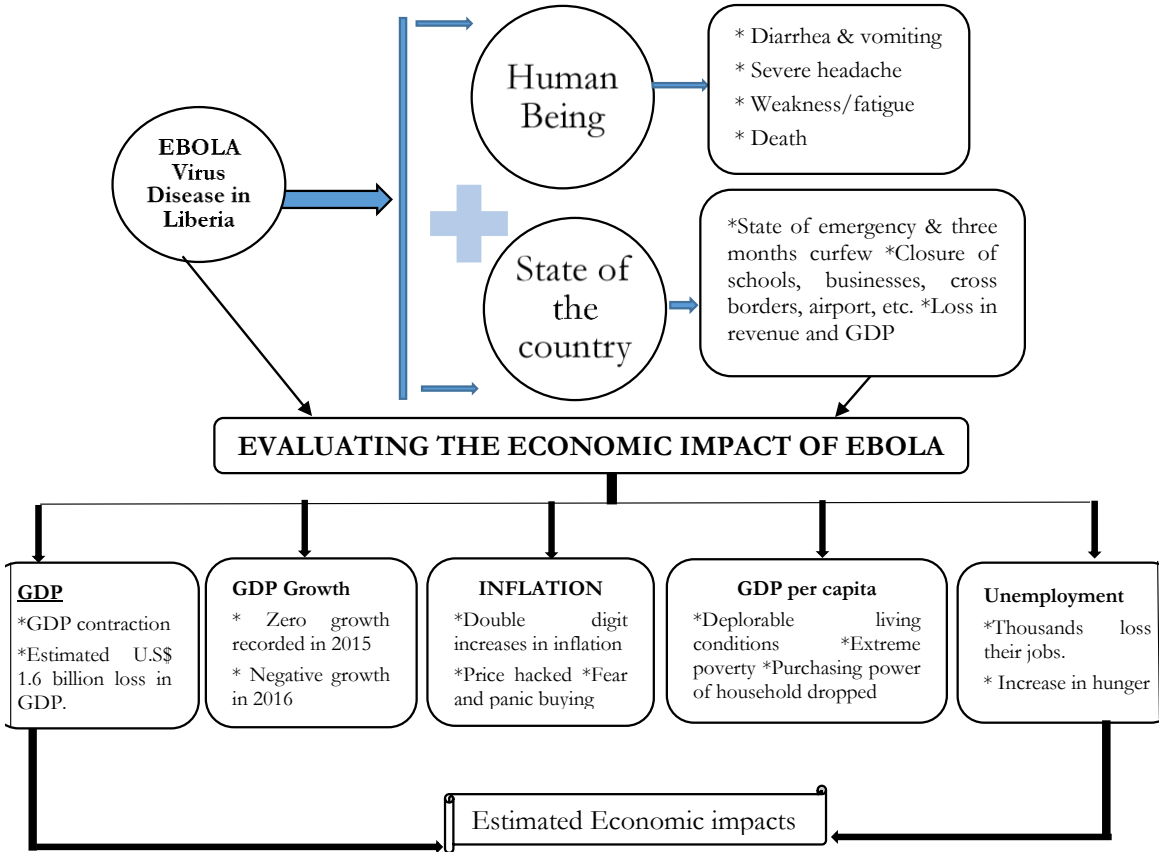
At one point, 1,000 cases per week and over 2,000 cases per month were reported in Liberia in September 2014 (see *Appendix 1* for a detailed overview of the health impact in Liberia). By the end of the crisis, 28,616 confirmed cases were reported in Liberia, Guinea, and Sierra Leone (hereafter refer to as: core countries) with 11,310 fatalities (WHO, 2016). In furtherance, the Ebola epidemic also affected the Liberian society's social paradigm as many children became orphans. Factoring in the "hidden" social value, Huber et al. (2018) argued that the estimated loss of human life has been missing from existing literature. Therefore, in addition to the economic effect, the authors suggested that the cost of the 2014 Ebola epidemic is in the range of $US53 billion. Against these backdrops, this research, like many other studies, is interested in the economic impact on the Liberia economy. Specifically, the research will seek to evaluate how the EVD impacted the Liberian economy's macroeconomic performance. Firstly, we briefly zoom in on the Liberian economy's contextual background, which epitomizes that of a low income and fragile nation. It is imperative to emphasize that the Liberian economy comprises of an import and export-based economic system.

As such, The Liberian economy has performed poorly relative to its abundant natural resources compared to other countries in Africa; these abundance endowments have since become a resources curse instead of a blessing. In the 1960s, Liberia's growth rate in terms of real income was compared only to Japan. That is, Liberia was richer than many developed countries today but said endowments had become a growth failure relative to its low 4.8 million populations. Interestingly, by the end of the prolonged war in 2003, Liberia's GDP declined by 30%, coupled with a fall in its major export commodities. There was progress made in restoring the collapsing economy, but the outbreak of the EVD in 2014 decelerated the economy's macroeconomic performance. Real GDP contracted from 1.2% in 2018 to 1.4% in 2019 due to a slowdown in the agriculture, service, and manufacturing sectors. The inflation rate hit a new record high of 23.5% in 2018 to 26.96% in 2019, specifically attributed to the increase in basic commodities' prices and depreciation of the Liberian dollars against the U.S. dollars. However, there is a projected growth of 7.8% in the mining sector due to a slight increase in the prices of gold and iron ore. Therefore, due to this research's nature, *Appendix 2* expounds on the different stages characterizing the Liberian economy's macroeconomic performance.

Based on these analyses described above, this research plays a significant role in accessing how the EVD disadvantaged the Liberian economy. Moreover, this study will make an informed projection about the long-term implication of the EVD on the fragile economy. Howbeit, before estimating the impact of the crisis, *Figure 2* gives an overview of the conceptual framework, which visually outlines the economic impact of the EVD crisis. Thus, such a framework is based on assessing the selected macroeconomic outcome variable of interest discussed in the literature review (next chapter).

**Figure 2**

Conceptual Framework




*Source*: Author's construction.

The above framework includes an independent variable that comprises the two variables directly affected by EVD – human beings and the country. In contrast, the dependent variables include all outcome variables used in this research to account for the economic impact of the EVD. Therefore, this research relies on the below hypothesis: 'Regarding all outcome variables herein, the Ebola epidemic had a negative correlation on the performance of the macro-economy, but such impact is not of high magnitude'. Building on this hypothesis, this research examines the effect of the Ebola epidemic over a 14 years treatment period ranging from 2004-2018. More specifically, this study uses the synthetic control approach by estimating the causal impact on the economy in the absence of the EVD shock, investigating the correlations between the EVD and selected outcome variables, which potentially hinder the economy's macroeconomic performance.

Since there has not been a consensus in attributing the Liberian economy's breakdown to EVD, this study's findings deduced a less substantial effect of the Ebola epidemic on the economy. It will inform policymakers in amending macroeconomic reforms to revitalize the economy in the aftermath of the Ebola crisis and create a blueprint for any future occurrences arising thereof.

## 1.2 Chronology of the EVD crisis

The Ebola crisis in West Africa started in late 2013 December with the infections of an 18 months old child in Guéckédou in Guinea of what was described as unknown diarrhea and fever. The local health authority in Guéckédou informed the Guinean ministry of health on 10 March 2014 and 12 March, the WHO was informed by the Guinean authority of the mysterious disease. On 18 March, Médecins sans Frontières of Europe who before the outbreak had been working on a malaria project in Guéckédou collected blood samples of infected patients for testing in France and Germany (Baize et al. 2014:1418). After testing at the French Institute Pasteur, it confirmed the disease as the Zaire Ebola virus, the fatal agent of all the diseases (WHO, 2015c). On 23 March 2014, the WHO declared the Zaire Ebola in Guinea; this would later spread via land border to Liberia, the first case was discovered on 30 March 2014. Subsequently, it later spread to all counties in Liberia (see *Map 1*). With the unavailability of the information reaching the surveillance team, the EVD was also discovered in Sierra Leone by 26 May 2014. Thus, the 2014 EVD mainly affected Liberia, Guinea, and Sierra Leone. These countries got compromised primarily due to the poor health infrastructures and limited healthcare in these fragile countries, and a shortage of health care workers (HCW) exaggerated the EVD outbreak (WHO, 2015a; Shoman et al. 2017). Besides, due to existing political instabilities and public sector corruption, many people had distrust in their government concerning the EVD. Also, unsafe burial practice such as cleansing the dead body and heavy dependence on traditional healers give led to fast spread of the EVD in these core countries. As previously mentioned, Liberia was the epicenter of the EVD and most affected in terms of Ebola deaths. For instance, 3,423 people died during the peak of the crisis from EVD majority of which occurred between 7 August – 31 December 2014. The country also experienced 1,364 deaths between January – 9 May 2015, the date WHO declared the country free of the virus. Unfortunately, there was a re-emergence of the virus with additional 9 cases and 4 deaths rendering the total casualties for the year-end 31 December 2015 to be 1,387. By the end of the crisis, the EVD spilled over with confirmed cases reported in Nigeria, Senegal, Mali, UK, USA, Italy, and Spain.

Containment of the EVD during its peak year was a paramount concern for the affected governments. In Liberia, the government established the Incident Management System (IMS) in partnership with WHO, set up two (2) Ebola treatment units (ETU) run by Samaritan Purse in the two most hotspots of the infection (Montserrado and Lofa counties). On

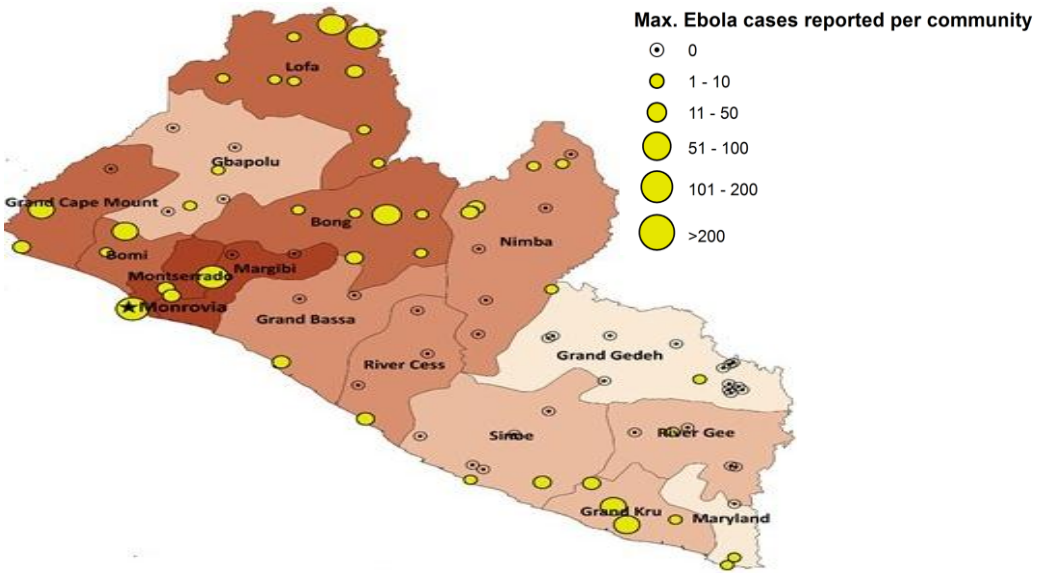
28 July 2014, the government closed all its border crossing points, and on 30 July 2014, all schools were order shutdown. As the crisis worsened, the GOL declared a three-month state of emergency on 6 August 2014 to curtail people's movement. The EVD rapidly spread within all locations, including densely populated urban cities of the three affected countries. This led the WHO to declared Ebola on 8 August 2014 as an epidemic of public health emergency that required a well-coordinated international response (WHO, 2014a).

Furthermore, the GOL imposed curfew and quarantine within those hotspots on 19 August 2014. The availability of a treatment facility was a real-time response in treating those with the virus, against this backdrop; the U.S. military was deployed to build more ETUs in Liberia between August – September 2014. The leadership and sense of urgency exhibited by the government of these poorest, fragile, and disadvantaged health sectors led to the containment of the EVD (Nyenswah et al. 2016). These confinement measures and government interventions though harmed economic activities but were vital in flattering the infections curve and transmission evidence of the reduction in confirmed cases at the beginning of 2015.

Meanwhile, the WHO primary response was to provide the routine epidemiological situation report, laboratory services, contact tracing, infection control, and vaccination, among others, through the affected governments. However, the WHO announced an adopted UN Security Council mandate to setup United Nation Mission for Ebola Emergency Response (UNMEER) in Ghana to support surveillance for EVD to the most affected countries by achieving its 70-70-60 goals. Based on the WHO (2014b), it helps UNMEER isolate and treat 70% of the EVD cases with HCW training to achieve 70% of safe burial practices within 60 days as of 1 October 2014. However, the WHO has been criticized for the lack of an effective operational response mechanism and blamed for the speedy spread of EVD epidemic (Wenham, 2017). For example, even though the WHO had its field epidemiologist's presence in the affected regions, it took them nearly five months after the first EVD case to announce the EVD as a global public health emergency.

**Map 0**

Map of Liberia with confirmed EVD cases

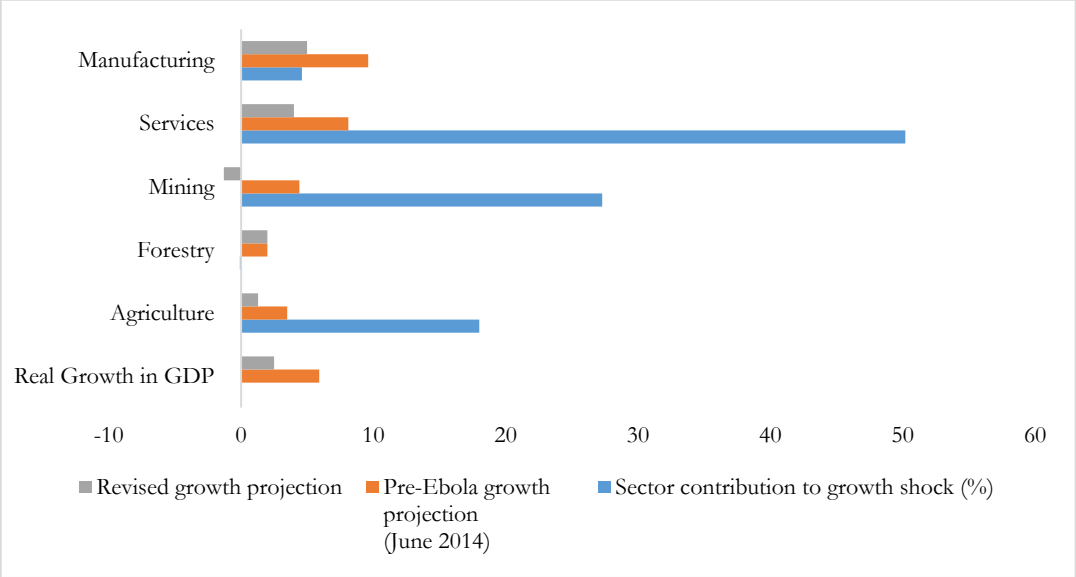



*Source*: Extracted from Gatiso et al. (2018)

## 1.3 Channels through which EVD affected economic activities in Liberia

Liberia is a fragile economy that depends heavily on foreign assistance and remittances from abroad. With an end to the civil war in 2003, a lot of development was initiated to stabilize the economy and return to its pre-war status. In 2008, the GOL introduced the Liberia vision of poverty reduction strategies (PRS), which aimed to promote economic growth and development; and one of the focus was around revitalizing the broken economy. The PRS gives rise to the renaissance of the agricultural sector. During this time, the mineral development agreement (MDA) was amended for the mining sectors to expand, which was vital toward economic growth. Since then, the Liberian economy has had a promising outlook with a double-digit growth rate before the EVD. For instance, as depicted in *Figure 3*, the Services sector accounted for over 50% of GDP in 2014. The mining sector, one of Liberia's highest export sectors, contributed around 30% of GDP.

**Figure 3**
Projected impact of EVD on Liberia's GDP




*Source*: Author's compilation using IMF and World Bank estimates.

As seen from *Figure 3*, the adverse impact of the EVD on these different sectors, the revised growth forecast saw the mining sector running into a negative growth projection. Similarly, the real GDP growth later declines to 0.3%. However, the rapid spread of the EVD disadvantaged the macroeconomic activities across the country.

### 1.3.1 Agriculture sector

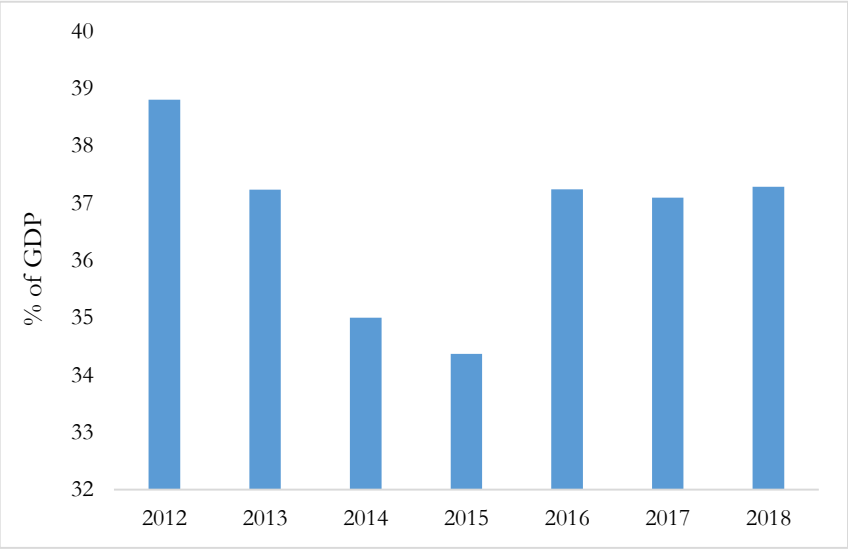
The EVD had some severe repercussions on the agricultural sector in Liberia, which limited productive activities in the fragile economy. The agricultural sector, which includes farming, forestry, rubber, and others, is arguably one of the most important sectors contributing toward GOL poverty reduction strategies, with most of those employed in the sector's labor force. Following De La Fuente et al. (2019), this sector has around 70% of those in the workforce, and interestingly, it contributes to over 38% of the country's GDP. As a result of the EVD, the spillover was not only felt on productivity but also hugely affected people's

daily livelihood. For instance, the harvest in 2014 of substance farming was far less than in 2013 (Himelein and Kastelic, 2015). The authors result from a high-frequency telephone survey show over 65% of farmers alluded to a significant reduction in the harvest. In a way, the EVD negatively correlated with the agriculture sector on a household's ability to produce substance crops. Recently, Gatiso et al. (2018:10), find that about 54% of farmers in Liberia reported a decline in their agricultural produce during the epidemic. The study emphasizes that EVD further worsened the problem being face by chronic food insecure communities in Liberia.

Already, Liberia is extremely poor with over 60% of the citizenry below the international poverty threshold. There are around 630,000 people that are chronic food insecure nationwide (FAO and WFP, 2014). Of that total number, 170,000 people became food chronically insecure due to Ebola. This is attributed to the complete shutdown in agricultural activities and people's inability to commute from one location to another due to nationwide restriction to contain the EVD (Gatiso et al. 2018; De La Fuente et al. 2019). These measures disrupted the regular agricultural season directly and indirectly; thus, limiting agricultural mobility due to loss in labor productivity and market (Qureshi, 2016; Rohwerder, 2020). Hence, the EVD exacerbated human suffering in an impoverished population. Likewise, the rubber industry – a segment of the agricultural sector, one of the main exports sectors was negatively impacted due to these EVD health related protocols. Additionally, according to the World Bank, (2014a), export revenue from the rubber industry decrease by 20%. Notwithstanding, the fiscal bearing on this sector cannot be overemphasized; World Bank (2014b) highlighted that GOL anticipated revenues dropped from $US 499 million to $US 413 million. Therefore, it is suggested that the agricultural sector was significantly and negatively affected compared to other sectors, such as manufacturing.

As depicted in *Figure 4*, the agricultural sector contributed steadily toward GDP before the outbreak of the EVD. The sector contributed around 37.58% of the country's GDP in 2013. However, the sector contributions towards GDP declined by 2.58% in 2014 and 3.58 %. In 2015.

**Figure 4**
Agriculture sector share of GDP in Liberia




*Source*: Author's compilation using IMF and World Bank data.

