

Estimating the Economic Impact of the Ebola Epidemic: Evidence from Computable General Equilibrium Models

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Abstract: Beyond the terrible toll in human lives and suffering, the Ebola epidemic which affected West Africa continues to have a measurable economic impact on several of the most economically fragile countries in the region. This paper uses two computable general equilibrium models to estimate the impact on West Africa as a whole, as well as specific impacts for the directly affected countries. Two alternative scenarios are used: a “moderate Ebola” scenario corresponding to the actual containment within the three most severely affected countries, and a “High Ebola” scenario corresponding to the damage that a slower containment in the core three countries and broader regional contagion might have brought. The paper discusses the implications for the macroeconomic resilience of the region, the distributional impacts of the epidemic within the most affected countries and the likely effect of the disease outbreak on the already hard task of fighting poverty in this region.

JEL Codes: I15, C54, E17

Keywords: Ebola, Infectious Disease, Economic Growth, CGE Modeling

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Section 1: Introduction

Overview

The 2014 outbreak of the Ebola Virus Disease² in West Africa³ has taken a devastating human toll. Although the outbreak originated in rural Guinea, it has hit hardest in Liberia and Sierra Leone, in part because it has reached urban areas in these two countries, a factor that distinguishes this outbreak from previous episodes elsewhere. As of October 3, 2014, there had been 3,431 recorded deaths out of 7,470 probable, suspected, or confirmed cases of Ebola.⁴ Experts fear that the true numbers may be two to four times larger, due to underreporting.⁵ Misery and suffering have been intense, especially in Liberia where doctors have had to turn patients away for lack of space in Ebola treatment centers.

Inevitably, before the outbreak is contained the human impacts will increase considerably beyond these numbers. Epidemiological estimates are acknowledged as highly uncertain and are not the subject of this note. What is certain is that limiting the human cost will require significant financial resources, a rapid response, and a concerted partnership between international partners and the affected countries. Particularly in Liberia and Sierra Leone, government capacity is already overrun and the epidemic is impacting economic activity and budgetary resources.

This paper informs the response to the epidemic by presenting best-effort estimates of its macroeconomic and fiscal effects. Any such exercise is necessarily highly imprecise due to limited data and many uncertain factors, but it is still necessary in order to plan the economic assistance that must accompany the immediate humanitarian response. The goal is to help affected countries to recover and return to the robust economic growth they had experienced until the onset of this crisis.

Channels of impact

The impact of the Ebola epidemic on economic well-being operates through two distinct channels. First are the direct and indirect effects of the sickness and mortality themselves, which consume health care resources and subtract people either temporarily or permanently from the labor force. Second are the behavioral effects resulting from the fear of contagion, which in turn leads to a fear of association with others and reduces labor force participation, closes places of employment, disrupts transportation, motivates some governments to close land borders and restrict entry of citizens from afflicted countries, and motivates private decision-makers to disrupt trade, travel and commerce by canceling scheduled commercial flights and reduction in shipping and cargo service. In the recent history of infectious disease outbreaks such as the SARS epidemic of 2002-2004 and the H1N1 flu epidemic of 2009, behavioral effects

² Hereafter the term Ebola is used to refer to the virus, the disease or the epidemic outbreak.

³ West Africa, in this analysis, includes Benin, Burkina Faso, Cabo Verde, Cameroon, Cote d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

⁴ World Health Organization, "[Ebola Response Roadmap Update](#)," October 3, 2014.

⁵ World Health Organization, "[Ebola Response Roadmap](#)," August 28, 2014. The U.S. Centers for Disease Control use an underreporting factor of 2.5 (Meltzer et al., "[Estimating the Future Number of Cases in the Ebola Epidemic – Liberia and Sierra Leone, 2014-2015](#)," 2014).

are believed to have been responsible for as much as 80 or 90 percent of the total economic impact of the epidemic.⁶

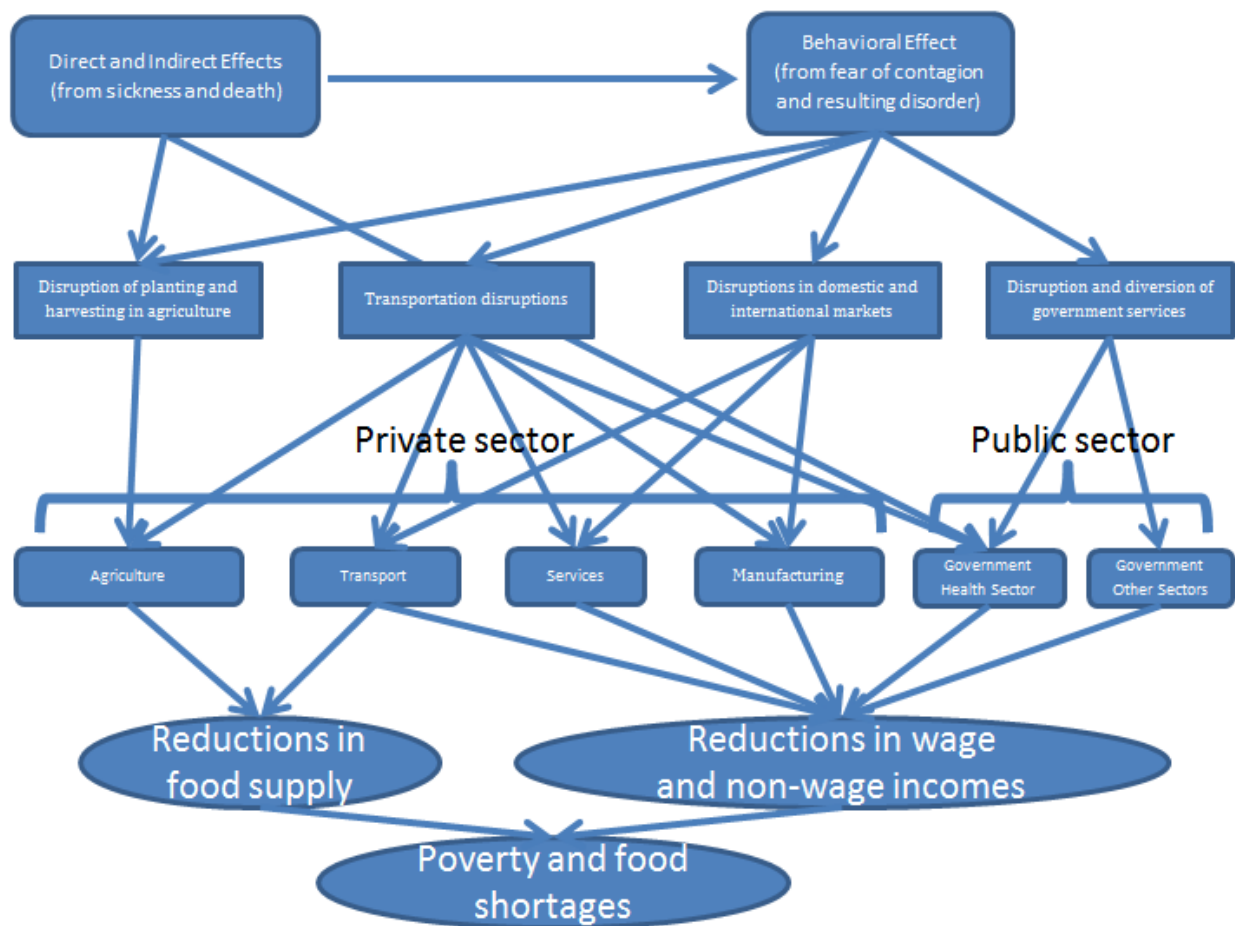
The first of these channels, consisting of the labor force and health expenditure impacts arising from the direct and indirect effects of the epidemic, closely tracks the number of suspected and actual cases of the disease (see Figure 1). The second, or behavioral channel, is less sensitive to the actual number of cases of Ebola because it is driven by aversion behavior, and it is potentially more sensitive to information and public response. For example, employers who learn how to protect themselves and their workers from contagion will reopen workplaces and resume production and investment. Similarly, governments that demonstrate they have controlled the epidemic and have resumed normal activity will inspire confidence in both domestic and international economic agents to resume their former pace of economic intercourse.