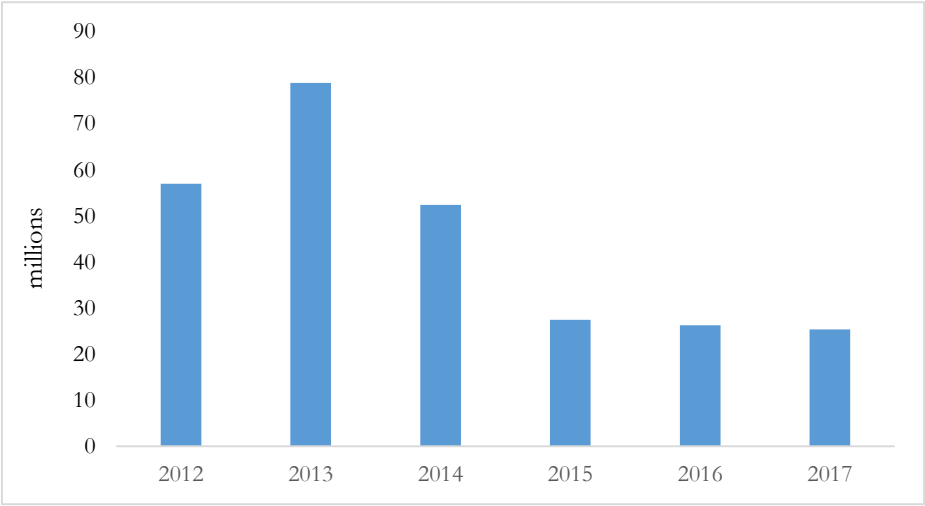
### 1.3.2 Mining sector

The mining sector remains one of the vibrant sectors and the cornerstone of the Liberian economy. It is enriched with many natural resources such as iron ore, diamond, and gold. About four decades ago, the post-war country was one of the largest iron ore destination worldwide. Since the end of the country, fourteen years of civil war in 2003, the country has attracted $7.6 billion dollars in investment, especially in the iron ore industry (LEITI, 2016a:15). In 2006, the newly elected GOL attracted the first single largest private sector investment by signing an initial MDA for twenty-five (25) years with ArcelorMittal and later with five other iron ore companies. Since then, the mining sector has contributed immensely toward boosting economic growth and remained the most massive inflow of FDI among Liberia's productive sectors (MFDP, 2015: viii).

Before EVD in 2013, the mining sector contributed enormously towards the country's macro-economy, with about 17% of GDP. Based on the World Bank (2014a), it accounted for 56% worth of the country's total export. For instance, ArcelorMittal Liberia mining production level is currently on an export target of 5 million metric tonnes per year and had drawn a roadmap for the execution of phase three of scaling up its production to 15 million metric tonnes a year. However, the EVD outbreak halted the projects implementation, which was poise to provide thousands of jobs and lift many out of poverty. China Union mining with current production of 2.5 million tonnes was also projected to expand to 9.5 million metric tonnes of iron ore. However, due to the EVD, its shutdown operations and repatriated its international staff in fear of the deadly EVD.

Similarly, there was an exponential reduction of 37% in Gold mining activities a year after eradicating EVD. Simultaneously, in 2014, there was a 6% decline in the mining sector, which relies on iron ore production (LEITI, 2016b). Due to the EVD shock, government revenue previously generated from the mining sector decline by 13.8% from $34.6 million to $29.9 million in 2014 (MFDP, 2015: 23). These declines are attributed to EVD and a fall in the country's mineral exports (Kala and Mensah, 2018). Thus, this study describes it as the twin shocks: the forceful shutdown of mining activities across the country, and the weak demand for the iron ore commodity coupled with a fall in its price on the global market.

**Figure 5**
Mining sector share of GOL revenues




*Source*: Author's compilation using LEITI estimate

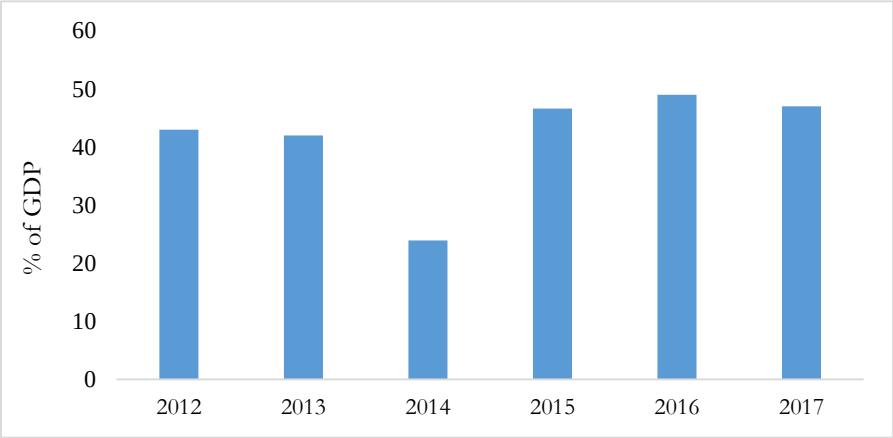
Generally, in 2015 fiscal year, the mining sector contributed 42.3% of government revenues, and represented 11.4% of the country's GDP, meaning a drop-in from 17% as observed before Ebola. As seen in *Figure 5*, the sector contributed around $80 million to GOL revenue in 2013. Such contribution declined during the Ebola disaster and had since continues after Ebola with reductions in revenue.

### 1.3.3 Service sector

Like in many developing countries, the service sector remained the single largest source of revenue generation and the bedrock of the Liberian economy. It comprises of transports, hotels, restaurants wholesale and retail traders, etc. The sector contributes $419.2 million, corresponding to over 46% of Liberia's GDP (MFDP, 2015), and accounts for over 40% of the total workforce. The sector suffers the most challenging consequences of the EVD due to different mobility restrictions and businesses' forceful closure. Therefore, the service sector's monetary value declined by 13.8% in 2014 due to the Ebola crisis (Central Bank of Liberia (CBL), 2014:38).

Similarly, expatriates' departure from the different business establishments and the draw-down of the UNMIL peacekeeper in fear of contagions was also a key factor behind the decline in the service sector. In a way, US$7.5 billion flow into the country on the UNMIL budget (mostly salaries and expenditures) for the duration of their operations and US$16 billion on projects. As a result, the presence of UNMIL's highest GDP contributions was around 11.5%. However, due to the mission's draw-down, it shrunk to 2.5% in 2015 after the Ebola crisis. Therefore, UNMIL employees who spend significantly in the service sector, coupled with businesses, were the primary beneficiary of the different services rendered in the country. For instance, there was between 60-75% reduction in income collection from the wholesale and retail markets during the outbreak of the EVD. Likewise, regular hotel and guest house booking plunged from 80% in the absence of the EVD to little under 10% occupancy during the peak of the crisis (World Bank, 2014a:13). Hence, the country's hospitality industry was severely affected due to the cancelation and banned on international flights to Liberia.

**Figure 6**
Service sector share of GDP




*Source*: Author's compilation using MFDP estimate

As depicted in *Figure 6*, the service sector's average GDP contributions have ranged between 40-50%. Still, such impact was negatively affected when it falls from 42% in 2013 to a little under 23% in 2014 during the EVD crisis. For instance, even with the lowest contribution of the service sector observed during the EVD crisis, yet; the share of GDP is larger than the industry and manufacturing sectors combined, contributing 13% of GDP (MFDP, 2014).

## 1.4 Research Objectives

This research's main objective is to estimate the economic effect of the Ebola virus disease and find the correlations between the poor performance and breakdown of the Liberian economy concerning different outcome variables of interest such as GDP, GDP growth, GDP per capita, inflation rate, and the unemployment rate. Mainly, it investigates how the EVD disadvantaged the macroeconomic performance of the economy and its long-term implications. However, this research utilizes a comparative case study tool coined as the synthetic control approach for each outcome. Therefore, if the likelihood of the collapse of the Liberian economy could be attributed to the outbreak of the Ebola in 2014, then, this research shall formulate relevant policy prescriptions that would enable policymakers to stabilize the economy in the aftermath of any exogenous shock in the future.

## 1.5 Perspective and original contribution to the literature

My main contribution in evaluating the effect of the Ebola epidemic in the Liberia economy informs the literature through the synthetic control approach, it was originally used by (Abadie and Gardeazabal, 2003; Abadie et al. 2010) to assess the impact of an intervention at the sub-national, regional, or aggregate level. By using the keyword, 'Ebola' across different peer reviews and academic journals produce thousands of literatures. Still, none of these existing studies has entirely given a complete empirical and economic impact of the crisis. Few empirical approaches, such as the Difference in Difference and computable general equilibrium model, have been utilized to determine the effect of the Ebola epidemic on a subsection of the economy. Similarly, more recently, Christensen et al. (2020) used a randomized experiment to determine the impact of the EVD on healthcare. In a way, household data could have easily accounted for the overall economic impact of the EVD. Still, unfortunately, such household datasets are not available during the time of these analyses. In the absence of these individual datasets, to justify the overall impact of the EVD on the Liberian economy, the SCM allows us to estimate what would have happened in the absence of the Ebola shock at the aggregate level. That is, by comparing similar outcome variables of interest for Liberia and the control group.

Unlike many other approaches, for example, the general equilibrium approach might miss out on some crucial indicators vital for aggregate intervention estimations and does not account for statistical significance. Among all these different empirical approaches in modern comparative studies, Bouttell et al. (2018) describe the SCM as the most essential tool and 'valuable' addition to policy intervention discourse. With that being said, the SCM's strength is that it deals with all these disadvantages and misstep encountered in the equilibrium and mobility models. With the availability of very long baseline data for inflation, unemployment, GDP, GDP growth, and GDP per capita; the SCM is cardinal because these selected macroeconomic indicators will be used to generalize the economy's performance before and after the EVD epidemic. To date, there is no single synthetic control approach study done in the context of this research topic and even beyond other social sciences related topic after the EVD in the Liberian context. This also speaks to the geopolitical and geographical relevance

of the SCM; it tends to give a definite impact of the EVD on the Liberia economy, and such will be used as a means of institutionalizing structural reforms for any future exogenous shock.

## 1.6 Research paper outline

With a detailed, in-depth analysis of this research context in the previous chapter, this research's remainder is as follows. Subsequently, this paper elaborates on a thorough review of the Literature in Chapter 2. Next, chapter 3 will discuss the empirical methodology. Chapter 4 describes the data and treatment period of the study. Chapter 5 discusses an overview of the SCM results, zoom in on each outcome variable, and robustness check. Chapter 6 makes conclusions, policy recommendations and suggestion for future research.

# 2 Literature Review[1]

Many existing studies evaluate the effect impact of EVD, but there is no literature that give a methodical assessment of its effect on the macro-economy. For instance, Elmahdawy et al. (2014:68) argued that the EVD worsened the core countries' economies due to limited resources and the high hospitalization cost of treating EVD patients. Nevertheless, evaluating economic impact of any infectious disease is often a debate in the contemporary social science disciplines. Accordingly, Tyrrell and Johnston (2006) defined economic effect as a process that seeks to evaluate the difference in output, inflation or poverty level.

## 2.1 The Economic impact of epidemic

There are numerous studies evaluating the economic effect of an epidemic - such as influenza, SARS (Meltzer et al. 1999; Burns et al. 2006; Brahmbhatt and Dutta, 2008; Keogh-Brown and Smith, 2008; Smith et al. 2009; Pendell et al. 2016) and more recently the novel Coronavirus (Atkeson, 2020; Nicola et al., 2020; Fernandes, 2020). Like in the aftermath of many shocks, the economic impact can be enormous or lesser depending on the affected region(s), which could undermine the macro economy's performance. The effect of the 2003 East Asian SARS or influenza in the U.K. has all been well documented in terms of the overall impact on the economy. Even though the SARS spread to 32 countries, it mainly affected four countries: China, Singapore, Taiwan, and Hong Kong. In a way, the impact of these shocks is often felt in the short term. According to Brahmbhatt and Dutta (2008), people's decision to leave from the affected regions created large demand shocks, which negatively led to a rapid tourism flow reduction. As a result, the service sector, which comprises trade, retail, etc. experience a loss in revenue generation during the crisis, accounting for almost 50% of GDP in China.

After a systematic review of the virus, Hanna and Huang (2004) hypothesize that SARS led to a 1.5% decline in China's GDP. But with the rapid eradication of the disease in the short term, they suggested the actual cost to be 0.5% of GDP with a 0.9 percentage points. SARS, like many disasters, tend to have an adverse economic impact; Keogh-Brown and Smith (2008) used the national statistics to analyze the impact of the epidemic. As such, they argued that the effect of SARS in the most affected countries was smaller than expected. For example, though it experienced a little loss of $3.7 billion, the authors suggested that Taiwan's GDP immediately returned to its pre-SARS status with a further increase in growth the following year after the virus's containment.

On the other hand, Smith et al. (2009) evaluated the effect of the influenza epidemic on the U.K. economy factoring in the cost of mortalities by using the CGE approach. The study showed that a reduction in the labor supply observed as the cost of the epidemic. As such, with a low mortalities rate, the British economy could experience a decline in the tone of 0.5% and 1.0% of GDP (between £8.4 billion – £16.8 billion), and high mortalities resulting from influenza could cost between 3.3% and 4.3% (£55.5 billion – £72.3 billion). Capturing the monetized values of human life in disease outbreak as we see for the case of the EVD can have a negative effect on any affected countries; a decline in the labor force with increase human suffering on households is just a few points to consider.

[1] This study will further zoom in to discuss the literature that will lie in the broader context of epidemic and its impact on selected macroeconomic indicators.

Simultaneously, the current coronavirus, which was discovered in China, has spread to 188 countries with about 13 million infections and with 568,250 plus deaths (at the time of writing this research). The economic impact of the coronavirus is in greater proportion in comparison to the 2008/2009 financial crisis. Due to quarantine procedures imposed in every affected country, the virus has led to the disruption of the global supply chains with cause between $3.1 trillion – $6 trillion to the global economy. For example, during its relatively short three-week lockdown period, the Ghanaian economy lost $1.3 billion in GDP. However, Amewu et al. (2020:10) utilities the Social Accounting Matrix (SAM) to determine the impact of the coronavirus; in a way, the SAM approach tends to be one of the techniques to evaluate short-term shock. The SAM model accounts for the macro-economy's performance by assessing the correlation between the output of the different sectors. Therefore, their findings led to a decline of 28% in national GDP and projected that every one-week shutdown in the aftermath of the initial lockdown causes the economy to loss about $450 million in GDP. Similarly, after a systemic review of stock market volatility, Baker et al. (2020) deduced that as of quarter four of the fiscal year, the U.S. real GDP contracted by 11% due to the coronavirus with a 90% confidence interval. As a result, the authors argued that the coronavirus created a negative impact on output.

## 2.2 The impact of epidemic on GDP

The impact of epidemics on the macro-economy is of higher proportion in most affected regions and could lead to some high socioeconomic implications for impending economic progress (Keogh-Brown et al. 2010; Verikios et al. 2012). Due to the abrupt nature of infectious diseases like EVD, it seems unlikely to evaluate the economic impact using household datasets. The outbreak of epidemics has been repeatedly evaluated at the aggregate level due to the availability of only macro-level dataset. As a result, GDP is always impacted by the outbreak of a shock. For example, influenza as a contagious disease had a high magnitude on the global economy, and a small outbreak will lead to some repercussions for economic activities. McKibbin and Sidorenko (2006:30) make used of the Asia Pacific G-Cubed model to determine influenza's impact. The model characterized the influenza epidemic as mild, medium, severe, and ultra. A mild outbreak of any proportion will lead to 1.4 million mortalities globally and 0.8% of GDP loss. Similarly, an outbreak with ultra-characteristics will cause 142 million lives and a $4.5 trillion loss in GDP. Keogh-Brown et al. (2010) used the clinical attack rate (CAR) and the case fatality ratio (CFR) to determine the epidemic effect on GDP. These two models track the total number of sick people and those who died from the crisis before evaluating the epidemic's impact. They estimated the GDP losses for four European countries from the influenza between 0.5-2.1%. Likewise, Smith and Keogh-Brown (2013) estimated that the impact of the influenza on average comprised of 1.1% of GDP for the economies of Thailand, Uganda, and South Africa. Even among these three developing countries, Uganda – a low-income country as the most vulnerable of the three was more affected than others.

However, as it seems early to account for the aggregate outcome of the coronavirus on GDP, a more recent study evaluated the initial impact of coronavirus on GDP in March 2020 when the virus had spread to over 188 plus countries and territories. Therefore, by using the CGE model, the overall GDP rate for the global economy declined by 3.9%, the poor regions of the world affected by the virus suffered over 6.5 percent decline and while developed countries experienced a 1.8% decline in GDP (Maliszewska et al. 2020:17). Nevertheless, the study backs the initial suggestion that developing countries have been severely affected due to the restrictive measures that led to a loss in billions of revenues. Also, these mobility restrictions are particularly observed in the form of nationwide shutdowns and

forceful closure of the business (Guerrieri et al. 2020). The authors argued that the macroeconomic impact of the coronavirus created a shortage in countries with an imperfect market, which compromised the level of GDP.

Similarly, the outbreak of EVD in 2014 hindered the economies of the core countries. It destabilized the entire West African regions, which was estimated to have a steady growth rate of 7.3% as a portion GDP. The growth rate in the ECOWAS region during the epidemic was the fastest in Africa, these growth rates were primarily driven by progress in the agricultural sector; which comprises 60% of the workforce and a third of the region GDP (African Development Bank (AfDB), 2014). However, due to the rapid spread of the EVD, there was a slowdown across all sectors in the most affected countries. For instance, in Liberia, the agriculture sector accounts for a large segment of the workforce, and in a way, a decline in this sector led to a contraction of 5% in GDP (Adegun, 2014:56; Omoleke et al. 2016). The author argues that failure to eradicate the EVD quickly could have disastrous macroeconomic implications in the long term for the entire West African regions. Supportably, the rapid contractions in Liberia's GDP did not account for all sectoral impact but only observed in three sectors: agriculture, mining, and the service sector. As such, Bambery et al. (2018:3) used the illustrative outbreak scenarios (systemic review) and deduced that these three observed sectors jointly accounted for about a 95% decline in Liberia's GDP, and each saw over 55% decline in economic growth. The authors overall estimates relying on the World Bank (2014a) initial predictions show that the region loss of GDP due to EVD is estimated to be $26.6 billion across the most affected countries provided if the EVD is not contained rapidly and the impact of EVD as a percentage loss in GDP is 3.3% for 2014-2015 fiscal year.

These core countries are somehow similar as they share common trade. As such, most of their revenues are disbursed on salaries and other government expenditures. As a result of the slowdown in productive activities due to restrictive measures and closure of marketplaces, Cangul et al. (2017) suggested that revenues generation declined in these core countries by 3.1% of GDP. For instance, like other affected countries, Liberia was unable and unprepared to handle the outbreak of EVD experienced the most significant decline in revenue generation and increase in government spending. Interestingly, while the other countries saw an increase of 5.0 percentage points (pp) of GDP in government expenditures, especially on the broken health sector, Liberia was on 9.1 pp increase as a portion of GDP for the time under review.

## 2.3 The impact of epidemic on the inflation rate

The outbreak of any infectious disease tends to destabilize the macro-economy of the affected region and have a serious bearing on the prices of food on the local market due to the idiosyncratic shock on the supply chain (OECD, 2020). There is a high demand for more products, mostly groceries, during the outbreak of an epidemic. Still, the supply side's inability to provide the necessary goods and services has often led to a shortage and panic buying on the market. Therefore, there is an increase in local consumable commodities prices due to the rise in the inflation rate. The outbreak of many infectious diseases such as influenza, SARS, or the coronavirus has similarly led to an increase in the inflation rate in affected countries and even beyond (Barro et al. 2020; Binder et al. 2020). As the influenza disease toll on human life, a 2.1% increase in the disease related death led to a 21 percentage points increase in the inflation rate. Following the assessment on the cost of an emerging epidemic in the UK, Stewart et al. (2004) estimate showed that the cost of the trial fibrillation epidemic was £459 million in 2000. As a result, there was about a 56% increase in the level of inflation.

To contain the EVD in West Africa, governments declared a state of emergency and imposed a curfew. These curtailing movements hamper crop productions, limited market access, and overall disrupted the region's cross-border trade. Building on Sim et al. (2020), the outbreak of an infectious disease such as the EVD can lead to fear and panic buying. Such panic buying in West Africa led to a shortage of basic commodities, which certainly increases consumable commodities' market prices. Based on the World Bank (2014a), these artificial shortages on the market created pressure on the inflation rate which led to a surge in the price of rice in the core countries. However, since Liberia has an import-based economy, the UNDP (2014) estimate deduced that hacked in the cost of Liberia's stable food (rice –which is somehow entirely imported) increases on average by 45% in most counties. For instance, 25kg rice prior to EVD was sold for $12.50 in Liberia, but the price increase by 100% during the peak of the EVD. These increases led to price shock for many households as thousands of vulnerable people became negatively affected (World Bank, 2014c). Hence, there was a double-digit increase in the inflation rate by 15% during the year of the outbreak because of shortages of basic consumable commodities (UNDP, 2014:22; IMF, 2016a). Like in many infectious disease outbreaks, the most vulnerable and needy segment of the citizenry with no access to basic health care and social amenities are the ones that experienced the grievous consequences of the shock (UN, 2015b; IMF, 2016a). This is because the core countries rely heavily on the agricultural and service sectors in term of the labour force. As such, the shutdown in this sector couple with increases in commodities price significantly impacts the population's destitute portion.

Moreover, the EVD seems to have a long-term macroeconomic implication on the core countries' economies. A recent estimate has shown that since eradicating the EVD, Liberia has not returned to its pre inflationary status yet. For example, the country has experienced a record double-digit increase in the inflation rate at 24% (World Bank, 2018). In addition to the EVD, presumed political uncertainties resulting from the 2017 presidential elections and the draw-down of UNMIL further exacerbated these fiscal uncertainties on the economy.

## 2.4 The impact of epidemic on poverty level

The outbreak of infectious disease such as SARS, Influenza, HIV/AIDS, and coronavirus, has a severe deleterious effect on the poverty level, especially in least developed countries with inadequate and poor health system (Bloom et al. 2005; Clay et al. 2018; Anser et al. 2020). As a result; these epidemics could have rendered millions of vulnerable people to fall below the poverty line. The poverty level in affected regions is the sole indicator that allows societies to succumb to existing and emerging epidemics (Alsan et al. 2011). Following Krieger and Higgins (2002) argued that households often diagnosed with infectious diseases are more likely to experience persistent poverty in the near future. The ongoing coronavirus has increased human suffering and undermines the global effort to end poverty in all form worldwide. Sumner et al. (2020) estimated the effect of the disease on monetary poverty level worldwide under three scenarios: minimum, moderate, and maximum. Therefore, the study deduces that people living in the poorest quantile due to coronavirus will more likely increase by 450-580 million people to add to the already 1.3 billion who live in extreme poverty globally. They argued that the current coronavirus has significantly increased global poverty for the first time in 30 years under the maximum scenario with consumption contraction of 20%.

However, the core countries prior to the outbreak of the EVD were classified as a 'least developed', post-war and fragile economies with an extreme level of poverty. Poverty has remained a vital impediment toward achieving their developmental agendas, and as such, it has affected every fabric of society. These core countries have the very least human development, with Guinea, Liberia, and Sierra Leone rank at 174, 176, and 181 with a human

development index value of 0.466, 0.465, and 0.438, respectively. Therefore, the total number of people living below the national poverty threshold and purchasing power parity (PPP) at $1.90 per day for the period between 2007-2017 is estimated at 50.9% and 40.9% in Liberia, in Guinea, it is put at 55.2% and 35.3%, and Sierra Leone is estimated at 52.9% and 52.2% (UNDP, 2019:18). Based on these figures, it seems impossible to achieve the Sustainable Development Goal one, 'ending poverty in all forms' in these core countries by 2030.

Also, with most of the citizenry in densely urban setting, Liberia has a very low per capita income of $ US728.019 and, due to the outbreak of the EVD, saw a 10% increase in the national poverty rate from 50.9% to an estimate of 60.9%. Similarly, Sierra Leone shows little sign of economic progress during the years before EVD in 2013, evidence by its $680 income per capita. Before the outbreak of the EVD, 53% of the population lived in extreme poverty. However, EVD worsened the situation, which saw the poverty rate at 66% (World Bank, 2014a). On the other hand, Guinea, where the first case of the EVD was discovered, has an income per capita of $460 was less affected than Liberia and Sierra Leone. Before EVD, 55.2% of the population were living in extreme poverty, but at the end of the crisis, the poverty rate increase to 61.9%. The rapid spread of the virus further deteriorated the poverty trend in these countries into densely populated capital cities and slum communities.

Most recent studies, which rely on a survey of published and peer-reviewed articles, has shown that the level of poverty in these core countries overall necessitated the spread of Ebola epidemic (Maphanga and Henama, 2019; Kapiriri and Ross, 2020:40). The authors argued the EVD significantly and negatively affected those at the layer of the poorest quantile with no access to affordable health care and proper hygiene. For instance, some studies have shown that slum communities with a high poverty rate experienced high infections, mortalities, and deleterious effects of EVD (Fallah et al., 2015; Buseh et al., 2015; Kamorudeen and Adedokun, 2020). These slum communities are most vulnerable because they cannot hoard food and other basic essential items for their upkeep in the event of a full lockdown. Therefore, the authors deduced that efforts to eradicate the EVD and any future occurrences would require relief aid and funding toward reducing poverty in these most vulnerable communities. In a way, evidence from some studies has shown that the rapid spread of the EVD exacerbated poverty rate in the three most affected countries (World Bank, 2014a; Troncoso, 2015). Considering that most of the population in the core countries are below and very close to the poverty line, getting impoverished was quickly on the radar due to the EVD. This is because of government shutdown measures imposed to contain the virus, which led to losses in jobs, household livelihoods, and food shortages on the market. Before the outbreak of the EVD, most of the citizenry in the core countries are chronically food insecure. The issue of food insecurity posed a serious challenge to the core countries and remained a threat to alleviating poverty in the regions.

Following FAO and WFP (2014), the reduced coping strategy index (rCSI) approach is used to determine the impact on food insecurity in the core countries by using the food consumption score. This mainly captures food insecurity in counties that experience a high rate of Ebola infections. Therefore, Liberia already had 460,000 people that were chronically food insecure before the outbreak of the EVD. Similarly, Guinea has 740,000, and Sierra Leone had a total of 330,000 people chronically food insecure. However, in Liberia, it can be deduced that additional 170,000 vulnerable people became food chronically insecure because of EVD. On the other hand, 230,000 and 120,000 people were chronically food insecure due to Ebola in Guinea and Sierra Leone, respectively (FAO and WFP, 2015:5).

Interestingly, as the poverty rate prevalence remained very high in these affected countries, it is more likely to see a surge in the chronically food insecure populations. Based on FAO (2014), the number of chronically food-insecure people due to Ebola was estimated to be 300,000 in Liberia by 2015. In contrast, it was likely to increase by over in Guinea by

470,00, and in Sierra Leone, it was projected to increase to 280,000. The bulk of these people who became food chronically insecure due to Ebola comprises those at the very last layer of the poorest quantile in the core countries, specifically those from the informal and agricultural sectors.

## 2.5 The Economic impact of the Ebola Epidemic

Lekone and Finkenstädt (2006) suggested that empirical method seems to be the most appropriate approach in understanding the dynamics of the overall impact of the epidemic. The estimation of the EVD impact by many studies relies on the combination of cost when determining the infectious disease's economic impact. The process of evaluating the economic effect of Ebola is the combination of two costs: some studies estimate the immediate economic cost, and some estimates have often been characterized as a short/long term or direct/indirect phenomenon. Thus, this study evaluates the Computable General Equilibrium approach (CGE) and the Global Epidemic and Mobility model used in recent studies. As such, existing studies have evaluated the Ebola economic effect to have a short or long term consequences on these core countries (World Bank, 2014a; Gomes et al. 2014; Punam and Ferreira, 2014; Huber et al., 2015; Qureshi, 2016). Most of these studies based their analysis of the economic impact under two assumptions: (i) Low Ebola, a term which coincides with WHO earlier called for a maximum and swift international response in containing the Ebola epidemic (ii) High Ebola as a minimum effort to flattened the EVD curve.

Therefore, the CGE model have been frequently used to estimate the impact of the EVD. The CGE (a non-forecasting model) typically uses some baseline year data for the macro-economy to find the correlations between EVD and some macroeconomic indicators (Evans et al. 2014; World Bank, 2014a) As such, the Bank suggested the short-term economic impact of the EVD presence in Liberia during the peak of the crisis caused growth to decrease from 5.9% to 2.5% in October 2014, with a 3.4 percentage points under low Ebola. Guinea and Sierra Leone experience similar fate with a reduction in growth from 4.5% to 2.4% and 11.3% to 8.0%, respectively. The EVD shock similarly led to an increase in the country's fiscal imbalances by the beginning of the first quarter of the 2014/2015 budget year; in a way, Liberia had forfeited $113 million, amounting to 5.2% of GDP. Their findings described the medium-term impact as the spills over to 2015 and deduced that it causes the post-war economy 12 percentage points of GDP in the situation of high Ebola. As a result, both the short-term and medium assessments for Liberia showed the EVD had an adverse impact on economic.

In the Bank updated estimate, the EVD continuously weakened the Liberian economy half-way into the second quarter with a negative impact on growth. Following the World Bank (2014b) revised the short term's GDP growth rate as it sharply shifted downward from 5.9 to 2.2%. Their study also used the CGE model to capture the spills over effects of the EVD into bigger economies for the West African regions. Hence, with Low Ebola they projected a loss of $1.6 billion in GDP and $25.2 billion under High Ebola scenarios. Therefore, the fiscal effect for the core countries for the duration of the Ebola epidemic was set at over $3.9 billion and $32.2 billion under the two assumptions, respectively (World Bank 2014b:2). In addition to the death toll, it is also deduced that a greater proportion of the economic impact of the EVD came because of the loss in the household's employability status. Bowles et al. (2016) relied on a dataset of registered businesses and applied the DiD approach to compare the decrease in certain regions' economic activities and the EVD epidemic. The DiD approach allows the authors to control for time and location invariant. In a way, it enables them to determine which business sector was highly affected in terms of jobs compared to the others. As such, the author deduced that the EVD led to a decline in economic

activities by 25%, and it is statistically significant at 24% in firms related jobs, 70% significant decrease in restaurant employability due to quarantine measures (Bowles et al., 2016:275).

Similarly, the slowdown in economic growth led to the disruption of normal productive activities in the sub-regions through forgone output, cross-border trade, supply chain, and fiscal imbalances (Punam and Ferreira, 2014:4; Bouttell et al. 2018). Interestingly, they are also factors in the economic effect of the EVD as proportional loss in these disadvantaged health sector resources across the regions. It impacted people either directly/indirectly by cut-in the affected countries' labour force; however, this gives rise to an increase in poverty and hunger in households. Likewise, Ichev and Marinč (2018) suggested that poverty increase in the regions due to the lack of fourth-coming investment in the private sectors. Investor's confidence drops due to perceived risks associated with core countries due to Ebola. As a result, regions with high EVD infections experienced more poverty rates than others with low infections. These negative externalities from the EVD spills-over to the following years after the end of the crisis. For instance, Liberia experienced consecutive negative GDP growth in recent years, which has also been attributed to foreign companies and their expatriate employees' exit.

On the other end, few empirical studies argued that the economic effect of Ebola was only significant during the year of the epidemic, and it did not have a spills-over effect immediately after the containment of the virus. IMF (2014) expound on the CGE model to account for the larger extent to which the EVD impacted normal economic activities; their estimates showed that the growth rate and the labour force declined in the core countries from 2.3% to 2.1%. Such declined was only observed in the short term due to the prevalence of EVD mortalities in households; the authors argued that the growth rate return to its pre-Ebola status and was stable in 2015. Similarly, the IMF (2016b:4) used a DiD approach to compare the variation between a macroeconomic indicator during and after the EVD crisis in Sierra Leone. Precisely, they estimated the impact of the epidemic on growth during the EVD crisis; their findings show that economic growth rate declined by more than 5% in 2014. Furthermore, they suggested that Ebola negatively influence economic growth only in during the year of the epidemic. By 2015, the impact of the EVD declined to 4.3%. In the same line, Kostova et al. (2019) utilized the DiD to evaluate the causality between the EVD and potential impact on economic activities across sectors such as export and export supported jobs in the U.S. Their estimates show a negative impact on trade between the U.S. and the core affected countries only in 2014 but not statistically significant. As a result, it led to a $1.08 billion reduction in export to these fragile economies. The adverse effect of the EVD also led to over 12,000 export-related job losses in the core countries' economies.

Recently, Huber et al. (2018) reviewed selected grey and published literature to determine the effect of EVD. Having included the abandoned economic value[2] of life lost, their findings suggested that social and economic cost of the Ebola crisis on the government s of the core countries is $53 billion. That is, if these core countries do not exert maximum effort in containing the epidemic. This narrative has been further corroborated dating back to the late 90s by a study evaluating the economic impact of an influenza in the U.S. Following Meltzer et al. (1999), after estimating the cost life demonstrated that the economic impact of the virus lies between $71.3 - $166.5 billion. Interestingly, the authors deduced that 83% of the total economic losses are attributed to human life (Meltzer et al., 1999:664). The economic impact of many epidemics is often considered, especially depending on its spread. However, factoring in the cost of human life makes epidemics such as EVD 'tremendously costly' (Bloom and Canning, 2006:2). In the same line, under the scenarios of low Ebola, the

[2] They referred to the abandoned economic value as the monetized value of human life, resulting in those who fell prey to the epidemic.

Unite Nation (2015a:113) deduced that the macroeconomic impact of Ebola is not substantial owing to the relatively small size of the three most affected economies. See *Appendix 3* for a summary of the literature review on EVD.

# 3 Methodology

## 3.1 Synthetic Control Method

This research intent in investigate the effects of the Ebola shock on the Liberian economy. While existing studies give a short term assessments of the economic impact of Ebola in Liberia and other affected countries, it does not account for a full estimate of the crisis. This is because most of the approaches used in these assessments, which determine the impact of the EVD relies on scenarios building. As such, in the absence of the appropriate econometrics techniques and the household dataset, these studies do not give a real impact of the EVD. Interestingly, some existing literature has based the effects of the EVD on results from the CGE previously used by the World Bank (2014a). Specifically, the CGE uses contemporary data to conclude how the macro-economy performs in the aftermath of the Ebola shock. Though the CGE model tracks the economy's performance, it is only used to interpret some specific circumstances of the EVD. Therefore, it is not for use for forecasting the impact of economic phenomena. As such, it does not check for the level of statistical accuracy in a model. Most of these estimations are somehow not consistent and differ from one study to another, either due to timing or data unavailability. This study differs from these existing literature and relies on a data driven empirical technique to evaluate the economic effect of the EVD on the Liberian economy. Therefore, this study will explore the statistical approach called synthetic control methods frequently used in comparative case studies (Abadie and Gardeazabal, 2003; Abadie et al., 2010). Hence, the SCM has often been used to evaluate the impact of an aggregate outcome at a household level, subnational, or national level. This method has gradually become a popular technique in the social sciences discipline and comparative case studies. As a result, the SCM is an important method for policy evaluation (McClelland and Gault, 2017); a valuable addition to evaluating the impact of a natural disaster (Cavallo et al, 2013) and an important tool to measure public health intervention (Bouttell et al. 2018; Kreif et al. 2016). For instance, it has been believed that Randomized control trials (RCTs) are the most convenient empirical methodology to determine the effect of an intervention, but it important to note that most of these intervention estimates are sometimes biased and its result does not replicate the original circumstances for the treatment group. This biasedness is derived due to missed steps in setups that might characterize the conduct of such research, according to Page et al. (2016); this might render the erroneous overestimation or underestimation of the true impact of the intervention.

However, to deal with these biases requires the selection of the appropriate comparison groups in these researches. With that in mind, based on Abadie et al. (2015), the SCM generates an efficient technique to choose the comparison group. To evaluate the impact of an aggregate intervention in the aftermath of the EVD shock, the SCM allows us to compared aggregate outcome for the "treated" and "untreated" which in a nutshell is the unit exposed and the units not exposed to the Ebola epidemic (Abadie, 2019:3). That is, to determine the evolution of the economic impact of the EVD at the macro level in Liberia to a synthetic Liberia will allow us to simply compare the development of an aggregate outcome of a treated unit that was affected by the shock at a household, subnational or national levels and compared to control units that was not negatively impacted by the Ebola shock (Abadie et al. 2010: 493). In a way, the SCM will isolate the intervention that took place at the aggregate level due to Ebola by creating an artificial unit that will be called synthetic Liberia.

If the EVD impact on Liberia's macroeconomic performance and to have an unbiased estimation resulting from the epidemic, it typically required data availability for an aggregate

level[3]. Since the determination of the economic impact of the EVD in the aftermath of the shocks is observed at the national level, it is realistic to conclude that the SCM sees the handy availability of national and regional level data as an advantage to this approach. Nevertheless, having the aggregate data does not solve all the selection bias that will be encountered in this research. Based on Abadie et al. (2010), the selection of such data for the control group remained an uncertainty about whether it will reproduce the unobserved or counterfactual outcome. To solve selection bias, the SCM applies weighted mean to the control group so that it can reproduce similar features for that of the treated unit (actual Liberia estimates). The weighted component of other countries will assign specific weight to the countries in the comparison group (Abadie et al. 2015). Therefore, it will create an artificial unit that is observable before the outbreak of the EVD that had some very similar characteristics toward Liberia in terms of the different outcome variables of interest such as inflation, unemployment, GDP, GDP growth, and GDP per capita. Hence, to estimate the causal effect after the EVD shock, the SCM will basically look at the pattern of the synthetic unit on the actual unit. The SCM allows us to control for several factors, i.e., for example, Liberia's economic growth will decline from its original trend. At the same time, the synthetic Liberia trend stays the same or deviate in opposite directions. The difference between the two scenarios will then be attributed to the EVD. Relying on these analyses, the SCM has developed a reputation in comparative studies, and it has proven to be the best alternative method to evaluate the economic impact in the aftermath of the Ebola epidemic where the treated and untreated units are very small in magnitude (Bouttell et al. 2018). Therefore, the authors emphasized that it differs from other methods such as RCTs or DiD because neither does not depend on the parallel trend's characteristics. Instead, it depends on the pre-treatment variable between the treated and synthetic control. Also, O'Neill et al. (2016) back this analysis and deduced that the SCM zoom in the tendency of unobserved outcome variables of interest to vary over time. On the contrary, Rieger et al. (2019) argued that the SCM is narrow in scope due to its reliance only on one country affected by the idiosyncratic shock couple with a very small sample size characterized in the assessment. As a result, they argued that the level of statistical significance cannot yield a reliable estimate.

## 3.2 Specification of the SCM econometric strategies

In evaluating the SCM, we relied on the mathematical intuitions behind (Abadie et al, 2010; Abadie et al, 2015; Cavallo et al, 2013) to estimate for the treated and the untreated units. Thus, we begin with the assumption for the sample of J+1 units: j=1, 2, …. J + 1. In a way, j=1 will be denoted for Liberia, while the remaining J (i.e., j=2 to j=J+1) will represent all countries that were not affected by the EVD (donor pool). Likewise, T denotes the number of years covering the assessment, which is classified as the pre-treatment or pre-Ebola and post-treatment or post-Ebola (see section 4.3 for the treatment period). However, it can be deduced from the hypothesis that the treated unit was vulnerable during the treatment period, based on that; consider $T_o$ for synthetic Liberia as the representation for the pre-treatment or before the Ebola period with $1 \leq T_0 < T$. The post treatment periods are denoted with $T_1$ where

$T = T_o + T_1$. Hence, unit 1 was vulnerable to the shock during the treatment. Relying on Abadie et al. (2010:494), consider $EVD_{it}^{N}$ as the different outcome variables of interest (GDP, GDP growth, GDP per capita, inflation, and unemployment) that were observed in the absence of EVD for region *i* in time *t. H*owever, consider if country *i* is exposed during

[3] Note that aggregate data to evaluate a natural disaster such as the Ebola virus is always interchangeably available. Still, at the whole face value, noticeably, it is not always error-free.

the outbreak of the Ebola epidemic during the time $T_o + 1$ to T. See *Appendix 4* for a detailed technical description of the SCM econometric technique.

## 3.3 Method of inference

The natural disaster assessment, like EVD in the absence of a household dataset, is often based on the hypothesis of uncertainty. This is done with some form of backing, and as in the SCM the standard error has been relied on to evaluate such uncertainty. The standard error usually estimates the uncertainty and measurement error that exists within a macroeconomic dataset. Therefore, the usages of such macro-level data for the inference would most certainly equate to zero standard error (Abadie et al. 2010:496). Still, it is no guarantee whether these uncertainties about the predictor of the outcome variables will be eliminated even with the availability of a perfect macroeconomic dataset. For instance, the doubt about the data will always occur in such research to evaluate the economic effect of EVD because of the inability of the comparison or the untreated unit to replicate the synthetic counterfactual that resembles actual Liberia in the absence of the EVD shock.