Structure of the Paper

This paper presents estimates of the economic impact of the Ebola outbreak in West Africa for 2014 and 2015. Section 2 presents computable general equilibrium model estimates for the impact in Liberia, and Section 3 presents estimates for West Africa as a whole. Section 4 concludes.

⁶ See, for example, Lee & McKibbin, "[Globalization and Disease: The Case of SARS](#)," Australian National University Working Paper No. 2003/16, August 2003.

Figure 1: Broad channels of short-term economic impact



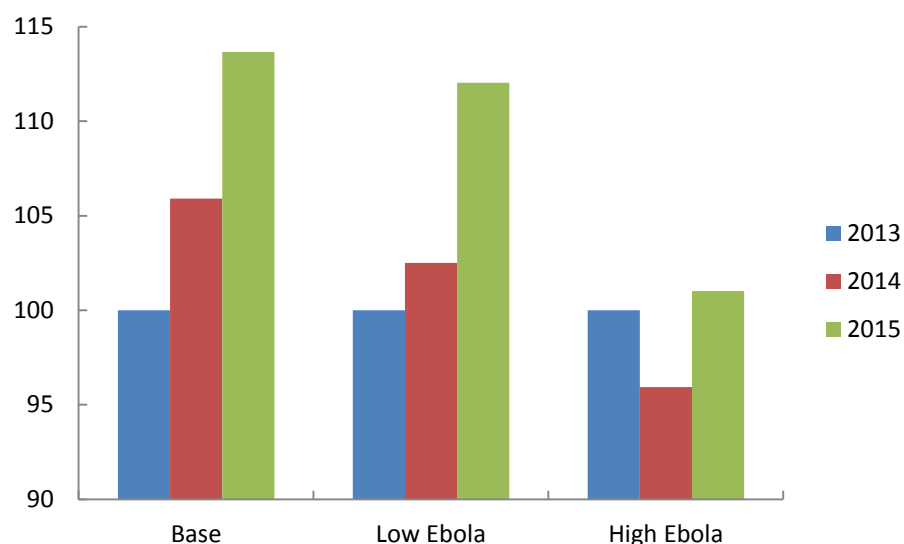
Section 2: Computable General Equilibrium Estimates for Liberia

In the case of Liberia, we begin with macroeconomic forecasts estimated jointly between the World Bank and the International Monetary Fund, incorporating the latest information (World Bank 2014). Those forecasts are used to seed the CGE analysis. (The assumptions and results of the MAMS analysis are laid out in more detail in Appendix 3.) Two scenarios are assessed, a Low Ebola scenario with fewer cases due to a relatively stronger government response in 2014, and a High Ebola scenario with more cases (over a longer time) due to a weaker government response in 2014. For each scenario, we develop a set of shocks to transactions, input coefficients, and factor supplies. For the Low Ebola case, the assumptions generate outcomes that, in terms of GDP (i.e., production) changes, are quite close to those generated by the existing macroeconomic forecasts (World Bank 2014). However, given that the methods are distinct, the results are not identical. For the High Ebola case, the assumptions are designed to explore the impact of a more severe (but still plausible) Ebola trajectory with a serious deterioration during the remaining months of 2014 before new cases come to an end during 2015.

Given these assumptions, the results for these simulations permit us to highlight how Liberia's economy reaches different outcomes under the Low and High Ebola cases. As shown in Figure 2 for Low Ebola, total

real GDP at factor cost (a measure of the quantity of production) declines compared to the base scenario during 2014 but returns to close to base levels in 2015, thanks to a significant growth catch-up as labor and other factor inputs that were underutilized in 2014 return to production, and Ebola-related impediments to domestic and foreign trade vanish. By contrast, for High Ebola, a severe worsening of the crisis toward the end of 2015 leads to severe factor underutilization, trade obstacles and other negative repercussions; in 2015, the crisis remains severe. As a result, real GDP losses during 2014 are more severe, and in 2015 the GDP gap between High Ebola and the two other scenarios increases further.

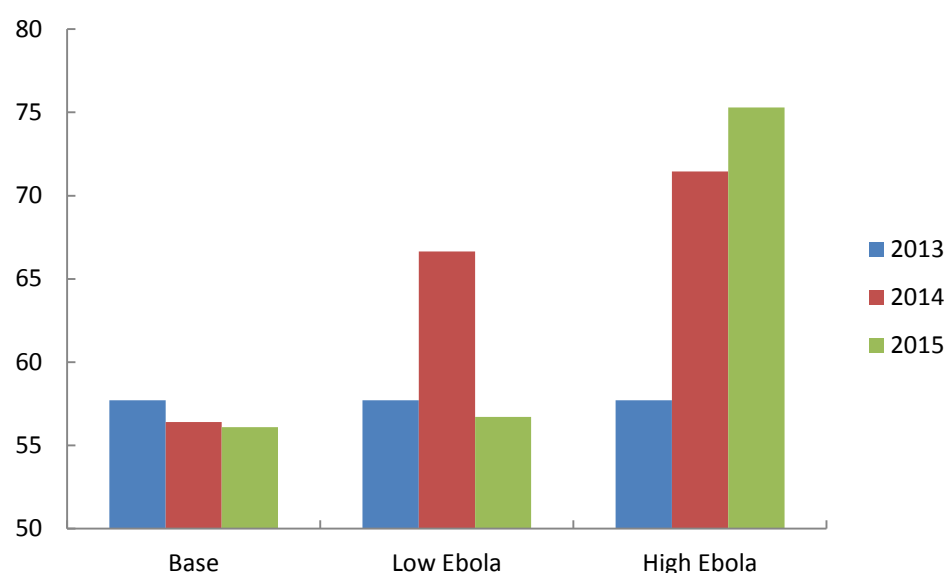
Figure 2: Liberia -- Real GDP at factor cost in 2013-2015 (Index: 2013 = 100)



The impact on per-capita household consumption is more severe than indicated by the GDP figures – one significant consequence of the Ebola-related interruption of trade is severe efficiency losses, reflected in increasing wedges between consumer and producer prices, which reduce consumer purchasing power. Without Ebola, some 55-60 percent of the population lives under the national poverty line. Furthermore, many households live close to the poverty line, so even a small shock can plunge them into poverty. As a result, the decline in household consumption under Ebola is reflected by a strong increase in poverty.⁷ The results are summarized in Figure 3. In the Low Ebola scenario, the headcount poverty rate in 2014 jumps from 57 percent to 67 percent in 2014, although it returns to pre-Ebola and base levels in 2015: Rapid response and containment can limit the poverty impact. However, in the High Ebola scenario, the headcount poverty rate jumps even higher in 2014 and continues to increase in 2015, reaching 75 percent, i.e. an increase of 18 percentage points over already high levels in 2013. Beyond the mortal tragedy that is Ebola, there is the potential of a further tragedy, as poverty levels increase dramatically among the survivors.

⁷ The poverty data are generated assuming that inequality does not change – available data is not sufficient to determine the likely impact of Ebola on inequality.

Figure 3: Headcount poverty rate in 2013-2015 under alternative scenarios



Section 3: CGE Estimates for West Africa

The shocks to transaction costs (both domestic and international), to labor force participation, and to capital utilization are assumed to be at their worst in Liberia. Those shocks were backed out of the initial macroeconomic forecasts for Liberia (World Bank 2014) and subsequently applied in the Liberia-specific CGE model (MAMS). In order to estimate the impact of the Ebola epidemic for West Africa, those shocks to transaction costs and factor inputs are scaled down for other countries in the region and around the world and then incorporated into the LINKAGE model.

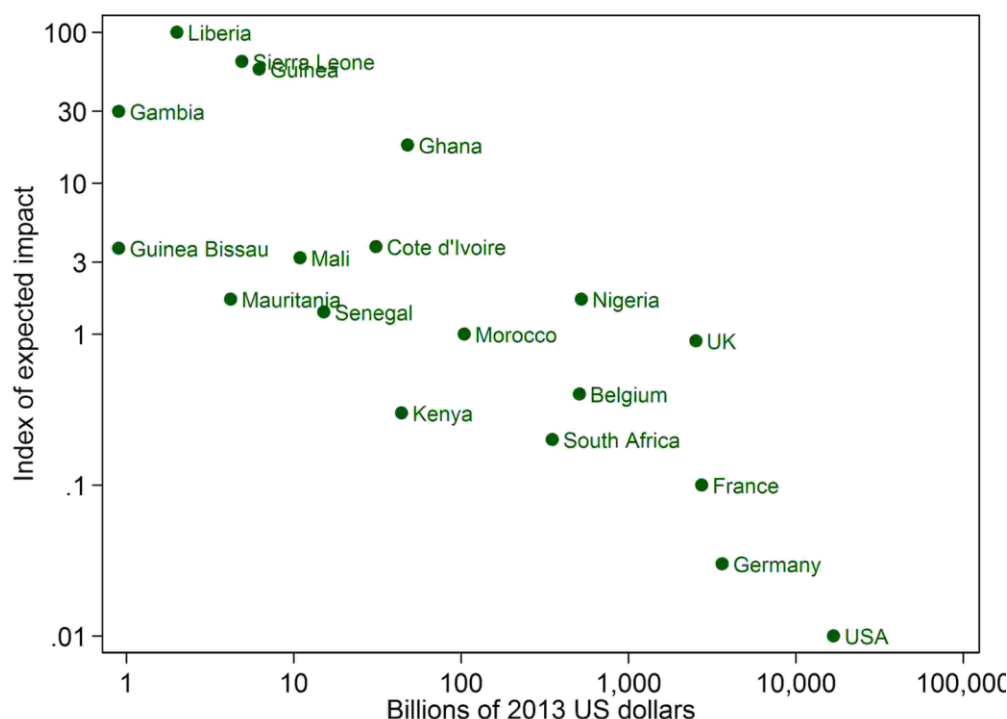
In order to scale the level of the shocks in other countries, an “Ebola impact index” is constructed, based on two attributes of each country. The first attribute is the size of a potential Ebola outbreak: This potential outbreak size is calculated using the likelihood of a single case arriving in a given country, multiplied by the number of cases likely to emerge once a single case breaks out. The second attribute is the country’s GDP, a proxy for the quality of the healthcare system.⁸ The likelihood of a single case and the likely number of cases were estimated using airplane flight patterns in a recent paper by Gomes et al.⁹ Of course, flights are not the only way that Ebola travels: The patient who arrived in Nigeria came by flight, but the patient who arrived in Senegal came by land. However, flight patterns serve as one useful albeit imperfect proxy for the likely spread of the epidemic. Both the likelihood of a single case and the likely number of cases have low and high scenarios, which we convert into a Low Ebola scenario (with relatively little spread) and a High Ebola scenario (with much more spread). The precise calculations are detailed in