Following Cavallo et al. (2013), the assumption that the comparison unit will replicate the synthetic counterfactual of the treated unit creates more uncertainty. Such, it is problematic to hypothesize the characteristics of the Liberian economy in the absence of the Ebola epidemic. As a result, the size of the dataset, whether micro or macro level, does not eliminate the problem of uncertainty in the estimates. Since this research's main result relies on a small donor pool size, it is important to state that macro-level inferential procedures are not the only options in comparative studies considering the insignificant nature of the untreated units (Abadie and Gardeazabal, 2010; Abadie et al. 2015). These studies deduced that a permutation assessment (hereafter placebo or randomization) should be explored in the determination of inference method in the study of this nature regardless of the potential comparison countries, i.e., the technique herein when applied can be used with any nature and size of the dataset available as in the case for this research. As such, it is important to determine if the difference between Liberia and synthetic control Liberia is substantial or not. Therefore, the placebo test can be used to evaluate the statistical significance and guarantee certainty to estimate the distribution of the projected impact of the Ebola epidemic.

Accordingly, as explained by Abadie et al. (2015), the placebo test applied the SCM technique to all African countries in the donor pool. This technique allows us to isolate the synthetic control for Liberia (affected by the EVD) to determine if the shock was of high proportion regarding countries chosen at random and not affected by the EVD. Hence, in the SCM application, if the placebo study reconsiders each country in the control group during the same period, it's more likely coined as the distribution of "in place" placebo impacts (Galiani and Quistorff, 2017:836). Ideally, it can be deduced that the economic impact of the EVD would be compromised if we consider the performance of the economy during the crisis for other countries that did not experience Ebola. See *Appendix 5* for the technical details of the SCM inference technique.

# 4 Data Description

## 4.1 Outcome variable of interest

To evaluate the economic effect of the EVD, we used selected macroeconomic indicators that drives the economy's performance. Therefore, this study depends on five outcome variables affected during the EVD crisis, such as inflation, unemployment, GDP, GDP growth, and GDP per capita. Hence, to find the correlations between the idiosyncratic shock and the economy, we used these indicators with data applicability for both the treated and control groups. As a result, this study used these selected outcomes variables because, for example, the flow of GDP tracks the overall progress of an economy. Therefore, data on GDP and inflation rates were obtained from the IMF World Economic Outlook (WEO)[4] database (see *Appendix 6* for description of the variables of interest). In the same line, since GDP per capita, which is typically used to determine the wealth of an economy, this study relies on GDP per capita as another outcome variable to account for wellbeing. Assessing the economic impact of the health-related crisis in a fragile economy with weak institutions can be a challenge, but; GDP per capita can somehow give the dimension of such a crisis considering wellbeing. As a result, it believed that GDP per capita is the most "important measure of the economic welfare of individuals" within a specific region (Harvie et al. 2009:483). Hence, we obtained data on GDP per capita, GDP growth, and unemployment from the World Bank data series coined as the World Development Indicators (WDI)[5] through its metadata.

## 4.2 Control variables

Simultaneously, we rely on selected macroeconomic control variables in determining the counterfactual of what would have happened in the absence of Ebola. These control variables are also important determinants of the Liberian economy's macroeconomic performances in the aftermath of the EVD. As such, data on general government total expenditure, and population size were obtained from the WEO database. Henceforth, these control variables are averaged over the entire pre-intervention period 2004-2013.

## 4.3 Treatment period

The analysis of this study covered the treatment period beginning from 2004 - 2018. Considering Liberia as a post-war country, the period's choice was informed by the timing of decades of civil disturbances and political instability within the region. As such, to avoid an

[4] The WEO is the IMF flagship database which encompasses values for the different macroeconomic indicators. The database contains data from 1980 to the present with a post estimated period for four years from the latest publication date. The WEO biannual publication series is released in April and September or October of every year (IMF, 2020).

[5] The WDI is the World Bank group primer collection of high-quality comparable indicators and statistics for economic development for all countries and territories. The dataset contains 1,600 different indicators and information dating back to 1960. These indicators represent the Bank's global fight against extreme poverty; these statistics used are compilations of the Bank's staff using other international UN organizations and local and national datasets from statistical institutions (World Bank, 2020a).

erroneous and biased result, the research begins its analysis in 2004 as the baseline year because the preceding year prior was characterized by civil war and disorder in the treated unit. The over two decades of havoc ended in 2003, with a new interim government being inaugurated in 2004. Moreover, the baseline year is when complete data from different sources are available for all countries in the donor pool. Since then, the region has remained stable and enjoyed a decade of relative peace until the outbreak of EVD in 2014. Therefore, the pre-Ebola period ranges from 2004-2013. This research models its estimation to all African countries since this is a comparative case study across countries. That is, of the total 54 African countries, 39 countries will be classified as a comparison/control group while one will be considered the treated unit.

We will also analyze the study with data for all developing countries (as a robustness check). Still, the main choice of analysis will involve the donor pool from Africa because Liberia, like many African countries, tends to have the same economic system involving cross border trade, manufacturing, and agriculture. Secondly, our main choice is motivated by cultural characteristics across the African continent. As such, to avoid interpolation biases, our selection of the donor pool supports Abadie et al. (2015) recommendations. Here, the authors recommended that the control group be limited to units with similar characteristics to the unit affected by the shock (Liberia). However, all the countries with a previous outbreak of Ebola will be dropped from the donor pool. Somalia will also be dropped because of limited data availability and persistent civil wars experienced for the duration of this study's treatment periods. Hence, this analysis will utilize its assessment with 40 countries, including Liberia. Likewise, the EVD post-treatment period will range from 2014 – 2018 because the WDI had no additional data for evaluating these outcome variables. However, on the other hand, the WEO has data up to 2020 with a projection beyond. Thus, to have a balanced result, this research limits its post-treatment periods to 2018 – the year in which data are available from all sources. As stated in (section 4.1), the study relied on data from the WDI and WEO to do these evaluations in Stata 16.0 (StataCorp. 2019).

# 5 Results

## 5.1 Discussion of main results

Since this is a comparative case study, with the origin of the Ebola virus being traced to Africa and with more prevalence on the continent, it should be recalled from section 4.3 that we consider our main analysis to the donor pool for all African countries with no Ebola occurrences in previous years. The results herein derive using the SCM often used in policy evaluation. The SCM allows us to determine the impact of the Ebola epidemic in relation to the Liberian economy's poor performance. Therefore, our result relies on assessing five macroeconomic outcomes: unemployment rate, inflation rate, GDP, GDP growth rate, and GDP per capita. As a result, the study estimated and compared the EVD effect on the pre-treatment and post-treatment periods considering these five outcomes for the unit affected by the Ebola outbreak. Noticeably, this will be done with the aggregate of all countries in Africa that have not experienced EVD to determine the counterfactual.

Similarly, this paper estimated the same effect of the EVD with a pool of all developing countries for robustness check. As a result, for each outcome variable, the SCM will create a value of weighted average for each country in the donor pool that tends to replicate a counterfactual outcome like that of real Liberia estimates. Therefore, our analysis aims at estimating the counterfactual was carried out separately for each of the five outcomes variables. *Appendix 7* depicts the weights of each comparison country in the donor pool. These weights were averaged separately for each outcome variable to generate the synthetic control (synthetic Liberia) trends. These weights enable the pre-Ebola period's estimates to display a trend of actual Liberia, which is similar to synthetic Liberia.

For instance, the trajectory of the unemployment rate before the outbreak of the Ebola epidemic in Liberia is likely replicated by the combined weights of Burundi (0.101), Chad (0.585), Eswatini (0.016), Guinea Bissau (0.072), Madagascar (0.05), Niger (0.099), Rwanda (0.062), Seychelles (0.078), and Tunisia (0.016). Likewise, it is deduced that the course of the inflation rate in Liberia before the EVD is also replicated by combining the weights of Central African Republic, Equatorial Guinea, Ethiopia, Malawi, Mozambique, Sao Tome & Principe, and Seychelles. Whereas Niger, Mozambique, Eritrea, and Burundi weights form the trends for the GDP per capita outcome. Therefore, all other countries in the donor pool for the outcome variables mentioned received zero weights. Also, see *Appendix 7* for the weights of other outcomes not mentioned.

In context, these comparison units herein present a good fit that is similar to Liberia for the pre-intervention outcome variable (i.e., inflation, unemployment, GDP, and GDP per capita) and covariate. It can be used to determine what would have happened to Liberia in the absence of the EVD outbreak. Moreover, it tends to decrease the interpolation biases due to their basic similarity of the donor pool with the treated unit exposed to the Ebola epidemic (Abadie et al. 2010). Generally, as depicted in the next sections, the result for these outcomes variables (apart from GDP growth) shows a similar trend between Liberia and the counterfactual - synthetic Liberia during the pre-Ebola period till 2014 - the year of the shock. For instance, Liberia and synthetic Liberia path for GDP following each other closely until after the shock, while the path for the inflation rate, unemployment, and GDP per capita follows a similar path but deviates just on the verge of the EVD shock. Moreover, the impact of the Ebola epidemic for Liberia tends to persist for all outcome variables after the Ebola shock. However, such an effect on GDP, GDP growth, GDP per capita, and unemployment is not too large.

On the other hand, we rely on the placebo regression, highlighting the gap, and determining each outcome variable's significance level. The placebo was then estimated for each year after the Ebola epidemic for the individual outcome variable. Broadly, the findings herein show a mixed result under two conditions. (i) Using the conventional SCM technique produces a p-value that is of greater conservative nature, and the results are insignificant for all five outcomes variables, (ii) using the ANRDS, an unconventional method produces on average a less conservation p-values and standardized p-values for all outcome variables with a statistical level of significance than the former. Therefore, findings herein rely on the ANRDS approach (method discuss in *Appendix 5*) to determine the level of statistical significance for each of these variables (hereafter referred to as adjusted p-value).

## 5.2 Descriptive statistics

**Table 2**
Balancing means for GDP per capita and unemployment outcomes

| | GDP per capita current price – USD | | | Unemployment Rate | | |
|---|---|---|---|---|---|---|
| Variables | Liberia | Synthetic | Sample Mean | Liberia | Synthetic | Sample Mean |
| GDP per capita | | | 2579.41 | | | |
| 2004 | 205.35 | 189.08 | | | | |
| 2006 | 244.92 | 248.08 | | | | |
| 2008 | 305.16 | 300.88 | | | | |
| 2010 | 332.01 | 343.54 | | | | |
| 2012 | 419.28 | 418.10 | | | | |
| 2013 | 455.70 | 443.58 | | | | |
| Government expenditure | 21.19 | 35.49 | 27.39 | | | |
| Population size | 3.22 | 3.09 | 14.55 | | | |
| population growth | 3.42 | 10.14 | 2.24 | | | |
| Unemployment Rate | | | | | | 8.04 |
| 2004 | | | | 2.282 | 2.280 | |
| 2006 | | | | 2.162 | 2.157 | |
| 2008 | | | | 2.073 | 2.054 | |
| 2010 | | | | 2.266 | 2.265 | |
| 2012 | | | | 2.215 | 2.188 | |
| 2013 | | | | 2.196 | 2.220 | |
| Government expenditure | | | | 21.19 | 21.97 | 27.39 |
| Population size | | | | 3.22 | 3.20 | 14.55 |
| population growth | | | | 3.42 | 9.95 | 2.24 |

Note: Variables without specified year are averaged over the entire pre-Ebola period (2004-2013)

*Source*: Author's construction.

Due to multiple outcomes variable being estimated in this paper, the descriptive statistics comprise only two variables to give a sense of how these outcomes form their pre-treatment match, which also corresponds to Figure 7, left panel. As such, *Table 2* provides an overview and compares the result of GDP per capita and the unemployment rate for Liberia and the convex combination of African countries, which forms synthetic Liberia during the pre-treatment period (2004-2013). Therefore, the above result compares the real Liberia estimate

and its synthetic counterparts and an overall average means of each outcome and its predictors. The corresponding pre-treatment result for the two outcomes: GDP per capita is balanced with slight disparities. In contrast, the unemployment rate is tightly balanced and close between Liberia and its synthetic partners. For instance, the gap in 2004 between Liberia's GDP per capita and its synthetic unit is $16.27. For the last pre-treatment year (2013), it is $12.12, which further signifies Liberia as a poor country in terms of the population's living standard. Therefore, it deduced that the GDP per capita average of all countries in the donor pool is higher than actual Liberia before the EVD outbreak. As such, there is no economic convergence about per capita outcome, which can potentially be traced to our choice of the comparison group.

Similarly, the difference in the unemployment rate between Liberia and synthetic Liberia range from 0.002% in 2004 to -0.024% in the last pre-treatment year. In a way, the unemployment rate is higher on average in the control countries than Liberia. Notwithstanding, total government expenditure is higher in the average donor pool than in Liberia before the EVD shock. Moreover, though Liberia was the most affected in terms of the Ebola death toll, it is important to highlight that it has one of the lowest population sizes (4.8 million) in Africa. As such, when compared to other African countries in the comparison units with bigger population size, Liberia's population growth is higher than the average of the donor pool.

## 5.3 Analysis of each outcome variable

In this section, we emphasize the effect of the Ebola epidemic on the economy in the aftermath of the EVD on the selected outcomes variables between 2004-2018. The findings of the EVD on these outcomes generally persisted between Liberia and its synthetic counterparts after the crisis but to what extent? Let's find out.

### 5.3.1 Overall impact of Ebola epidemic

The overview of Ebola's economic impact is summarized through selected macroeconomic outcome variables, which shows the trend of these outcome variables during the pre-treatment and post-treatment period for Liberia and its counterfactual. Therefore, *Figure 7* shows each outcome variable's trajectories on the left panel and presents the corresponding gap (differences) between Liberia and synthetic Liberia on the right panel. Foremost, the black vertical dotted line represents the year of the EVD outbreak. Panel A shows the unemployment estimate with synthetic Liberia vigorously following Liberia's trajectory for nearly the entire pre-Ebola year. Similarly, panel B, C, and E show that Liberia closely followed the synthetic Liberia track during the pre-Ebola periods for the inflation rate, GDP, and GDP per capita. On the other hand, the GDP growth rate as display in panel D shows that the real Liberia estimate deviated from its synthetic counterpart for most of the pre-Ebola period, implying an unsuccessful match. As such, by relying on these close tracks for panel A, B, C, and E can deduce that the comparison units are a perfect match for the treated unit. In these scenarios, we determine the impact of the Ebola epidemic on the economy with these selected outcomes by assessing the change between Liberia and its counterfactuals right after the shock. As such, after the Ebola shock, the outcomes for all variables in *Figure 7*, left panel for the treated unit, continues to deviate from each other with its counterfactuals heading the opposite direction. As we will elaborate further through the estimated impact, this trend can be deduced to have short and long-term implications on the Liberian economy. For example, Liberia has experienced a successive negative growth rate since the containment of the EVD. In addition to other exogenous factors, this study results suggest a decline in the

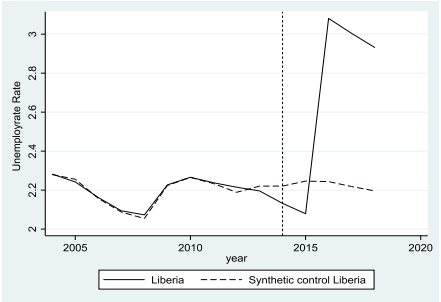
economy's performance due to this shock. However, this study is further corroborated by the World Bank (2015). Their findings show a dropped in the output of some of these outcome variables in Liberia after the Ebola crisis compared to its pre-Ebola performance. For instance, Liberia had a GDP growth of 8.7% just before the EVD shock but in 2014, said growth shrunk to 0.7%. As such, some of this slowdown in the economy can be attributed to the Ebola epidemic. Hence, the differences between Liberia and its counterfactual are represented by the distance between the black and dotted lines, which depicts that the EVD, to a certain extent, had an adverse influence on the performance of the Liberian economy.

Notwithstanding, the differences between these outcome variables of interest for Liberia and synthetic Liberia (placebo countries) are shown in the right panel, *Figure 7*. The differences (placebo effects) are represented by the light grey line observed in the pre-EVD and post-EVD periods. Noticeably, the pre-treatment fit for most countries in the donor pool seems to have a linear trend except for a few countries. Apart from panel E1, the pre-treatment estimate is scattered around zero, as seen in panel A1, B1, C1, and D1. Interestingly, the gap between Liberia and synthetic Liberia started emerging from the beginning of the pre-EVD period for unemployment and inflation rate while continuing during the entire treatment period for GDP per capita. Also, the straight black line is the observable gap that is estimated for our treated unit of interest. Therefore, apart from GDP per capita, graphically, there exists a gap. Still, such can be interpreted that the gap for Liberia compared to the 39 placebo countries is not substantial during the treatment period. For instance, the gap observed in 2015 for the unemployment rate between Liberia and synthetic Liberia is negative 0.08% and slightly increase to 0.78% in 2018. Likewise, the gap for the inflation rate in 2015 was 2.21%, but the same increased over time, and in 2018 the estimated gap equated to 18.8%. GDP gap immediately after EVD was negative 0.25% and increased over time to negative 0.63% between Liberia and its counterfactuals in 2018. Furthermore, the 2015 gap between Liberia and synthetic Liberia for GDP growth was negative 0.57% and increased to negative 4.12% in 2018, while the gap for GDP per capita in 2015 was negative $4.57 and increased over time to negative $138.40 in 2018.

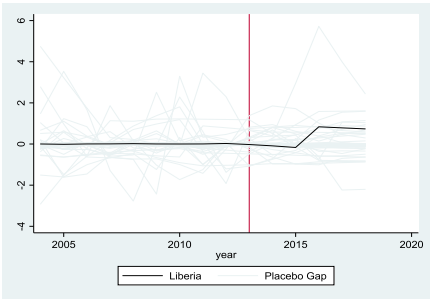
**Figure 7**

Left panel – outcome variables trajectories and Right panel – placebo gap

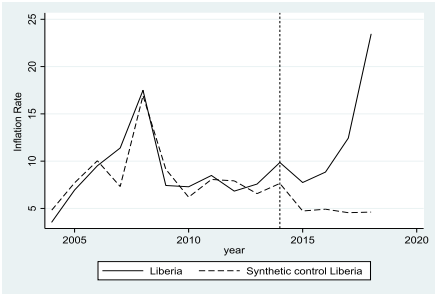
Panel A: Unemployment trend: Liberia vs. Synthetic Liberia



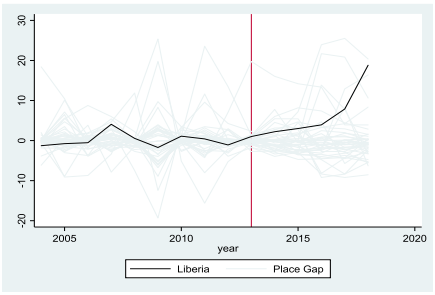

Panel A1: Unemployment: Placebo gap



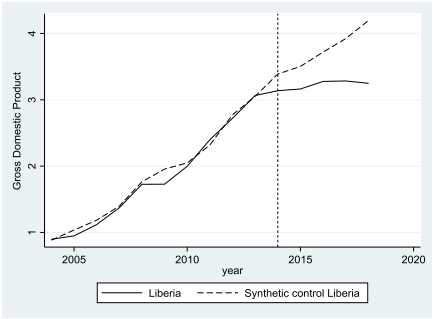

Panel B: Inflation trend: Liberia vs. Synthetic Liberia



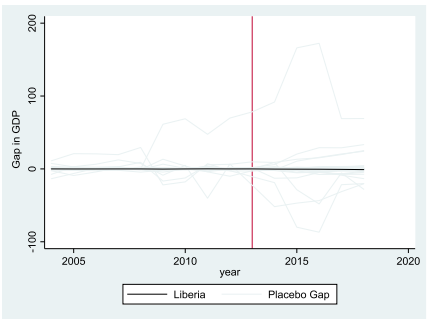

Panel B1: Inflation: Placebo gap



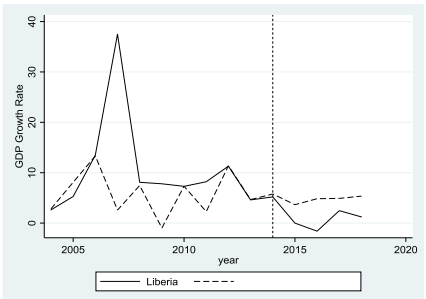

Panel C: GDP trend: Liberia vs. Synthetic Liberia



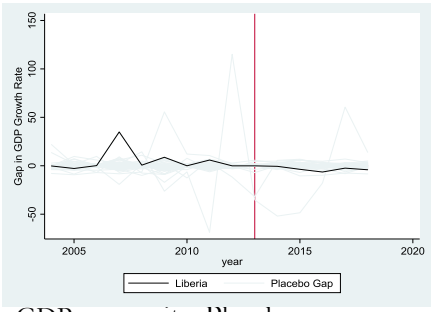

Panel C1: GDP: Placebo gap



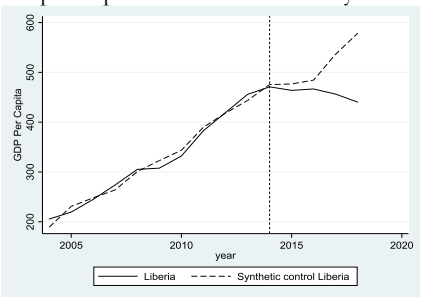

Panel D: GDP Growth trend: Liberia vs. Synthetic



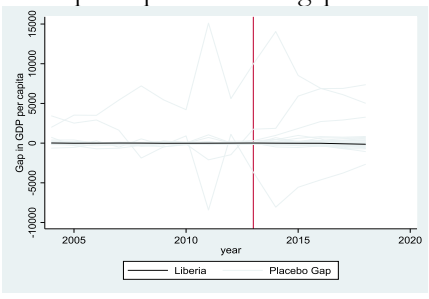

Panel D1: GDP Growth rate: Placebo gap




Panel E: GDP per capita trend: Liberia vs. Synthetic




Panel E1: GDP per capita: Placebo gap




*Source*: Author's construction.