⁸ The GDP is incorporate as a square root, which captures diminishing returns to income in terms of healthcare system quality.

⁹ Gomes, Marcelo, et al, “Assessing the International Spreading Risk Associated with the 2014 West African Ebola Outbreak,” PLOS One, September 2, 2014.

Appendix 1. Figure 4 displays a scatter plot of the “Ebola Impact Index” against a country’s GDP. Note the log scale, which indicates that the probability of an outbreak in richer countries with fewer direct flight connections to affected countries is very low, and even neighbor countries have dramatically lower expected impacts than the three most affected countries. The countries with the highest impact index will not necessarily get an Ebola case, nor will they necessarily greatly suffer if they do. However, the Ebola Impact Index does suggest which countries are at greatest danger of potential infection.¹⁰

Figure 4: Ebola impact index and national GDP under the Low Ebola scenario



Source: World Bank, based on World Development Indicators (2013).

The LINKAGE model uses these Ebola Impact Index values to scale down the perturbations (in transaction costs and factor levels) that we assume are introduced because of aversion behavior. By virtue of both their GDP and their relatively few links by air with Liberia, Sierra Leone and Guinea, the U.S. and Germany are not predicted to bear a large Ebola burden. But all the West African countries are at risk to one degree or another. Building on the assumptions in Gomes et al. (2014), we model the five countries or country groupings¹¹ most likely to have an Ebola case, assuming the disease does not travel beyond those.

The inputs to the LINKAGE model in terms of reductions in labor, capital utilization, and trade and transaction margins for the West Africa region are as illustrated in Table 1. (The LINKAGE estimates are described in great detail in Appendix 2.) All of those inputs are scaled from the effects in Liberia according

¹⁰ Even countries that have successfully combatted cases previously have the unfortunate potential for re-exposure as long as the Ebola epidemic is present among some West African populations.

¹¹ These are Ghana, Nigeria, Senegal, South Africa and the rest of Africa.

to the probability of having a case and the likely number of cases, per Gomes et al. (2014) using the Ebola impact index.

Table 1: Assumptions about changes in factor availability in the West Africa region as compared to the baseline (percentage point deviations)

<i>Variables</i>	<i>Baseline</i>		<i>Low Ebola</i>		<i>High Ebola</i>	
	<i>2014</i>	<i>2015</i>	<i>2014</i>	<i>2015</i>	<i>2014</i>	<i>2015</i>
Labor force growth rates	2.3	2.3	2.2	2.3	1.7	0.9
Capital utilization	100	100	99.2	99.9	97.7	95.6
Trade and transaction margins*	100	100	102	100	105	110*

Source: World Bank staff projections based on LINKAGE model. Note: * refers to international trade and domestic transaction margins. The increase in trade and transaction margins shown above refers to the Rest of West Africa regional aggregate, while the impacts are scaled for Ghana, Senegal and Nigeria, as well as other regions.

The result is that, in the Low Ebola case, there is quite a modest difference in economic growth for West Africa as a whole for the year 2015 (Table 2). The average growth over the course of 2014-2015 would be lower because growth takes a significant hit for the three core countries in 2014 and a much smaller hit for other countries in the region. But with swift, effective action, the regional economic impact of the crisis could be contained. However, in the High Ebola case the economic impact is much more dire. With a large expansion of the outbreak and Ebola spreading to some other countries within the region, there is a more significant reduction of labor and utilization of capital. In addition, transaction costs increase by a further 3 percentage points and the impact on exports and imports is much more significant. Export growth would be more than 5 percentage points lower in 2014 in the High Ebola scenario compared to the baseline. Exports recover in 2015, but their volume remains significantly below their baseline value in 2014. The GDP growth rate declines to 4.1 percent in 2014. This is the GDP growth rate for the West Africa region as a whole, which indicates that for the countries most affected by Ebola outbreak the economic decline is likely to be much more significant.

The resulting slower growth rate results in a loss of output worth US\$7.35 billion in 2014. Output continues to grow at a much slower pace in 2015 than in the Baseline case, leading to a further loss of US\$25.2 billion.¹² Overall, in the High Ebola scenario the GDP of West Africa is only 10 percent higher than its 2013 level by the end of 2015, while in the absence of Ebola it would have been 19 percent higher (see Table 2, columns 3 and 7). In addition to the immeasurable costs of lives lost, the loss of income in the High Ebola scenario could take years to recover.

¹² These values (loss of US\$7.35 billion in 2014 and US\$25.2 billion in 2015) refer to the difference between the estimated GDP in the High Ebola scenario compared to the baseline scenario (no Ebola), for the respective years.

Table 2: Annual GDP growth rates of the West Africa region in the baseline and the Low Ebola and High Ebola scenarios (percent)

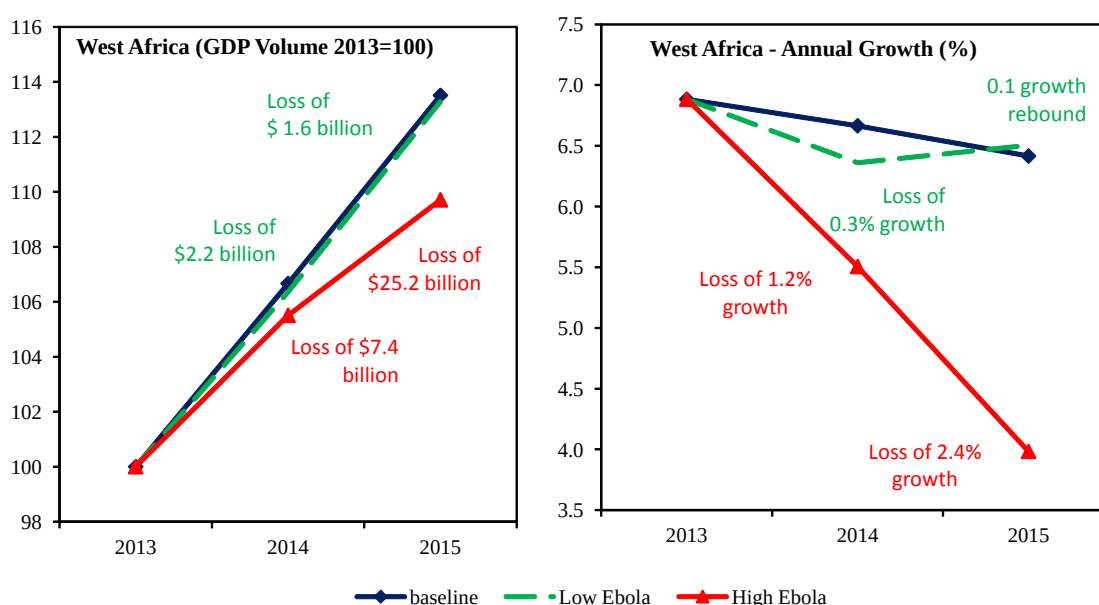
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Baseline			Low Ebola		High Ebola	
	2013	2014	2015	2014	2015	2014	2015
Investment	100	107.7	117.5	107.6	120.6	104.4	106.3
Price of exports*		100	100	98.5	100	96.4	93.1
Exports	100	109.6	119.3	107.6	119.2	104.0	105.7
GDP Volume	100	106.7	113.5	106.4	113.3	105.6	109.9
GDP annual growth rates	6.9	6.7	6.4	6.4	6.5	5.6	4.1
GDP (2013 USD billion)	709.3	756.6	805.2	754.4	803.5	749.3	779.9
USD billion GDP lost	-	-	-	2.2	1.6	7.4	25.2

Source: World Bank staff projections based on LINKAGE model.

Note: * refers to price of exports net of transaction costs. Dollar figures are in 2013 dollars.

Taking the two years together, this translates into a moderate loss in GDP volume in the Low Ebola case: The lost GDP amounts to US\$3.8 billion by the end of 2015 (2013 dollars). But in the High Ebola case, the loss in GDP reaches almost nine times that, at about US\$32.6 billion over the two years (Figure 5): That is 3.3 percent of what regional GDP would have been in the absence of Ebola in 2014. This is an enormous cost, not only for the most affected countries, but for the region as a whole. It has the potential to be deeply destabilizing and requires an immediate response.

Figure 5: Impact of Ebola on GDP and Annual Growth Rates for West Africa



Source: World Bank calculations.

Section 4: Concluding Remarks

Diseases and the pain and suffering they cause engender treatment costs and also the costs of reduced productivity. At the time of writing, more than 5,00 people have died in Liberia, Sierra Leone and Guinea alone, with some experts placing the true number two or three times higher. Cases continue to accumulate at a rapid pace in Sierra Leone.¹³

A correct primary focus is on containment, treating the ill, and helping relatives and communities to recover. However, there will also be a need over time to help the affected countries in their post-Ebola economic recovery. The magnitude of the estimated impacts demonstrates the need for a concerted international response. While it is beyond the scope of this paper to assess how much donor funding is needed either to aid the health sectors of African countries or to return their economies to robust economic growth, abating the aversion behavior that causes most of the economic impact will require at least the following four related sets of activities.

¹³ World Health Organization, "[Ebola Response Roadmap Update](#)," October 3, 2014.

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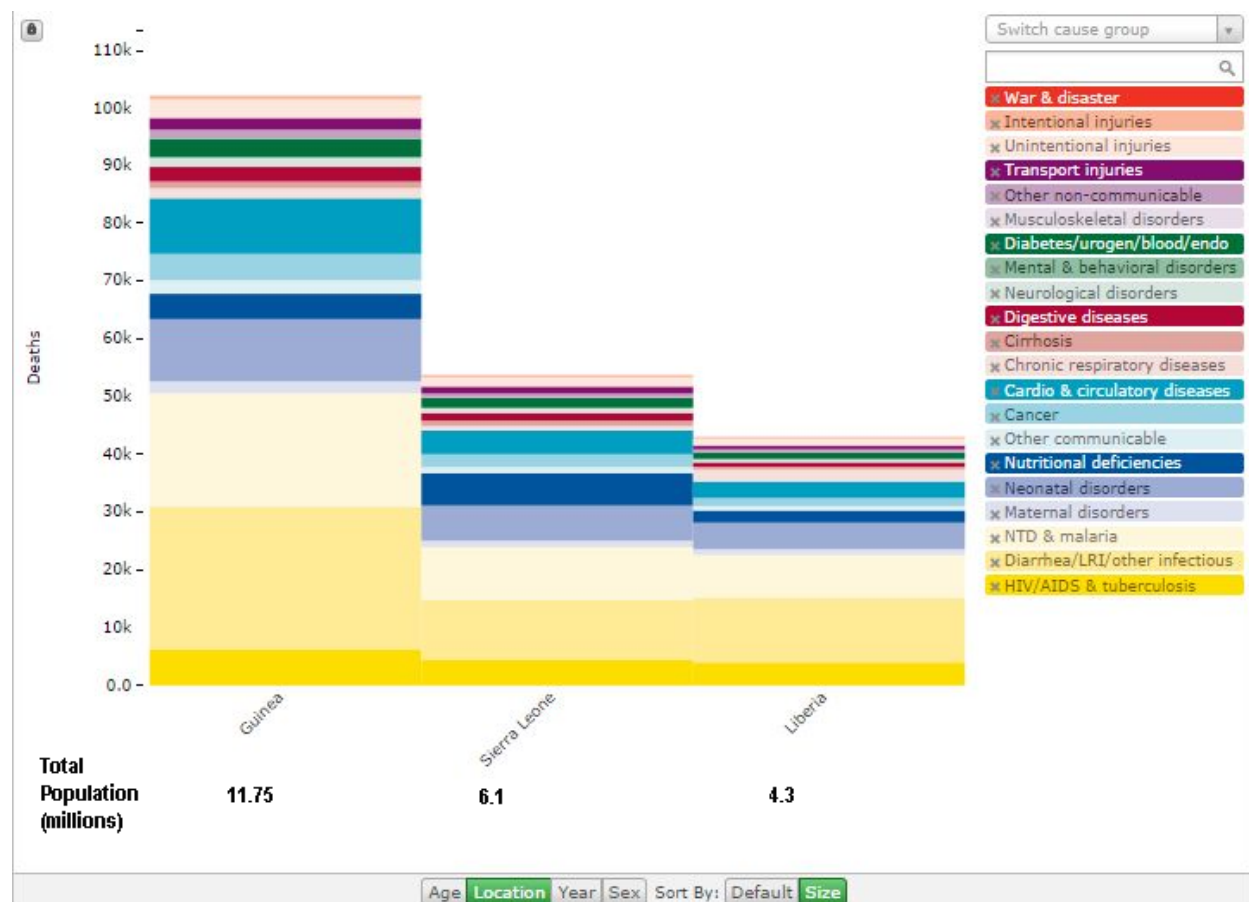
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Appendix 1: Estimating the Expected Economic Impact across West Africa