The estimated impact of the Ebola epidemic on the outcome variable is depicted in *Figure 8* (left panel), and the right panel plot the significance level, as shown through the adjusted p-values. Foremost, the result herein generally suggests that EVD had a negative correlation on the economy, but to what extent? As we attempt to find an answer to this question, we start with the unemployment outcome. Firstly, the gap from *Figure 8* for the unemployment rate between Liberia and its counterfactuals tends to be very small in the post-Ebola years, although it increases over time. As previously highlighted, the gap immediately after the shock is negative 0.08%, and in 2016 it is estimated at a negative 0.16 percentage points. Therefore, as depicted in panel A and A1, the overall impact of the Ebola on the unemployment rate is estimated at around 0.8 percentage points (with a difference being statistically significant level at 5%), and this study deduced that such impact is not substantial. Therefore, we reject our initial hypothesis that about half of the labor force became unemployed due to Ebola.

Next, we contextualize the impact of the EVD on the inflation rate. The track between Liberia and synthetic Liberia deviated just before the EVD shock with a difference of 2.21% (adjusted p-value of 0.26) in 2015, 3.01% (adjusted p-value of 0.23) in 2016, and 3.92% (adjusted p-value of 0.23) in 2017. Before the outbreak of the EVD and even during the first and second quarters of 2014, Liberia had single-digit inflation (9.8%), but the same quickly increased to double digits as the crisis took a center-stage. The statistical significance impact of EVD on the economy is at a 5% confidence level (panel B1). As a result, the inflation rate increased over time in Liberia by approximately 18 percentage points (panel B). Typically, one would attribute such an increase in inflation to an economic boom, potentially leading to a rise in prices. However, quarantine measures, travel restrictions, and closure of cross-border trade to stop the transmission of the EVD also contributed to the increase in inflation. The Liberian economy relies heavily on importing almost every commodity; thus, when the country shut-down, the price of food – the country's basic import commodity skyrocketed, leading to an increase in the inflation rate. Furthermore, the rise in inflation, as observed in panel B is due to the dollarization of the economy. In a way, the Liberian dollar depreciated against its U.S. dollar counterpart. Thus, we deduced that between 2015-2018 the inflation rate increased by about 9 percentage points, summing the total inflation to 18% in 2018; therefore, the impact of EVD is substantial with this outcome.

Subsequently, we evaluate the estimated impact of EVD on GDP, and it can be deduced that such effect is small though it increased over time. For example, the estimated post-treatment effect on GDP in 2015 is negative 0.25% (adjusted p-value 0.30), in 2016, it was negative 0.34% (adjusted p-value 0.23) and in 2017, the effect is negative 0.44 with an adjusted p-value of 23%. Notwithstanding, this research study finding suggest that the impact of Ebola on GDP, as seen in panel C is not substantial in the aftermath of the crisis (because the Ebola epidemic was a temporary shock) and statistically significant at 5% confidence (panel C1). Overall, there is a negative effect of the Ebola epidemic on GDP performance, and precisely, the decline in GDP due to Ebola is about negative 0.9% (*Figure 8*, Panel C). Hence, we reject our initial hypothesis that the Ebola epidemic entirely contributed to the Liberian economy's collapse. Hence, this study now determines that the economy's breakdown cannot solely be attributed to Ebola but other exogenous factors. These factors, among others, include lower commodities prices (as previously explained in the context of inflation) and the withdrawal of UNMIL, whose presence in Liberia attracted $7.5 billion into the economy for the duration of its 14 years' mission. Liberia has one of the smallest economies in Africa, specifically an economy that depends heavily on importing basic commodities and investment from abroad. Thus, the negative impact of the crisis on GDP can be attributed to the country's shutdown due to Ebola. In a way, these quarantine measures hampered its GDP base due to low investment. For instance, 65.1% of Liberia's GDP came through foreign investment prior to the Ebola outbreak in 2013. Nevertheless, the sector contribution

proportionally dropped to 7.3% by the end of the crisis in 2015. Building on these factors, the estimated impact of Ebola did not have a large magnitude though it seems to have a long-term influence on the economy.

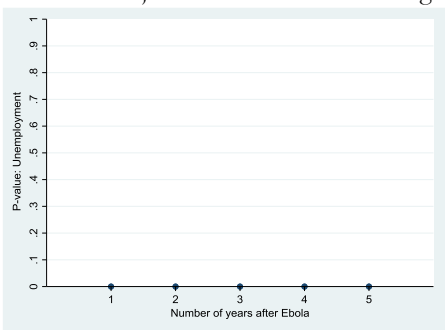
Regarding GDP growth, though (*Figure 8*, panel D) slightly shows a bad fit for some of the pre-treatment years, generally, there is not much difference between Liberia and synthetic Liberia. For example, before the outbreak in 2013, the difference in GDP growth rate between Liberia and synthetic control was negative 0.06%. However, the Ebola epidemic somehow deaccelerated GDP growth progress, with an adverse decline over time. As such, the post-Ebola impact on GDP growth rate in 2015 is estimated at negative 0.57% (adjusted p-value of 0.7). By 2016 it was negative 3.65% (adjusted p-value of 0.21), and in 2017, it was negative 6.43% (adjusted p-value of 0.02). Overall, the post-Ebola effect on GDP growth is negative but not substantial and statistically significant at a 5% (Panel D1). As seen in Panel D, on average, the Ebola's actual impact can be attributed to a decline of approximately negative 4% in GDP growth rate as observed during the post-treatment years. Lastly, we consider the effects of Ebola on GDP per capita. It is deduced that the Ebola shock in Liber further compromised the living standard of the population. As such, it had a steady declined in per capita values. For instance, the estimated impact of the Ebola in 2015 is negative $4.57% (adjusted p-value of 0.66). By 2016 it increases to negative $12.81% (adjusted p-value of 0.66), and in 2017, it also increases to negative $17.87% (adjusted p-value of 0.66). Therefore, this research finding suggests, on average, a non statistically significant effect at 10% (Panel E1). Against this background, as seen in Panel E, the estimated impact of EVD led to a dropped in GDP per capita between negative $40 & $140 overtime. Hence, such a decline is considerable, especially considering a country with a per capita value of $US728.019. As such, our hypothesis, which relied on the human development index about Liberia's impoverished nature, tends to be true. Therefore, our findings deduced that the Ebola epidemic does not merely cause such low human development and poverty but other exogenous factors, as already explained.

**Figure 8**

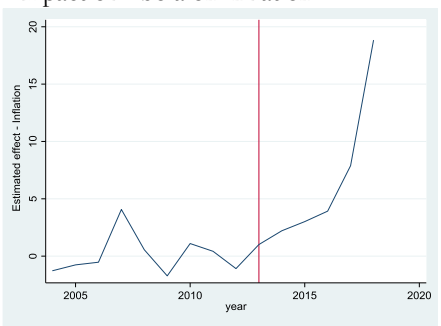
Left panel – estimated impact of EVD and Right panel – adjusted p-values

Panel A: impact of Ebola on unemployment

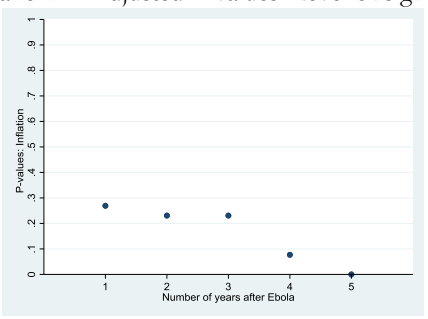

Panel A1: Adjusted P-values: Level of significance



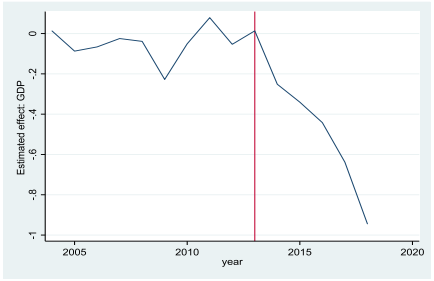

Panel B: impact of Ebola on inflation



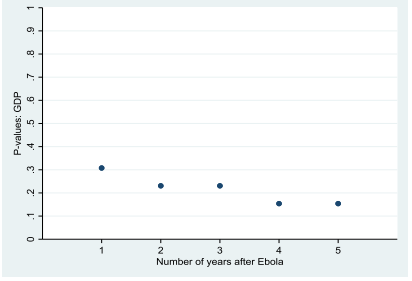

Panel B1: Adjusted P-values: Level of significance



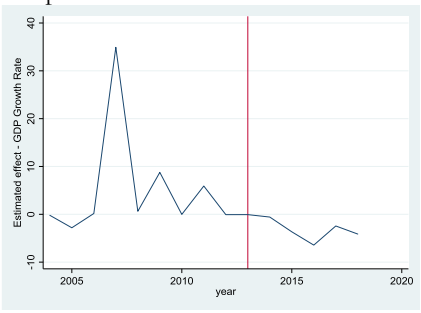

Panel C: Impact of Ebola on GDP



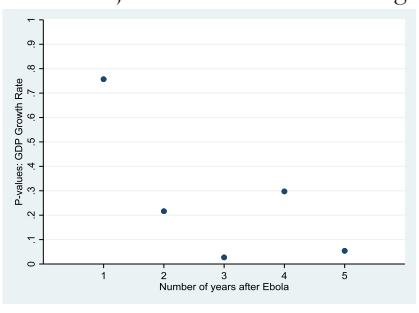

Panel C1: Adjusted P-values: Level of significance



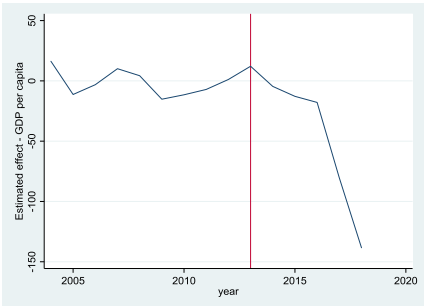

Panel D: Impact of Ebola on GDP Growth



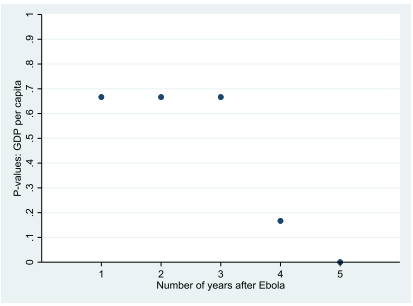

Panel D1: Adjusted P-values: Level of significance




Panel E: Impact of Ebola on GDP per capita




Panel E1: Adjusted P-values: Level of significance




*Source*: Author's construction.

## 5.4 Robustness check – effect of EVD in Liberia using a large pool

The main results of this paper relied on a donor pool of only African countries. However, for the robustness check of the study findings, we used a larger donor pool (all developing countries) to construct the synthetic control. As such, the weights received by each country to form the synthetic counterfactual for each outcome variable is seen in *Appendix 8*. Interestingly, except for Indonesia and Pakistan, every other country in the donor pool receives weight for the unemployment outcome. For instance, the tendencies of GDP per capita in Liberia before the Ebola shock are replicated by the combined weights of Burundi, Central Africa Republic, Ethiopia, Niger, and Zimbabwe. Generally, apart from the inflation outcome variable, our post-Ebola findings for unemployment, GDP, GDP growth, and per capita are somehow like our main analysis. As such, there is no observable substantial pretreatment difference between Liberia and its synthetic counterfactuals (implying a good fit) regardless of how many countries in the donor pool. As such, the post-Ebola effect on these outcomes does not differ significantly from the main results. For instance, the estimated impact of Ebola for the unemployment outcome is negative 0.08% and 0.77% for the larger pool in 2015 and 2018, whereas, for the main result, it is negative 0.08% and 0.78%, respectively.

Similarly, the impact on GDP per capita in 2018 is negative $66 with an adjusted p-value of 0.81 (lesser effect but higher adjusted p-value) in comparison to negative $80.43 (adjusted p-value 0.16) for our main results. Also, the post-Ebola impact on the inflation rate in 2015 is negative 0.45% (adjusted p-value of 0.77) as compared to 2.21% (adjusted p-value of 0.26) for our main results. The impact on GDP in 2018 is negative 0.37% (adjusted p-value of 0.48), whereas, for our main analysis, it is negative 0.63% with an adjusted p-value of 0.15. As a result, using the ANRDS method, the donor pool used for our main results produces, on average lesser p-values for all these outcome variables of interest compared to the large pool.

Notwithstanding, the overall impact of EVD is shown in *Figure 9*. There is an increase of 0.8% in Liberia's unemployment rate, as seen in panel A, the same effect derived from our main analysis with a statistical significance of 5%. Also, the analysis for inflation and GDP outcomes consists of a mixed result (positive and negative effect) and deviate from our main findings. As such, the result herein deduces that the estimated impact of the EVD resulted in a negative 50% declined in the inflation rate as depicted in panel B compared to 18% increase in inflation for our main analysis. However, there is a 5% statistical level of significance for both donor pools. As explained in section 5.3.1 about possible reasons that give rise to the inflation rate, the result here holds for the opposite. For instance, the decline in the inflation rate with the large pool is because, after the shock, which was temporary, the inflation began to decline. Thus, it is believed that there were a huge backlog and stockpile for businesses during the economy recovery after the shock. As a result, for these businesses to maximize profit, they reduce their commodities' prices to get them out of stock. Therefore, this decline means that when there are lower prices, the inflation rate will drop, as seen herein.

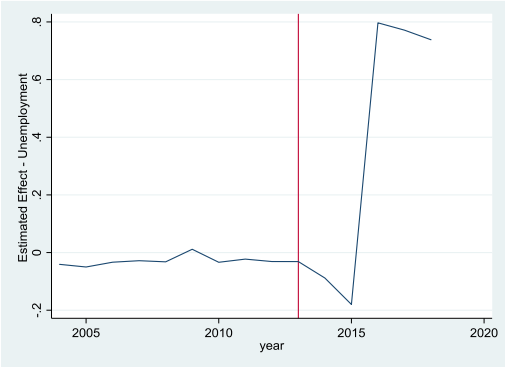
Similarly, panel C shows a positive effect by an increase of 0.6% in GDP with a 5% statistical significance level; however, it declines to 0.24% over time. This finding herein deduces that the EVD did not have any adverse effect on Liberia's GDP; thus, it runs contrary to our main analysis, which shows a less substantial decline of negative 0.9%. Nevertheless, GDP growth and GDP per capita outcomes are similar (negative impact due to Ebola) for both donor pools. Therefore, GDP growth declined by around negative 4% over time compared to a similar negative 4% decline for our main analysis and a statistical significance of

5%. Also, GDP per capita decline by $100 over time compared to about $140 decline for our main analysis, and both results not statistically significant at 10%.

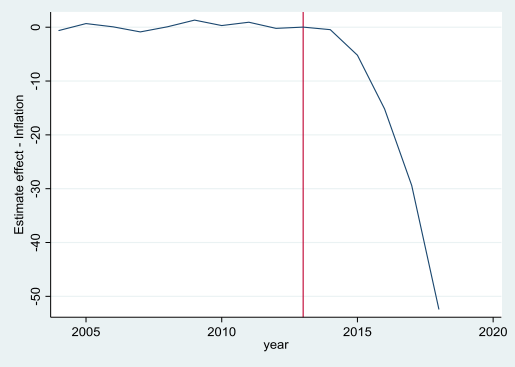
**Figure 9**

Estimated impact of EVD in Liberia using the large donor pool

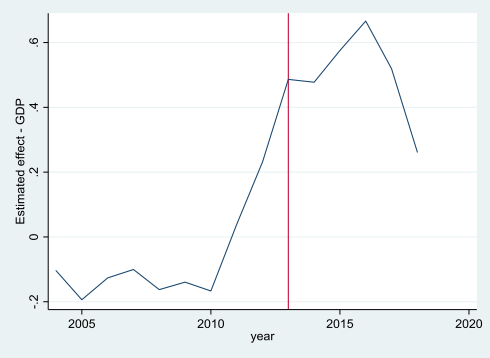
Panel A: Impact of Ebola on unemployment



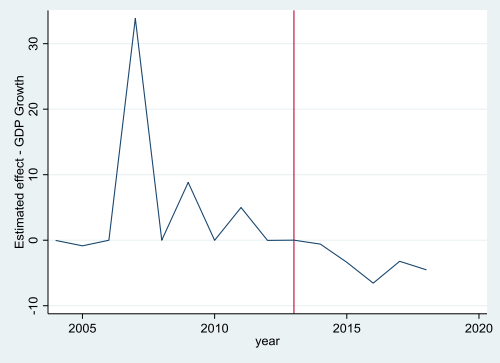

Panel B: Impact of Ebola on inflation



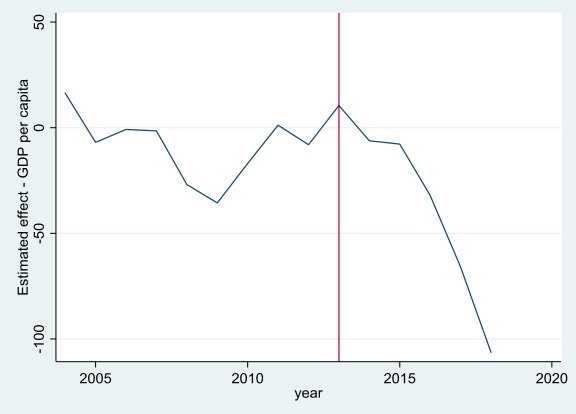

Panel C: Impact on GDP




Panel D: Impact on GDP growth




Panel E: impact on per capita




*Source*: Author's construction.

### 5.4.1 Robustness check – EVD in the other two hit countries

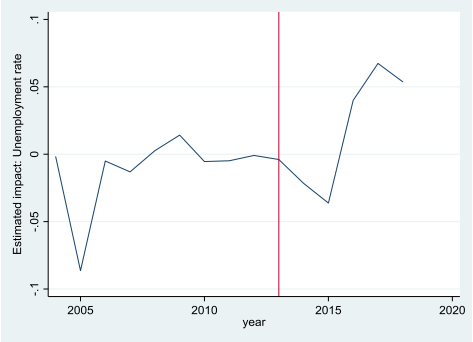
The main focus of this research is assessing the economic impact of EVD in Liberia. However, since our study did not involve multiple treated units, we evaluated the effect of EVD on the other two affected countries using the same outcomes as a robustness check. We separately estimated for Guinea and Sierra Leone using our main donor pool (African countries).