As described in the text, our method for modeling the economic impact of the Ebola epidemic is to shock each of two computable general equilibrium models with direct costs of illness (health care spending), indirect costs of illness (the lost productivity of the dead and, during their illness, of the sick and their caregivers) and both the domestic and international aversion costs. We posit that, at least during 2014, aversion behavior due to fear of Ebola will generate economic losses that far exceed the direct and indirect costs of Ebola.

That the direct and indirect costs will be relatively small in 2014, and possibly also in 2015 can be inferred from a comparison of the estimated number of 2013 Ebola deaths with the pre-Ebola estimates of deaths from all other causes in Liberia, Sierra Leone and Guinea in 2010. At this writing, the number of suspected or confirmed deaths from Ebola in Liberia, Sierra Leone and Guinea in 2014 is less than 3,000.

Figure 6: Estimated annual deaths in 2010 in Guinea, Sierra Leone and Liberia, by country and cause of death



Source: Institute for Health Metrics and Evaluation (2014)

Figure 6 shows the distribution by cause of the approximately 200,000 deaths estimated to have occurred in Guinea (102,301), Sierra Leone (53,767) and Liberia (43,052) in 2010.¹⁴ If the Ebola epidemic were to be arrested today in these three countries, Ebola would only slightly expand the category of “Other communicable diseases”. We would not be talking seriously about the economic impact of this disease.

But all of the causes of death catalogued in Figure 6 are endemic to these countries, varying little in their burden from year to year. Both business and labor have become somewhat accustomed to these health risks, and the recent rapid economic growth in all three of these countries has occurred despite this continuing disease burden.

Ebola is different. The number of Ebola cases and deaths, rather than remaining roughly constant from year-to-year, is growing at an increasing rate. When releasing its “roadmap” for intervention, the WHO mentioned that the total number of cases for the whole duration of the outbreak might be held to 20,000 (WHO 2014b). At a 50% mortality rate, this estimate implies a total of about 10,000 deaths in Liberia, Sierra Leone and Guinea. If the Ebola epidemic kills 10,000 people before it is controlled, which seems optimistic, it will rival HIV in its one-year impact on the disease burden in these three countries. This is the number of deaths to which we calibrate our “Low Ebola” estimates of economic impact.

More recent estimates from the U.S. Centers for Disease Control (Meltzer, et al. 2014) and the World Health Organization (WHO Ebola Response Team 2014) give more pessimistic projections, with the former extrapolating to a total of 1.4 million cases or 700,000 deaths before the end of January 2015 in Liberia and Sierra Leone and the latter predicting 20,000 cases by early November without adjusting for underreporting. If Ebola kills 700,000 before January 2015 and continues to grow thereafter, it would be killing more residents of these countries each year than would normally die in three or more years, a catastrophic mortality event that has not been seen on earth since the 1918 influenza epidemic.

Most observers believe that the Ebola epidemic will not continue to expand as fast as predicted by Meltzer, et al. (2014). We have adopted the more moderate assumption for our “High Ebola” scenario: a total of 200,000 cases and about 100,000 deaths through 2015, with the Ebola outbreak extinguished before the end of 2015. Even worse scenarios are of course possible, but require extremely pessimistic assumptions regarding the scale-up of international assistance and the adaptive behavior of the affected populations.

The microeconomic and macroeconomic data cited in the text provide evidence that, despite the fact that number of Ebola deaths that have so far occurred in Liberia, Sierra Leone and Guinea is only a small fraction of annual deaths from other causes, the economic impact is already substantial. We ascribe this impact to both domestic and international aversion behavior. To capture this behavior in computable general equilibrium models, we assume that aversion behavior can be translated into increased transactions costs and the withdrawal from the production process of factors of production.

¹⁴ Lower and upper bounds for the three countries are 171,000 to 232,000. See Wang, Dwyer-Lindgren, et al., (2013).

We distinguish transactions costs and factors of production by whether we deem them more likely to be affected by domestic or international aversion behavior. Domestic aversion behavior can be translated into a lockout or voluntary withdrawal of workers from places of employment and an increase in the cost associated with all domestic transactions, especially domestic transport. International aversion behavior can be translated into a reduction of price received for exports combined with an increased cost of imports. Since a large share of the capital in the nascent manufacturing sectors of Liberia, Sierra Leone and Guinea is foreign owned, we further assume that international aversion behavior will dramatically reduce foreign direct investment and also reduce the capacity utilization of existing capital stock.