### *a. Guinea*

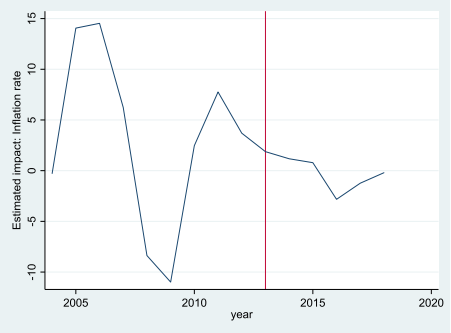
To construct the synthetic control for the unemployment outcome, only Algeria (0.006), Cameroon (.048), Chad (0.205), Eswatini (0.037), Ghana (0.046), Madagascar (0.01), Niger (0.162), and Zimbabwe (0.486) received weights. Also, only Angola, Malawi, and Sao Tome and Principe received weights for the inflation outcome. As such, every other country not mentioned for each outcome received zero weights. However, *Appendix 9A* shows that the difference between Guinea's unemployment rate and its synthetic partners in 2013 is negative 0.003%, and the GDP per capita in 2013 is $8,154. As such, there is a close pre-treatment match between Guinea and synthetic Guinea. However, the estimated post-treatment effect of EVD on unemployment in 2015 is negative 0.02% (adjusted p-value of 0.63) (see *Appendix 9B* for the adjusted p-values). The GDP per capita in 2015 is negative 4.92% (adjusted p-value of 0.92) and not statistically significant. Overall, the impact of the Ebola on these outcomes variable of interest is shown in *Figure 10*.

**Figure 10**
Estimated impact of EVD in Guinea

Panel A: Impact on Unemployment

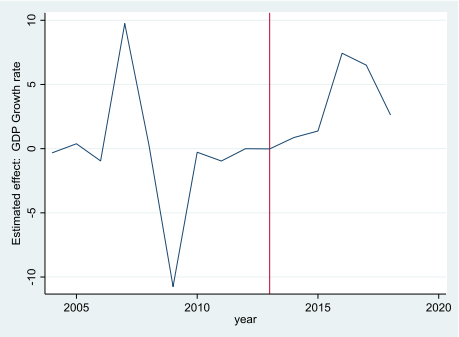



Panel B: Impact on Inflation Rate

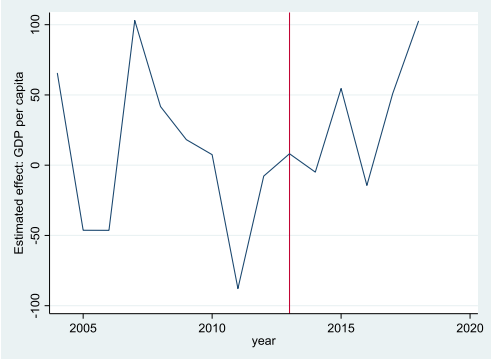



Panel C: impact on GDP


Panel D: impact on GDP growth




Panel E: impact on GDP per capita




*Source*: Author's construction.

Notably, the impact of the Ebola on average has a small magnitude in the Guinean economy. As shown above, in panel A, the unemployment rate only saw a decline by negative 0.04% in the first year after the EVD but later experienced a positive effect (increase overtime) after that. The crisis did not increase the inflation rate as display in panel B, and such, it even decreases by negative 0.25% over time. Interestingly, after the EVD, GDP increase by 1.7% over time (panel C). Also, GDP growth increase by approximately 7% in 2016 and drop to 3% in 2018 (panel D), and GDP per capita increase over time by $100 but saw a slight decrease in 2015 by $2 and 2016 by $10 (panel E). Therefore, this research finds that the EVD did not have substantial adverse effects these outcome variables for the Guinean economy.

### *b. Sierra Leone*

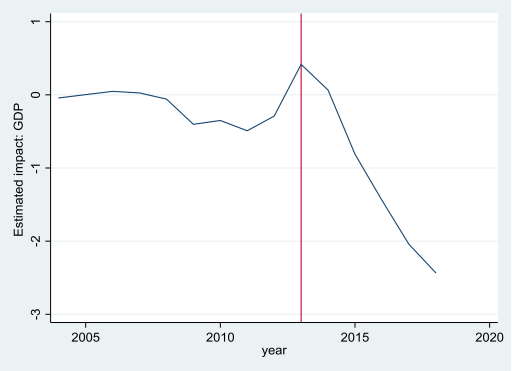
Countries such as Benin (0.061), Burkina Faso (0.281), Chad (0.365), Eswatini (0.032), Madagascar (0.31), and Zimbabwe (0.23) are countries whose weights were used to construct the synthetic control for the unemployment outcome. Also, the weights of Angola, Comoros, Eritrea, Ethiopia, Mozambique, and Zimbabwe form the synthetic control for GDP outcome. Moreover, all countries not mentioned from the donor pool received zero weight for each outcome. The pre-Ebola outcomes between Sierra Leone and synthetic Sierra Leone are shown in *Appendix 10A*. As such, the pre-Ebola estimate for unemployment and GDP are well balanced between Sierra and its counterfactuals, which indicate a perfect fit. For example, the difference in the unemployment outcome in 2012 and 2013 for Sierra Leone and its synthetic counterfactuals is 0.008% and 0.004%, respectively. Similarly, it is negative 0.29% and 0.417% in 2012 and 2013 for GDP outcome. Overall, the pre-Ebola differences between Sierra Leone and synthetic Sierra Leone for these outcomes variables are similar.

Therefore, the estimated post-treatment effect in 2015 and 2016 for the unemployment rate in Sierra Leone is negative 0.003% and negative 0.018% (adjusted p-value 0.92) and not statistically significant at 10% (see *Appendix 10B*). Similarly, the estimated post-Ebola effect for GDP in 2016 is negative 0.81% (adjusted p-value 0.26) and in 2017 it is negative 1.43% (adjusted p-value 0.17) and statistically significant at 5%. Against this background, we summarize from *Figure 11* that the impact of the EVD in Sierra Leone is not substantial but larger than Guinea.

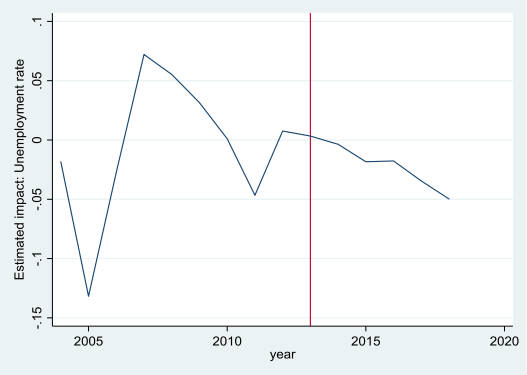
Hence, as observed in panel A, there was an overall decline in Sierra Leone's GDP over time by approximately a negative 2.3%; however, it was not significant. Similarly, panel B shows that there was no substantial decline in the unemployment rate (decline by 0.02% in 2015 and increased over time by 0.05% in 2018). Moreover, the results for these outcomes are diverse. Also, the inflation rate increase by 10 percentage points over time as display in panel C. Interestingly, GDP growth decline sharply by about 23%, as depicted in panel D. However, such decline was temporary and only experience in 2015. The growth rate eventually became normalized around zero in 2016 onward but did not return to its pre-Ebola growth projection of 10%. Therefore, the most substantial declined in Sierra Leone is observed in the living standard of the population. That is, panel E shows that GDP per capita declined by over $400. Such declined back our previous claim that developing countries are usually vulnerable to a health-related natural disaster. Since these core countries have the same economic system, this research deduced that these declines (of any magnitude), as observed, are not only attributed to Ebola but other exogenous factors already explained.

**Figure 11**
Estimated impact of EVD in Sierra Leone

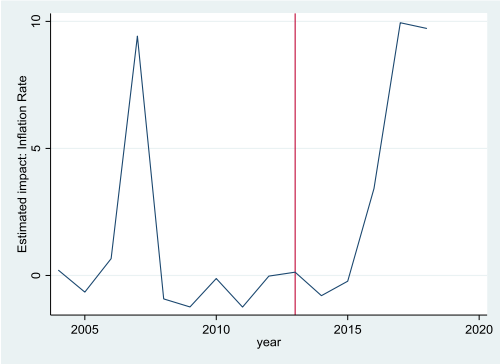
Panel A: Impact on GDP



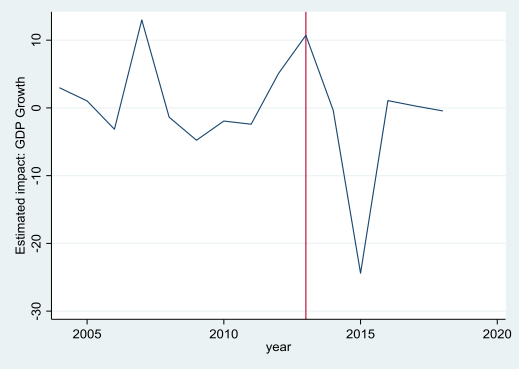

Panel B: Impact on Unemployment



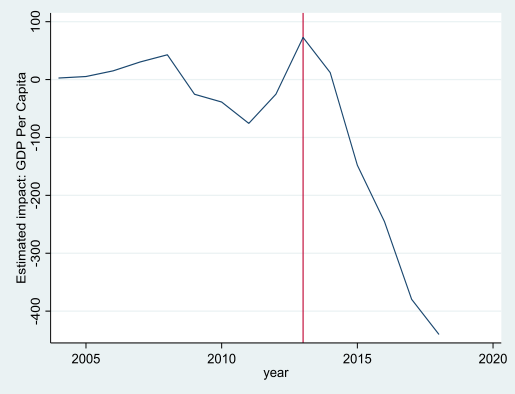

Panel C: Impact on Inflation




Panel D: Impact on GDP Growth




Panel E: Impact on GDP per capita




*Source*: Author's construction.

# 6 Conclusion

Before the EVD shock, previous civil disturbances hindered progress in the country's macroeconomy; thus, it weakens the country's effort to economic prosperity and development. As the country transition from war to a UN back peace, its economic progress was relatively steady until the 2014 EVD epidemic. Hence, it has been generally speculated by policymakers that the broke down, and poor performance of the economy is attributed to the Ebola shock. Many existing literature has deduced that the shock seriously affected the core countries' economies. Likewise, others argue that the impact of the EVD was not large because the crisis did not affect countries with much bigger economies. However, this research contributes to these existing studies through an empirical comparative case study tool by evaluating the economic impact of the EVD in Liberia. To date, this is the first empirical study to assess the economic effect of the Ebola epidemic in Liberia using the synthetic control approach. This approach allowed us to compare selected outcome variables for Liberia to other African countries that have never experienced Ebola previously. This research separately evaluated the effect of the EVD on these selected macroeconomic indicators such as inflation rate, unemployment rate, GDP, GDP growth, and GDP per capita to determine the overall impact of the epidemic in the economy. This research compared the post-Ebola results for each outcome with a synthetic counterfactual. Hence, it's important to note that the SCM gives us the best alternative for evaluating the economic impact of the EVD in Liberia.

Therefore, findings herein are mixed. For instance, the empirical SCM intuition for unemployment outcome deduces that the EVD has an adverse effect on the labour force and contributed to job losses and insecurity. However, its impact though statistically significant, was not substantial. Therefore, the EVD did not solely lead to a large upsurge in the unemployment rate, especially in the aftermath of the Ebola shock. Similarly, this research showed that Ebola shock has some negative consequences on GDP and GDP growth outcomes. Notwithstanding, both outcomes are statistically significant, but such impact is comprised of a very small magnitude. Likewise, there was a significant difference between Liberia's inflation rate and its synthetic counterparts. The study findings show a large increase in the inflation outcome and statistically significant at 5%. However, the study suggests that such an increase was not entirely due to Ebola, but other factors such as the withdrawal of UNMIL, increase commodities prices, and reduction in the price of the country's main exports (iron ore and rubber). Additionally, the effect of the shock on GDP per capita was somehow large when comparing the average per capita income for an individual in Liberia but statistically insignificant.

As a result, the inflation and GDP per capita outcomes were mostly affected by the Ebola epidemic compared to unemployment, GDP, and GDP growth outcomes. Hence, the study findings suggest that the Ebola epidemic's overall impact on the Liberian economy was not substantial, as previously believed by the Liberia public. However, though the effects of the EVD is not substantial, it has persisting implications on the fragile economy but in a small magnitude. This small magnitude and implications are due to the relatively small nature and vulnerability of the Liberian economy, which can be traced to weak institutions and structural weakness. Thus, this research corroborates with the World Bank (2014c), which suggested that the EVD shock is less likely to have any substantial economic impact on countries with bigger economies. As a result, this research deduced that the Liberian economy would continue to deteriorate in the aftermath of the EVD until the necessary economic reforms and policies are implemented. Thus, if there is a re-emergence of the EVD and to avoid potential economic break-down, this research recommends that the GOL should first

strive to contain the epidemic in the short-term and implement an urgent government intervention with the following terms:

- GOL should initiate a fast and efficient stimulus program such as unemployment benefit (cash) for every head of households.
- GOL should subsidize salary allowance for all institutions (businesses, companies) in an effort for them to continue paying employees' remunerations.
- Depending on population mobility in the West African region, the GOL and its partners should fast track efficient EVD vaccines and built permeant ETUs as a means of providing a swift intervention in the event of EVD re-emergence.
- GOL should invest heavily in scientific research, which will track and identify risk factors related to the re-emergence of EVD or any future infectious disease.

Therefore, with rapid GOL health and financial intervention, the economic impact of the EVD would not be large. For instance, these institutions would not lay-off employees or shut down their operations. As such, these reforms are vital and will mitigate the burden faced by households and institutions in case of an epidemic nationwide lockdown.

Moreover, the EVD will continue to disadvantage the Liberian economy, which has been further exacerbated by the current coronavirus until activities in the productive sectors can begin to boom. The economy could experience a swift rebound from the EVD shock, but such a rebound will rely on full recovery in some of the country's productive sectors. Hence, corroborating with the World Bank (2014a) assessments, the EVD would have had an adverse impact on the Liberian economy in the long term only if the Ebola epidemic were not curtailed under the low response scenario. Nevertheless, a rapid epidemic response will be cardinal to avoid economic repercussions for the fragile economy in the long term. Considering that the EVD shock was temporary, its overall impact is observed in the short-term. This research concludes that though there is a negative correlation between Ebola and the Liberian economy, the Ebola epidemic is not entirely responsible for the economy's breakdown and poor performance. Thus, the crisis did not substantially compromise the economy as evaluated on these selected macroeconomic indicators.

Furthermore, the results herein have some limitations. Firstly, this research initially considered interesting variables such as tourism, aviation (travel via flight arrival), and poverty headcount ratio. But due to data unavailability (absolutely NO data is available for both treated and control countries during the pre-treatment and post-treatment period), the findings did not include these interesting outcome variables that were severely affected by EVD. Secondly, this research tried to assess the impact of the EVD on non-economic indicators. That is, loss in human capital (educational enrolment and completion for both secondary and tertiary schools). Still, we could not proceed due to the absence of data. Howbeit, future research should endeavour to use household data and zoom-in on these missing outcome variables of interest to reproduce the synthetic control results for specified missing variables. Nevertheless, the overall SCM is said to be limited also. Following Abadie et al. (2015), the method is more applicable with the restriction of the comparison countries that have characteristics akin to Liberia.

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# Appendices

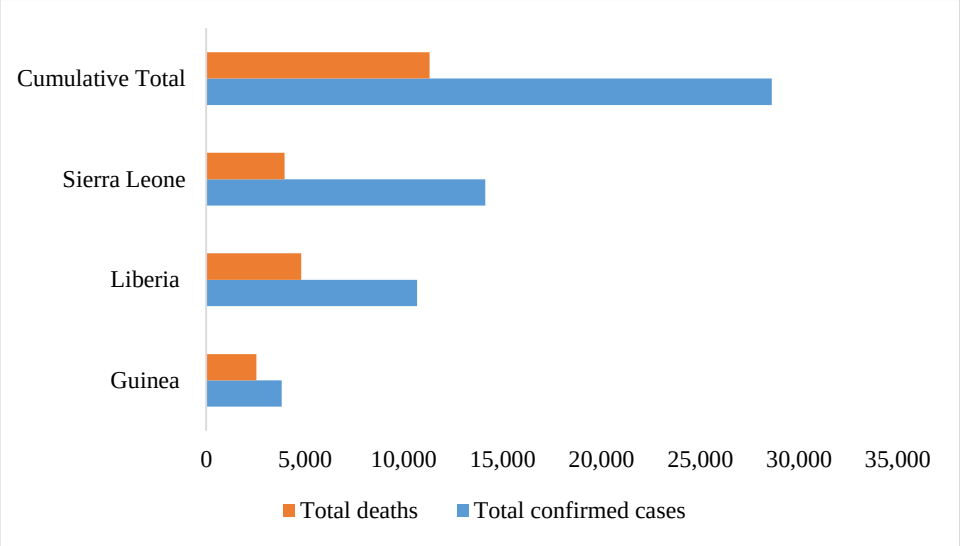
**Appendix 1**

Detailed health implication of the EVD

The Ebola virus disease (EVD) causes severe and fatal illness affecting human beings and other primates. Based on Pourrut et al. (2005), it was first discovered in November 1976 in Zaire[6] near the Ebola river with a death rate of over 55%. In a way, the Zaire ebolavirus, one of the six species of the virus, is the most fatal and deadliest of the Filoviridae virus family, causing about 90% mortalities among patients within few days of infection (Wauquier et al. 2010). A total of 11,310 mortalities was reported in the core countries from 28,616 EVD cases (see *Figure 12*). It has since remained the biggest public health threat in Africa for the past five decades. Since then, it has spread across thirteen countries, following Frieden et al. (2014), the 2014 EVD outbreak was the deadliest ever on the continent with a cumulative human toll surpassing all previous outbreaks combined.

**Figure 12**

Statistics of EVD confirmed cases and deaths




*Source*: Author's compilation using WHO stats

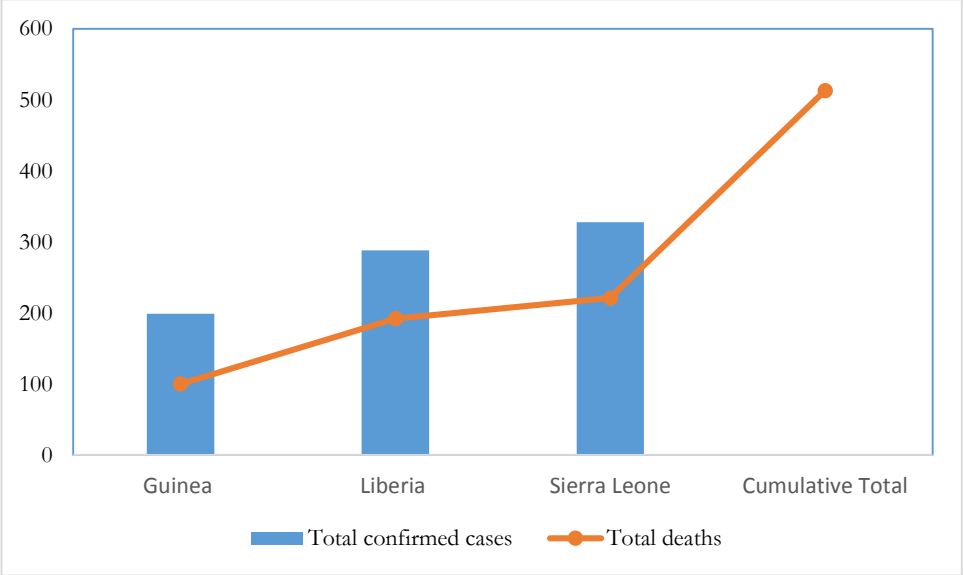
However, there number of EVD cases reported in the core countries has been criticize for lack of accuracy. It has been argued by Elston et al. (2016) that such figures are far under-reported and does not represent the precise data on the ground. Their findings relate to a discrepancy in the numbers, which can be attributed to the inadequate and 'core weakness' in these countries' information systems. This study supports the argument; as someone present during the outbreak, I heard of thousands of families who buried their deceased family member secretly in denial that the EVD did not existed. Such denial was one of the recipes that give rise to the rapid spread and mortalities resulting from the virus in Liberia. Like anyone of the core countries, Liberia has some of the world's poorest health systems, and lack of basic social services contributed to an escalation of the Ebola epidemic. Therefore,

[6] The virus has since been named after Zaire, now The Democratic Republic of Congo.

Shoman et al. (2017) emphasized that to break the transmission of any future outbreak of EVD will require an efficient, trained health workforce and serviceable health sector to contain any re-emergence.

Prior to the epidemic outbreak, Liberia did not have a proper and well functional laboratory system to test and identify infectious disease like EVD (Kennedy et al. 2016). Even more, unfortunately, Green (2016) argued that the country is constrained with a shortage of health care workers and specialized doctors in a different field to treat outbreaks of infectious disease adequately. Hence, the health sector is still a challenge even now (considering the loophole in dealing with the current coronavirus).