All the Ebola-related effects are expressed as percentages of baseline projections in the absence of the Ebola epidemic. We first establish these percentage shocks to transactions costs, prices and factor supplies which are sufficient for the MAMS CGE model of Liberia to generate the reductions in output growth that we anticipate in that country based on the macroeconomic forecasting methods described in World Bank (2014). We then scale these shocks from a benchmark value of 100 in Liberia to reduced values in all other countries of the world.¹⁵ To assign values, we construct an index scaling function based on two attributes of each country: the size of its potential Ebola outbreak and the strength and resilience of its health system and government. Specifically we compute the index according to the following equation:

$$I_i = 100 \times \frac{P_i \times N_i}{Y^{1/2}} \times \frac{1}{L_i}$$

Where i indexes the scenario, with $i=1$ for the Low Ebola scenario and $i=2$ is the High Ebola scenario. The variables are defined as:

I_i = Index value for a given country, other than Liberia, for Ebola scenario i

P_i = Probability of a single undetected seed case in any given month that the epidemic is active, for Ebola scenario i

N_i = Number of cases within a month after the seed, given a single undetected seed case, for Ebola scenario i

Y = Gross National Product, which we assume to be correlated with the country's resilience and the strength of its health system.

$L_i = \frac{P_i \times N_i}{Y^{1/2}}$ for Liberia, for Ebola scenario i

We take the values of P_i and N_i from the results of a simulation model by Gomes, et al. (2014). In this article, the authors embed a standard epidemiological model of Ebola transmission within a detailed model of the world transportation system to simulate the seeding of Ebola from one of the three most

¹⁵ The Gambia in the high Ebola scenario is the only instance of a country that has a larger expected index value than Liberia.

affected countries to other countries via air travel. Figure 7 displays a stylized map showing the number of passengers who travel on some of the most highly traveled air routes.

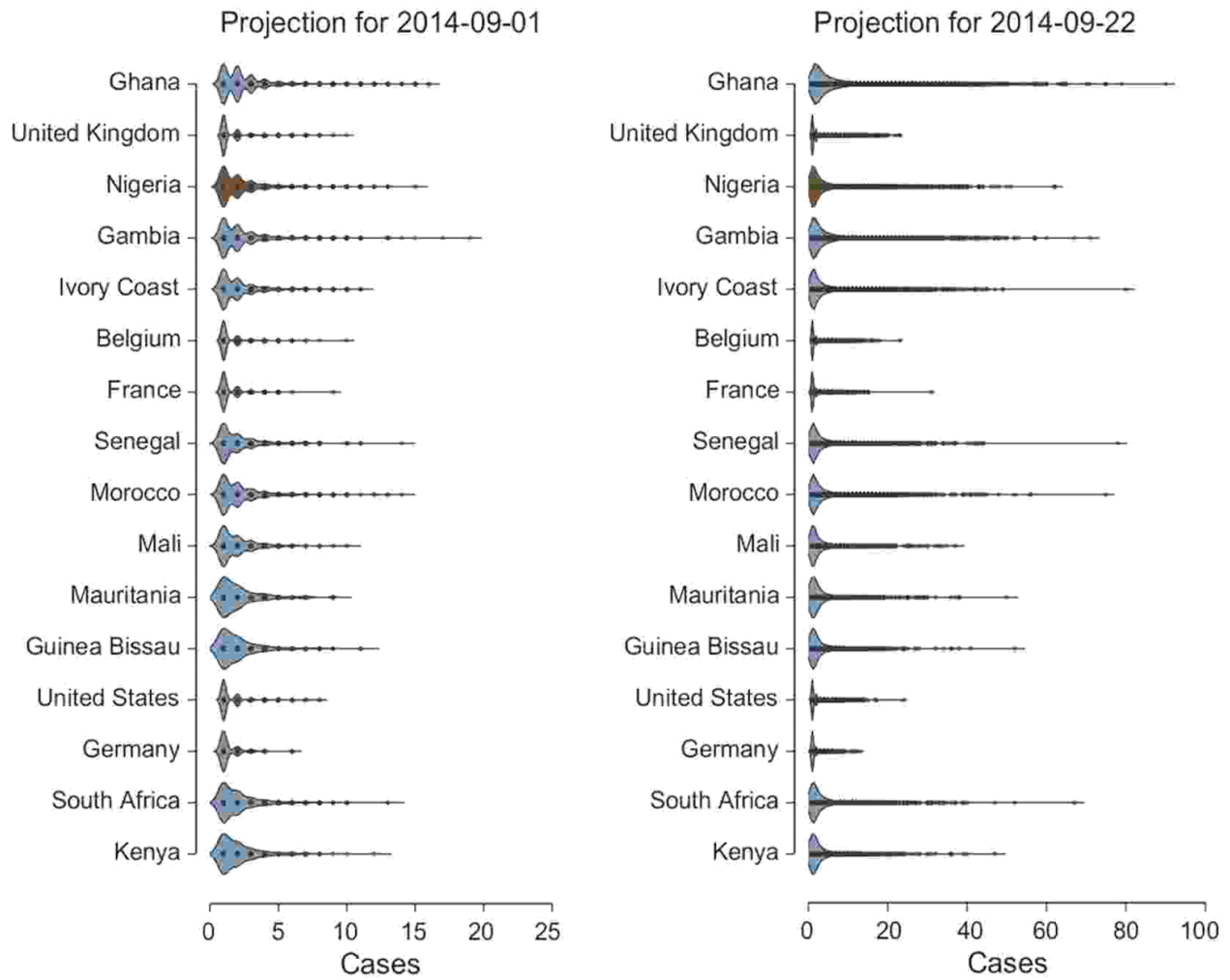
Figure 7: Air traffic connections from West African countries to the rest of the world



Source: Figure 1 of Gomes, et al. (2014). Used with permission.