**Figure 13**
EVD infections among health care workers




*Source*: Author's compilation using WHO stats

Additionally, the lack of early detections and unpreparedness of the health sector escalated the crisis as 851 HCW[7] got infected in the core countries. A total of 513 deaths (see *Figure 13*) was reported among health workers; of that figures, 192 deaths were reported in Liberia, resulting to 8% decrease in its health workforce. Similarly, 221 deaths in Sierra Leone and 100 in Guinea; the EVD shocks overwhelmed and weakened these poor health sectors (WHO 2015a, 2015b). The WHO further describes the EVD situation as 'unprecedented' and emphasizes the absence of personal protective equipment (PPEs) and its inappropriate use in health centers. However, exposure of PPEs at the point of care and limited infrastructure to isolate EVD patient from the general wards were some other reasons that gave rise to the high infections among doctors, nurses, and other health workers. The reality is that the EVD compromised these disadvantaged health sectors due to its vulnerability, under-resourced, limited qualified HCW, over-burdened, and unpreparedness to handle the EVD crisis (Elston et al. 2016:60, Delamou et al. 2017). For instance, Liberia has 261 Liberian and non-Liberian medical doctors. The doctor to patient ratio is 1: 19,000. This overwhelming demand for the health system is far below the WHO standard of 1: 1,000 standards. The doctor-to-patient ratio alone speaks volumes about why Liberia was highly affected. These pre-existing challenges pose a serious disruption to health services utilization as many health

[7] Health care workers refer to doctors, nurses, midwives, and non-health practitioners working for the different health teams such as ambulance drivers, lab cleaner, janitors, etc.

facilities were abandoned and closed by HCW in fear of contagions. For example, there was an increase in the number of deaths in pregnant women because HCW was afraid to encounter bodily fluid, which was one means of transmission.

However, the presence of EVD in affected communities also had a sheer magnitude with the inaccessibility of health centers, which increases the fatalities rate of other communicable diseases such as HIV/AIDS, tuberculosis, and malaria. By the end of the first outbreak in Liberia by March 2015, the EVD hit all the political subdivisions[8] of Liberia with confirmed cases and deaths. As seen in *Map 1*, Montserrado, where the capital city is located, Lofa, which border Guinea together with Bong, receives more confirmed EVD cases than the rest of the other providences. Therefore, this should serve as a wake-up call to the national government to assert more efforts in building a vibrant health system and be in full readiness to contain any future outbreak of the epidemic.

## Appendix 2

Stages of the Liberian economy

***Stage I: 1950 – 1980***. This period and the years proceeding thereof was a time of economic growth with no development in Liberia. There was a boom in key sectors, including the rubber and mining sectors. In 1926, Firestone Rubber Corporations signed a concession agreement with the GOL for 99 years and created thousands of jobs (the biggest private employer) for Liberian, and contributed immensely to government revenue generation. Additionally, the Liberian-American-Swedish mining company (LAMCO) was established in 1955 with a 50% ownership of the Liberia government. The mining sector's concessions rendered Liberia the biggest iron ore production destination in Africa with a capital inflow of around $85 million annually on average. As a result, Liberia was only second to Japan in terms of real income and one of the largest iron ore producers globally, with a proportional increase in its budget to $55 million by 1965.

Liberia's economic progress in the 1960s came directly through foreign investment in the mining and rubber sectors that relied on the 'Open Door Policy' which opens the economy to foreign investments. These foreign firms also took advantage of the system's weakness and invaded tax, which in addition to the hike in the price of oil by the mid-1970s, compromised the Liberian economy for the time under review' (IMF 2005:3). This had a spill over effect on the prices of local commodities on the Liberian market, which eventually led to a high living cost.

***Stage II: 1980-2003***. This era further deteriorated economic activities, which began with a military coup in 1980 that saw an end to the First Republic. Subsequently, the outbreak of the war in late 1980s eventually led to the death of 250,000 of our countrymen, women, and children. Liberia saw an increase in its external arrears with a UN ban on some of its export commodities; this was necessary because the UN said it was a source funding the war (UNTAD, 2000:1). The sanction led to a breakdown of relations with donors and development partners as they were unwilling to transact with the hostile military government.

The economy contracted into a tenfold negative digit. Most foreign enterprises left the country when the war entered Liberia's capital, as half of the population became internationally and externally displaced. Merchandise trade diminished to its lowest level and declined from $354.3 million to $278.6 million or by 21% in 2002 (Central Bank of Liberia (CBL) 2003:1). Due to this economic despair, the period under review also saw a proportional decrease in export from $176.1 million to $108.9 million compared to its pre-war period. The

[8] The political subdivision is divided into 15 counties or what is also known as providences covering a total land area of 43,000 square miles

latter part of this era involved widespread corruption, capital flight, and economic disintegration, which created untold human suffering and hunger for the rest of the population.

***Stage III-2004 – present***: with a new interim government in place, the economy began to show signs of recovery after the end of the war and the presidential election to be held in the following year in 2005. Enormous progress has been made by Liberia development partners, including the IMF, World Bank, and the United States Treasury Department, to restore the economy. Foreign investment again began to start due to the relative peace as the security of the state was in charge of the UN.

By 2006, a new democratically elected government was inaugurated and opened the economy. Once again, investor confidence began to grow in the new government. ArcelorMittal[9] became mining operation in Liberia and created thousands of jobs, and contributed immensely to government revenue generation. By the end of 2006, Government reserve increased by 70% from 6.5 million to 21.8 million; there was a boom in the overall economy, which was projected to grow by 9.4% due to the agriculture, mining, and service sector (Central Bank of Liberia (CBL) 2007: xii). The microeconomic performance of the economy is characterized in *Table 3*, using some selected indicators. As depicted from *Table 3*, the GDP increase by twofold from 1.1 billion in 2006 to 3.22 billion, relatively due to the inflow of foreign investments in key sectors such as mining and agriculture. However, there was a slight increase from $360.5 in the living standard to $703.6 concerning GDP per capita; nevertheless, these changes are ten times less than the international standard. Similarly, in 2006 inflation increased from 9.5% to 23.4% in 2018. The increase in inflation is due to the Liberia dollars' depreciation, coupled with a decline in its export commodities' global price such as iron ore and rubber.

**Table 3**

Selected macroeconomics indicators

| Macroeconomic variables | 2006 | 2010 | 2013 | 2014 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| GDP (U.S. billions) | 1.119 | 1.998 | 3.065 | 3.137 | 3.249 | 3.221 |
| GDP per capita (current U.S.) | 360.52 | 550.36 | 777.47 | 777.02 | 728.01 | 703.66 |
| Inflation rate (%) | 9.514 | 7.291 | 7.578 | 9.858 | 23.429 | 26.966 |
| Volume of imports (% change) | 48.478 | -9.668 | -7.117 | 70.171 | -17.007 | -3.206 |
| Volume of imports (% change) | -9.422 | 29.176 | -5.259 | 16.381 | 0.583 | 2.219 |
| Government revenue (% of GDP) | 14.634 | 25.798 | 27.091 | 29.208 | 27.269 | 28.963 |
| Government expenditure (% of GDP) | 10.471 | 24.652 | 33.049 | 32.322 | 32.836 | 34.965 |

*Source*: Author's compilation using IMF database.

After 10 years of sustained peace and steady economic progress, the economy plunged into recession and experienced successive budget deficit due to the outbreak of the EVD and other exogenous factors, such as the withdrawal of the UNMIL in 2018, whose budget had a significant impact on the country's GDP.

[9] ArcelorMittal is the world's largest steel producing company and was the first largest private investment since the war ended. They became the highest tax contributor to the government for many years.

**Appendix 3**
**Summary of the Literature Review**

| Title | Author(s) | Method | Impact of Ebola | Variables | Significance level | Focus |
|---|---|---|---|---|---|---|
| Short/Medium Term Impact of the Ebola virus | World Bank (2014a) | Commutable General Equilibrium model | Negative | GDP | n/a | West Africa |
| Ebola, jobs and economic activity in Liberia | Bowles et al. (2016) | Difference-in-Difference | Decline in economic activity and jobs | Firms | **statistically significantly | Liberia |
| Assessing the International Spreading Risk Associated with the 2014 West African Ebola | Gomes et al. (2014) | Global Epidemic and Mobility Model | Low | airline passenger/ aviation | *not significant | World |
| Estimating the Economic Impact of the Ebola Epidemic | Evans et al. (2014) | Computable General Equilibrium Models | Economic decline | GDP growth | n/a | West Africa |
| The Economic and Social Burden of the 2014 Ebola Outbreak in West Africa | Huber et al. (2018) | Systematic review of the grey and published literature | -Reduction in economic growth<br>-Long-term impact of social factors | GDP growth and value of statistical life (VSL) | n/a | West Africa |
| Economic and Political Impact of Ebola Virus Disease. | Qureshi (2016) | Systematic analysis | Negative effect on GDP growth | GDP growth | n/a | West Africa |
| The effects of Ebola virus on the economy of West Africa through the trade channel | Adegun (2014) | Systematic analysis | -Reduce production<br>-Contraction in GDP | GDP | n/a | West Africa |
| Impact of a hypothetical infectious disease outbreak on US exports and export-based jobs. | Bambery et al (2018) | Illustrative Outbreak Scenario | Decline in GDP (uneven) across all sector | GDP | n/a | West Africa |
| The Politics of Disease Epidemics: a Comparative Analysis of the SARS, Zika, and Ebola Outbreaks | Kapiriri and Ross (2020) | Review of peer-reviewed | Further increase poverty and income inequality | Poverty level | n/a | World |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sierra Leone Selected Issues: Measuring the impact of the Ebola Virus Disease epidemic on economic growth in Sierra Leone | IMF (2016b) | Difference-in-Difference | -Negative impact on growth during the first year of the EVD | Economic growth | ** Significant | Sierra Leone |
| Long-distance effects of epidemics: Assessing the link between the 2014 West Africa Ebola outbreak and U.S. exports and employment | Kostova et al. (2019) | Difference-in-Difference | Aggregate reduction in U.S. merchandise exports | Merchandise export | *Not significance | World |

*Source*: Author's compilation

## Appendix 4

Detailed technical description of the synthetic control method

Considering the SCM mode's intuition in section 3.2, the analysis herein does not depend on a household data, and as such, our analysis likewise may follow a random process. Therefore, the extent of the epidemic has no impact on the predictor variables prior to the EVD. Hence, consider $EVD_{it}^{I}$ be the observable variable of interest for *i in* time *t* as the unit that were exposed to Ebola in the periods $T_o+1$ to T. However, this study estimate from $\in \{1,\ldots, T_o\}$ as the period $T_o+1$ to T and $i \in \{1,...,N\}$. So, countries $i = 1,\ldots..,J+1$, and both the pre-treatment and post-treatment periods are denoted by $t = 1,\ldots..T$, therefore, $EVD_{it}^{I} = EVD_{it}^{N}$.

With that, consider $\lambda_{it} = EVD_{it}^{I} - EVD_{it}^{N}$ as the causal impact of the Ebola epidemic for region *i* in time *t* if region *i* is vulnerable to the shock at time t in the periods $T_0 + 1$, $T_o + 2,...,T$ - where $1 \leq T_0 < T$ and zero otherwise (Cavallo et al. 2013:1551). Nevertheless, it can hypothesize that the shock in the model estimation is the outbreak of the 2014 Ebola epidemic and its future implication for the macro-economy.

$$\text{Hence: } EVD_{it}^{I} = EVD_{it}^{N} + \lambda_{it} \quad (1)$$

As previously mentioned, consider $D_{it}$ as for the 1 if region *i* was vulnerable to the Ebola shock at time t and zero if not. In a way, the observable variables of interest for country i at time t will written as:

$$EVD_{it}^{I} = EVD_{it}^{N} + \lambda_{it} D_{it} \quad (2)$$

Of the core countries mostly affected by Ebola, this scope of this paper relies on its impact on the Liberian economy. We consider Liberia – let say value 'one' was vulnerable to the epidemic after the pre-intervention periods $T_o$. Imagine, $1 \leq T_o < T$, we can deduce below:

$$D_{it} = \begin{cases} 1 \text{ if } i = 1 \text{ and } t > T_o \\ 0 \quad \text{if not} \end{cases}$$

Similarly, the outcome variable that this study explores in estimating the impact of the Ebola epidemic is now $\lambda_1 T_o + 1,\ldots, \lambda_1 T$

Where $t > T_o$,

$$\text{Then, } \lambda_{1t} = EVD^{I} - EVD^{N} = EVD_{1t} - EVD^{N} \quad (3)$$

Note: Since $EVD_{1t}^{I}$ is the observable unit that was affected by the intervention, thus, to estimate $\lambda_{1t}$, we need to determine the outcome of the unit that was not affected by the intervention $EVD_{1t}^{N}$.

Hereafter, we now zoom in on the weighted matrix with (J x 1) as the vector of the weights $W = (w_2,\ldots, w_J+1)'$ in a way, $wj \geq 0$ for $j = 2,\ldots,J + 1$ and $w_2 + w_3 + w_4\ldots+w_{J+1} = 1$. Therefore, each weight W in the setup denotes a synthetic control. Thus, it is the weighted average of all the countries classified as the control group.

Imagine if we have weights of $(w^*,\ldots,w^*_{+1})$,

$$\text{Hence, } \sum_{j=2}^{J+1} w^*_j Y_{j1} = Y_{11,} \quad (4)$$

$$\sum_{j=2}^{J+1} w^*_j Y_{jT_o} = Y_{1T_o}, \quad (5)$$

and

$$\sum_{j=2}^{J+1} w^*_j Z_j = Z_j \quad (6)$$

In a way, if $\hat{\lambda}_{1t} = Y_{1t} - \sum w^*_j Y_{j1}$

Then, consider $t \in \{ T_o + 1,\ldots,T \}$ as an estimator of $\hat{\lambda}_{1t}$. For the following equations four–six to hold, it will rely on $(Y_{11},\ldots, Y_{1T_o}, Z'_1)$ as the property of the convex hull of $\{(Y_{21},\ldots,Y_{2T_o}, Z'_2),\ldots,(Y_{J+11,\ldots,}Y_{J+1T_o}, Z'_{J+1})\}$. Thus, relying on this notation, it is deduced that the weights do not exist. However, the synthetic control estimation is then carefully chosen so they can hold (Abadie et al. 2010: 495).

Following Cavallo et al. (2013) implementation, we rely on this intuition: consider Liberia as the country significantly affected by the outbreak of Ebola as Y1t, (t = 1,…,T) for the observable treatment T periods incorporating our different outcome variables in the model, and similarly; all other African countries that were not negatively affected by the 2014-2016 Ebola epidemic as (Yjt, (j = 2,…,J + 1; t = 1,…,T). As previously mentioned, $T_1 = T - T_0$ is considered as the post-Ebola period. Therefore, consider Y1 as the ($T_1$ x 1) by means of the vector of the pre-Ebola outcome for Liberia and Y0 as the ($T_1$ x J) matrix of post-Ebola outcome for countries that did not experience the Ebola epidemic. In a way, consider the ($T_0$ x 1) vector K = (k1,…, kTo) represents a linear combination of the pre-Ebola variables as

$\overline{Y_i}^K = \sum_{S=1}^{T_0} k_s Y_{is}$. So, the linear combination let 'M' can be deduced as the vectors $K_1,\ldots,K_M$.

Again, $X_1 = (Z'_1; \overline{Y_1}^K,\ldots, \overline{Y}^{K_M})'$ be consider as (k x 1) the vector of the pre-Ebola output of the outcome variables of interest that were not negatively impacted due to the Ebola epidemic in Liberia, by means of k = r+M. Likewise, consider $X_0$ as (k x J) matrix with similar characteristics vis-à-vis the outcome variables of interest for other countries in the donor pool that were not affected by the Ebola epidemic.

In a way, the $j^{th}$ pillar for $X_0$ is then written as $(Z'j; \overline{Y_j}^{K1},\ldots, \overline{Y_j}^{K_M})'$.

With that in mind, the SCM then use a vector W* to minimizing the distance such $||X_1 - X_0W||$ that exist between the treated and untreated units as $X_1$ and $X_oW$. However, to determine if there exist any disparity concerning the distance, we will then explore

$||X_1 - X_0W||_v = \sqrt{(X_1 - X_0W)'V(X_1 - X_0W)}$ where V is denoted as the as (k x k) symmetric and positive semidefinite matrix. In a way, V, as seen in the model, influences the estimator's mean square error. As a result, V assigns weights to $X_0$ and $X_1$ to reduce the synthetic control estimator's mean square error.

## Appendix 5

Detailed description of the inference method

Regarding the description of the inference method in section 3.3, the standard error usually evaluates the uncertainty and measurement error within the macroeconomic dataset. Therefore, the usages of such macro-level data for the inference would most certainly equate to zero standard error (Abadie et al. 2010:496). Still, it is no guarantee whether these uncertainties about the predictor of the outcome variables will be eliminated even with the perfect macroeconomic dataset. For instance, the doubt about the data will always occur in such research to evaluate the economic effect of EVD because of the inability of the comparison or the untreated unit to replicate the synthetic counterfactual that resembles the actual Liberia in the absence of the EVD shock.

Following Cavallo et al. (2013), the assumption that the comparison unit will replicate the synthetic counterfactual of the treated unit creates more uncertainty. In a way, it is problematic to hypothesize the characteristics of the Liberian economy in the absence of the Ebola epidemic. As a result, the dataset's size, whether micro or macro level, does not eliminate the problem of uncertainty in the estimates. Since this research's main result relies on a small donor pool size, it is important to state that macroeconomic inferential procedures are not the only options in comparative studies considering the insignificant nature of the untreated units (Abadie and Gardeazabal, 2010; Abadie et al. 2015). These studies deduced that a permutation assessment (hereafter placebo or randomization) should be explored in the determination of inference method in the study of this nature regardless of the potential comparison countries, i.e., the technique herein when applied can be used with any nature and size of the dataset available as in the case for this research. As such, it is important to determine if the difference between Liberia and synthetic control Liberia is substantial or not. Therefore, the placebo test can be used to evaluate the statistical significance and guarantee certainty always to estimate the distribution of the projected impact of the Ebola epidemic.

Therefore, as explained by Abadie et al. (2015), the placebo test applied the synthetic control technique to all untreated countries in the donor pool. This technique allows us to isolate the synthetic control for the country mainly affected by the EVD to determine if the shock was of high proportion regarding countries chosen at random and not affected by the EVD. Hence, in the SCM application, if the placebo study reconsiders each country in the control group during the same period, it's more likely coined as the distribution of "in place" placebo impacts (Galiani and Quistorff, 2017:836). Ideally, it can be deduced that the economic impact of the EVD would be compromised if we consider the performance of the economy during the crisis with respect to other countries that did not experience Ebola. Therefore, our estimation herein relies on mathematical notations from two studies. Firstly, to determine the immediate impact of the EVD in the post-Ebola period, Cavallo et al. (2013) consider inference about negative estimates. To determine the p-value - level of significance for the estimated impact of the Ebola epidemic in Liberia, let consider:

$$\text{p-value}_l = \Pr\left(\hat{\lambda}^{PL}_{1,l} < \hat{\lambda}_{1,l}\right) = \frac{\sum_{j=2}^{J+1} I\left(\hat{\lambda}^{PL(j)}_{1,l} < \hat{\lambda}_{1,l}\right)}{\text{num. of control countries}}$$

$$= \frac{\sum_{j=2}^{J+1} I\left(\hat{\lambda}^{PL(j)}_{1,l} < \hat{\lambda}_{1,l}\right)}{J}$$

Where $\lambda^{PL(j)}_{1,l}$ denotes the Ebola's impact when a country that was not affected by the shock j is assigned a placebo Ebola epidemic during the same period as Liberia 1. When we calculate $\lambda^{PL(j)}_{1,l}$ with respect to every country j in the untreated unit for Liberia 1, however, it can be deduced that the evaluation of the placebo impact $\hat{\lambda}_{1,l}$ will most certainly be positions in the analysis.

Secondly, relying on Galiani and Quistorff (2017) notations, we can zoom on the estimated impact of the Ebola epidemic in Liberia as $\lambda_{1t}$, whereas countries unaffected by Ebola as $\lambda^{PL}_{1t} = \{ \hat{\lambda}_{jt} : j \neq 1 \}$. Therefore, our two-sided p-value will be denoted as:

$$\text{p-value} = \Pr\left(|\hat{\lambda}^{PL}_{1t}| \geq |\hat{\lambda}_{1t}|\right)$$

$$= \frac{\sum_{j \neq 1} 1(|\hat{\lambda}_{jt}| \geq |\hat{\lambda}_{1t}|)}{J}$$

Furthermore, since the traditional inferential approach may not be suitable for the main pool herein, we rely on an additional (alternative) method to determine the inference, as suggested by Abadie et al. (2010). This alternative approach deals with the constraint that may characterize the donor pool setup and the Ebola cut-off point. This is done by deciding the pre-Ebola year gap between Liberia and synthetic control Liberia to determine the discrepancy thereof in the entire treatment years. In a way, this alternative approach allows for us to deal with p-values that are too high or excessively conservative by assessing the discrepancy which characterizes the treatment period against the pre-Ebola estimated impacts. This is conducted by dividing the observed effect of the post-Ebola estimate by the pre-Ebola root mean square percentage error (RMSPE). However, the p-value, in this case, tends towards being a portion of all countries in the donor pool that were not affected by the Ebola but had similar characteristics to that of Liberia (see Galiani and Quistorff, 2017: 836-837). In context, this alternative approach has been classified as the Adjusted Non-Restricted Donor Sample method (ANRDS) by Villar and Papyrakis (2017:798).

## Appendix 6
## Description and data source

| Variable | Description of the data | Source of the data |
|---|---|---|
| ***Outcome variables*** | | |
| Log of GDP | Current price – U.S. dollars | IMF (2020) |
| Log of GDP per capita | Current price - U.S. dollars | World Bank (2020b) |
| GDP growth | Annual % | World Bank (2020b) |
| Unemployment | Total (% of total labour force) | World Bank (2020b) |
| Inflation rate | Average consumer prices % change | IMF (2020) |
| ***Control variables*** | | |
| Population size | Persons | IMF (2020) |
| Population growth | Annual percent | World Bank (2020b) |
| General government total expenditure | % of GDP | IMF (2020) |

*Source*: Author's compilation

**Appendix 7**
**Assigned weights and Donor Pool**

| Outcomes: | Unemployment | Inflation | GDP | GDP Growth | GDP Per Capita |
|---|---|---|---|---|---|
| Pool | Weight | Weight | Weight | Weight | Weight |
| Algeria | 0 | 0 | 0 | 0 | 0 |
| Angola | 0 | 0 | 0.003 | 0 | 0 |
| Benin | 0 | 0 | 0 | 0 | 0 |
| Botswana | 0 | 0 | 0 | 0 | 0 |
| Burkina Faso | 0 | 0 | 0 | 0 | 0 |
| Burundi | 0.101 | 0 | 0.064 | 0 | 0.65 |
| Cabo Verde | 0 | 0 | 0 | 0 | 0 |
| Cameroon | 0 | 0 | 0 | 0 | 0 |
| C.A.R* | 0 | 0.282 | 0 | 0.028 | 0 |
| Chad | 0.585 | 0 | 0 | 0 | 0 |
| Comoros | 0 | 0 | 0 | 0 | 0 |
| Djibouti | 0 | 0 | 0 | 0 | 0 |
| Egypt | 0 | 0 | 0.001 | 0 | 0 |
| E. Guinea | 0 | 0.298 | 0 | 0.009 | 0 |
| Eritrea | 0 | 0 | 0 | 0 | 0.138 |
| Eswatini | 0.016 | 0 | 0 | 0 | 0 |
| Ethiopia | 0 | 0.067 | 0.026 | 0 | 0 |
| Gambia | 0 | 0 | 0 | 0 | 0 |
| Ghana | 0 | 0 | 0 | 0 | 0 |
| Guinea Bissau | 0.072 | 0 | 0 | 0 | 0 |
| Kenya | 0 | 0 | 0 | 0 | 0 |
| Lesotho | 0 | 0 | 0 | 0 | 0 |
| Libya | 0 | 0 | 0 | 0.011 | 0 |
| Madagascar | 0.05 | 0 | 0 | 0 | 0 |
| Malawi | 0 | 0.036 | 0 | 0 | 0 |
| Mauritania | 0 | 0 | 0 | 0.476 | 0 |
| Mauritius | 0 | 0 | 0 | 0 | 0 |
| Morocco | 0 | 0 | 0 | 0 | 0 |
| Mozambique | 0 | 0.041 | 0 | 0 | 0.104 |
| Namibia | 0 | 0 | 0 | 0 | 0 |
| Niger | 0.099 | 0 | 0.042 | 0.459 | 0.108 |
| Rwanda | 0.062 | 0 | 0 | 0.017 | 0 |
| Sao Tome* | 0 | 0.224 | 0.843 | 0 | 0 |
| Seychelles | 0.078 | 0.051 | 0 | 0 | 0 |
| Tanzania | 0 | 0 | 0 | 0 | 0 |
| Togo | 0 | 0 | 0 | 0 | 0 |
| Tunisia | 0.016 | 0 | 0 | 0 | 0 |
| Zambia | 0 | 0 | 0 | 0 | 0 |
| Zimbabwe | 0 | 0 | 0.021 | 0 | 0 |

*Central African Republic
*Sao Tome & Principe

*Source*: Author's compilation

**Appendix 8**
**Assigned weights and large donor pool (developing countries)**

| Outcomes: | Inflation | GDP | GDP Growth | GDP Per Capita | Unemployment |
|---|---|---|---|---|---|
| Pool | Weight | Weight | Weight | Weight | Weight |
| Afghanistan | 0 | 0 | 0 | 0 | 0.002 |
| Algeria | 0 | 0 | 0 | 0 | 0.001 |
| Angola | 0 | 0 | 0 | 0 | 0.002 |
| Argentina | 0 | 0 | 0 | 0 | 0.001 |
| Aruba | 0 | 0 | 0 | 0 | 0.006 |
| Bahama, The | 0 | 0 | 0 | 0 | 0.519 |
| Bahrain | 0 | 0 | 0 | 0 | 0.006 |
| Bangladesh | 0 | 0 | 0 | 0 | 0.001 |
| Barbados | 0 | 0 | 0 | 0 | 0.002 |
| Belize | 0 | 0 | 0 | 0 | 0.002 |
| Benin | 0 | 0 | 0 | 0 | 0.011 |
| Bhutan | 0 | 0 | 0 | 0 | 0.005 |
| Bolivia | 0 | 0 | 0 | 0 | 0.002 |
| Botswana | 0 | 0 | 0 | 0 | 0.001 |
| Brazil | 0 | 0 | 0 | 0 | 0.001 |
| Brunei Darussalam | 0 | 0 | 0 | 0 | 0.003 |
| Burkina Faso | 0 | 0 | 0 | 0 | 0.003 |
| Burundi | 0 | 0.424 | 0 | 0.341 | 0.002 |
| Cabo Verde | 0 | 0 | 0 | 0 | 0.002 |
| Cambodia | 0.07 | 0 | 0 | 0 | 0.003 |
| Cameroon | 0 | 0 | 0 | 0 | 0.002 |
| C.A.R* | 0.243 | 0 | 0.028 | 0.041 | 0.004 |
| Chad | 0 | 0 | 0 | 0 | 0.005 |
| Chile | 0 | 0 | 0 | 0 | 0.002 |
| China | 0 | 0 | 0 | 0 | 0.002 |
| Colombia | 0 | 0 | 0 | 0 | 0.001 |
| Comoros | 0 | 0 | 0 | 0 | 0.004 |
| Costa Rica | 0 | 0 | 0 | 0 | 0.002 |
| Djibouti | 0 | 0 | 0 | 0 | 0.002 |
| Dominica | 0 | 0 | 0 | 0 | 0.005 |
| Dominican Rep | 0 | 0 | 0 | 0 | 0.002 |
| Ecuador | 0 | 0 | 0 | 0 | 0.001 |
| El Salvador | 0 | 0 | 0 | 0 | 0.002 |
| Egypt | 0 | 0 | 0 | 0 | 0.001 |
| E. Guinea | 0 | 0 | 0 | 0 | 0.004 |
| Eritrea | 0 | 0 | 0 | 0 | 0.002 |
| Eswatini | 0 | 0 | 0 | 0 | 0.002 |
| Ethiopia | 0.061 | 0 | 0 | 0.29 | 0.001 |
| Fiji | 0 | 0 | 0 | 0 | 0.003 |
| Gambia, The | 0 | 0 | 0 | 0 | 0.027 |
| Ghana | 0 | 0 | 0 | 0 | 0.002 |
| Grenada | 0 | 0 | 0 | 0 | 0.006 |
| Guatemala | 0 | 0 | 0 | 0 | 0.004 |
| Guinea Bissau | 0 | 0 | 0 | 0 | 0.005 |
| Guyana | 0 | 0 | 0 | 0 | 0.002 |

| | | | | | |
|---|---|---|---|---|---|
| Haiti | 0 | 0 | 0.026 | 0 | 0.02 |
| Honduras | 0 | 0 | 0 | 0 | 0.001 |
| India | 0 | 0 | 0 | 0 | 0.001 |
| Indonesia | 0 | 0 | 0 | 0 | 0 |
| Iran | 0 | 0 | 0 | 0 | 0.001 |
| Iraq | 0 | 0 | 0 | 0 | 0.001 |
| Jamaica | 0 | 0 | 0 | 0 | 0.005 |
| Jordan | 0 | 0 | 0 | 0 | 0.001 |
| Kenya | 0 | 0 | 0 | 0 | 0.002 |
| Kiribati | 0 | 0 | 0 | 0 | 0.002 |
| Kosovo | 0 | 0 | 0 | 0 | 0.002 |
| Kuwait | 0 | 0 | 0 | 0 | 0.004 |
| Lao P.D.R | 0 | 0 | 0 | 0 | 0.003 |
| Lebanon | 0 | 0 | 0 | 0 | 0.002 |
| Lesotho | 0 | 0 | 0 | 0 | 0.001 |
| Libya | 0 | 0 | 0.017 | 0 | 0.001 |
| Madagascar | 0 | 0 | 0 | 0 | 0.002 |
| Malawi | 0 | 0 | 0 | 0 | 0.002 |
| Malaysia | 0 | 0 | 0 | 0 | 0.002 |
| Maldives | 0 | 0.334 | 0.097 | 0 | 0.063 |
| Mauritania | 0 | 0 | 0.347 | 0 | 0.003 |
| Mauritius | 0 | 0 | 0 | 0 | 0.002 |
| Mexico | 0 | 0 | 0 | 0 | 0.002 |
| Micronesia | 0 | 0 | 0 | 0 | 0.001 |
| Mongolia | 0 | 0 | 0 | 0 | 0.001 |
| Morocco | 0 | 0 | 0 | 0 | 0.001 |
| Mozambique | 0 | 0 | 0 | 0 | 0.002 |
| Myanmar | 0 | 0 | 0 | 0 | 0.002 |
| Namibia | 0 | 0 | 0 | 0 | 0.002 |
| Nauru | 0 | 0 | 0 | 0 | 0.003 |
| Nepal | 0 | 0 | 0 | 0 | 0.002 |
| Nicaragua | 0 | 0 | 0 | 0 | 0.005 |
| Niger | 0 | 0 | 0.414 | 0.303 | 0.002 |
| Oman | 0.114 | 0 | 0 | 0 | 0.002 |
| Pakistan | 0 | 0 | 0 | 0 | 0 |
| Palau | 0 | 0 | 0 | 0 | 0.003 |
| Panama | 0 | 0 | 0 | 0 | 0.002 |
| Papua N Guinea | 0 | 0 | 0 | 0 | 0.003 |
| Paraguay | 0 | 0 | 0 | 0 | 0.002 |
| Peru | 0 | 0 | 0 | 0 | 0.001 |
| Philippines | 0 | 0 | 0 | 0 | 0.001 |
| Qatar | 0 | 0.003 | 0 | 0 | 0.131 |
| Rwanda | 0 | 0 | 0 | 0 | 0.004 |
| Samoa | 0 | 0 | 0 | 0 | 0.003 |
| Sao Tome & Principe | 0 | 0.239 | 0 | 0 | 0.001 |
| Saudi Arabia | 0 | 0 | 0 | 0 | 0.001 |
| Seychelles | 0 | 0 | 0 | 0 | 0.001 |
| Solomon Islands | 0 | 0 | 0 | 0 | 0.002 |
| Sri Lanka | 0 | 0 | 0 | 0 | 0.001 |
| Suriname | 0 | 0 | 0 | 0 | 0.002 |

| | | | | | |
|---|---|---|---|---|---|
| Syria | 0 | 0 | 0 | 0 | 0.002 |
| Tajikistan | 0 | 0 | 0 | 0 | 0.002 |
| Tanzania | 0 | 0 | 0 | 0 | 0.001 |
| Thailand | 0 | 0 | 0 | 0 | 0.001 |
| Timor-Leste | 0 | 0 | 0 | 0 | 0.005 |
| Tonga | 0 | 0 | 0 | 0 | 0.002 |
| Trinidad & Tobago | 0.2 | 0 | 0 | 0 | 0.002 |
| Togo | 0 | 0 | 0 | 0 | 0.002 |
| Tunisia | 0 | 0 | 0 | 0 | 0.002 |
| Turkey | 0 | 0 | 0 | 0 | 0.001 |
| Turkmenistan | 0 | 0 | 0.072 | 0 | 0.001 |
| United Arab Emirates | 0.058 | 0 | 0 | 0 | 0.004 |
| Uruguay | 0 | 0 | 0 | 0 | 0.001 |
| Vanuatu | 0 | 0 | 0 | 0 | 0.004 |
| Venezuela | 0.078 | 0 | 0 | 0 | 0.001 |
| Viet Nam | 0 | 0 | 0 | 0 | 0.001 |
| Yemen | 0 | 0 | 0 | 0 | 0.002 |
| Zambia | 0 | 0 | 0 | 0 | 0.001 |
| Zimbabwe | 0 | 0 | 0 | 0.024 | 0.004 |

*Central African Republic

*Source*: Author's compilation

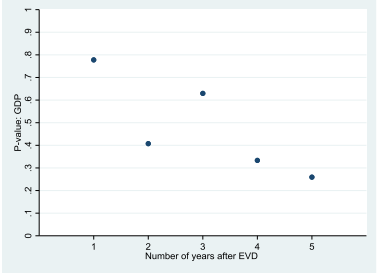
## Appendix 9A
## Guinea: means for unemployment and GDP per capita

| | Guinea | Synthetic | Guinea | Synthetic |
|---|---|---|---|---|
| Unemployment rate (2004) | 4.509 | 4.510 | | |
| 2006 | 4.333 | 4.338 | | |
| 2008 | 4.199 | 4.196 | | |
| 2010 | 4.487 | 4.492 | | |
| 2012 | 4.502 | 4.502 | | |
| 2013 | 4.518 | 4.521 | | |
| Gov't Expenditure (2004 - 2013) | 14.746 | 16.755 | | |
| Population size (2004 - 2013) | 10.494 | 12.828 | | |
| Population growth (2004 - 2013) | 2.186 | 2.153 | | |
| GDP Per Capita (2004) | | | 563.326 | 497.923 |
| 2006 | | | 453.403 | 499.772 |
| 2008 | | | 715.096 | 673.370 |
| 2010 | | | 672.424 | 664.926 |
| 2012 | | | 717.050 | 724.808 |
| 2013 | | | 769.003 | 760.849 |
| Gov't Expenditure (2004-2013) | | | 14.746 | 20.661 |
| Population size (2004-2013) | | | 10.494 | 7.304 |
| Population growth (2004-2013) | | | 2.186 | 2.516 |

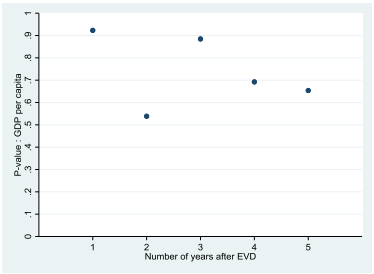
*Source*: Author's compilation.

## Appendix 9B
## Guinea outcome variables – level of significance

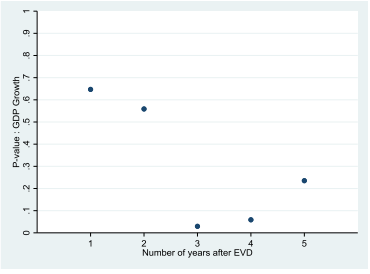
GDP: Adjusted p-value



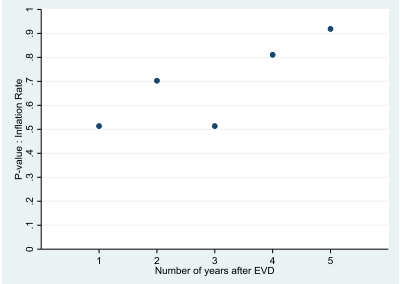

GDP per capita: Adjusted p-value



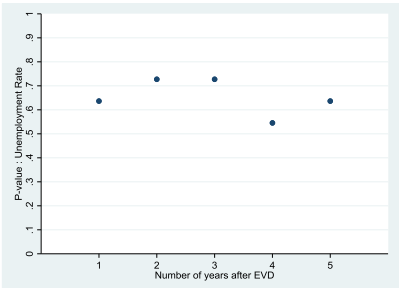

GDP Growth: Adjusted p-value




Inflation: Adjusted p-value




Unemployment: Adjusted p-value




*Source*: Author's compilation.

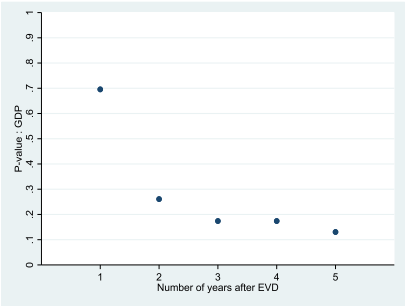
**Appendix 10A**
**Sierra Leone - means for unemployment and GDP outcomes**

| | Sierra Leone | Synthetic | Sierra Leone | Synthetic |
|---|---|---|---|---|
| Unemployment rate (2004) | 3.42 | 3.438 | | |
| 2006 | 3.512 | 3.539 | | |
| 2008 | 3.627 | 3.571 | | |
| 2010 | 4.157 | 4.155 | | |
| 2012 | 4.441 | 4.433 | | |
| 2013 | 4.597 | 4.593 | | |
| Gov't Expenditure (2004 - 2013) | 17.7087 | 19.417 | | |
| Population size (2004 - 2013) | 6.049 | 11.846 | | |
| Population growth (2004 - 2013) | 2.774 | 2.626 | | |
| GDP (2004) | | | 1.439 | 1.481 |
| 2006 | | | 1.884 | 1.836 |
| 2008 | | | 2.511 | 2.569 |
| 2010 | | | 2.578 | 2.928 |
| 2012 | | | 3.802 | 4.092 |
| 2013 | | | 4.916 | 4.499 |
| Gov't Expenditure (2004-2013) | | | 17.708 | 26.101 |
| Population size (2004-2013) | | | 6.049 | 5.531 |
| Population growth (2004-2013) | | | 2.774 | 2.334 |

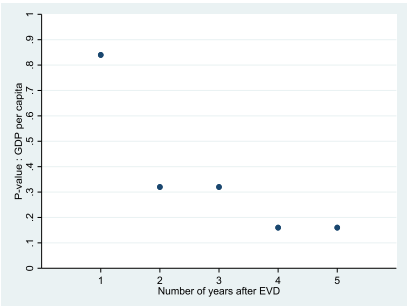
*Source*: Author's compilation.

**Appendix 10B**
**Sierra Leone outcome variables – level of significance**

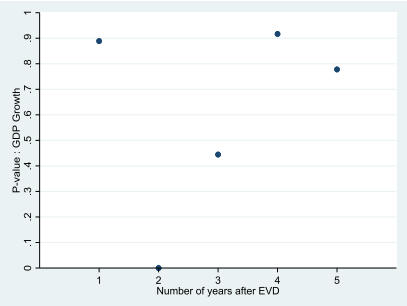
GDP: Adjusted p-value



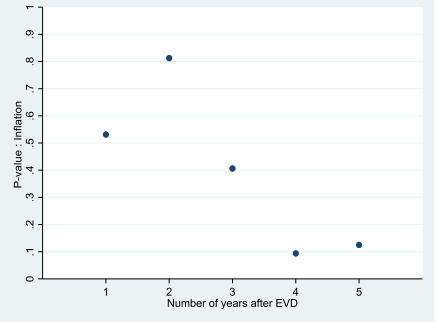

GDP per capita: Adjusted p-value



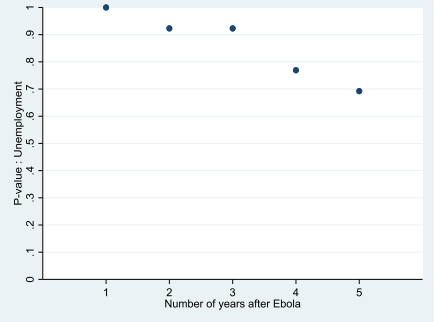

GDP Growth: Adjusted p-value




Inflation: Adjusted p-value




Unemployment: Adjusted p-value




*Source*: Author's compilation.