Of course, air travel is not the only or necessarily the principal form of disease spread. However, the Gomes, et al. (2014) estimates represent the most systematic projections of disease spread to date. Gomes, et al. simulate a month of the Ebola epidemic 10,000 times. Figure 8, also reproduced from that article, displays the distribution of the number of Ebola cases that would appear in each of the 16 most frequently seeded countries. A large portion of the probability density is massed close to zero in each of the density plots, suggesting that no country has a high likelihood of being seeded. For the value of N_i in our index, we used either the 25th percentile number of cases (for the Low Ebola scenario) or the 99th percentile number of cases (for the High Ebola number of cases).

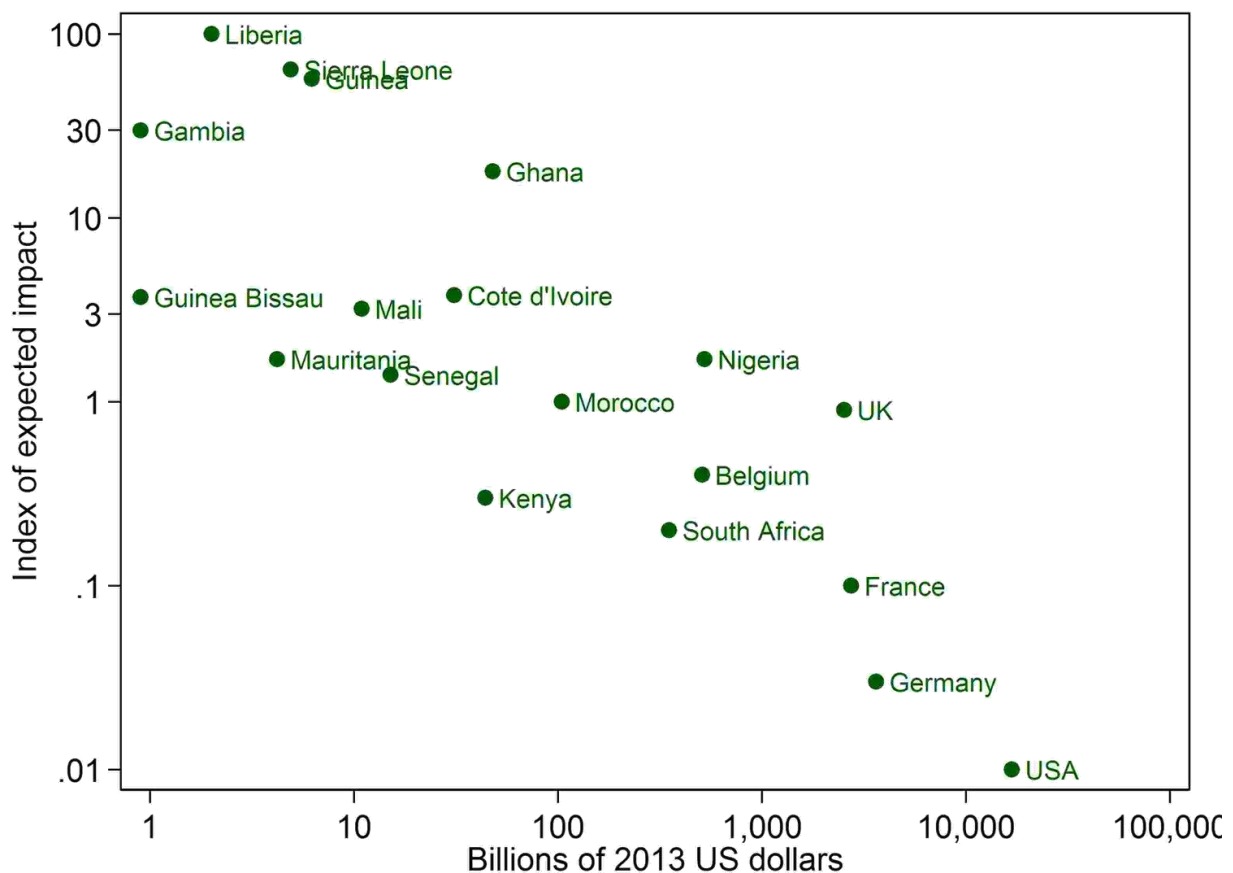
Figure 8: Frequency distribution of number of cases of Ebola within one month of the first seeded case



Source: Figure 4 of Gomes, et al. (2014). Replicated with permission.

Using these values for P_i and N_i , we construct index values for all the countries in the LINKAGE model. Figure 9 displays a scatter plot of our index against a country's GDP. Note that countries with higher GDP's, by our assumption, are much less vulnerable when a single case is seeded. At any given GDP, a country has a higher index if it has either a higher probability of being seeded or a higher number of cases if seeded. The probabilities, numbers of cases, and index factors are listed in Table 3.

Figure 9: Scatter plot of the Ebola impact index against a country's GDP for the Low Ebola scenario



Source: World Bank calculations.

The countries with the highest impact index in Figure 9 will not necessarily be seeded with a case of Ebola, nor will they necessarily greatly suffer if they are. However, the Ebola impact index does suggest which countries are at greatest danger of potential infection. As long as the Ebola epidemic is present among some West African populations, each week constitutes a new “throw of the dice,” which could lead to the arrival of a new Ebola-infected individual in any of the above countries.

The LINKAGE model uses these Ebola Impact Index values to scale down the perturbations that we assume are introduced because of aversion behavior. By virtue of both their GDP and their relatively few links by air with Liberia, Sierra Leone and Guinea, the U.S. and Germany are not predicted to bear a large Ebola burden. But all the West African countries are at risk to one or another degree.

Table 3: Ebola Impact Index

Country	Low Ebola					High Ebola			
	Probability of a seeded case in next 30 days	Number of cases if seeded in next 30 days	GDP (billions of 2013 US dollars)	Raw index	Scaled index	Probability of a seeded case in next 30 days	Number of cases if seeded in next 30 days	Raw index	Scaled index
Gambia	0.08	2	0.9	0.169	0.298	0.38	40	16.022	1.888
Guinea Bissau	0.02	1	0.9	0.021	0.037	0.03	25	0.791	0.093
<i>Liberia</i>	<i>0.40</i>	<i>2</i>	<i>2.0</i>	<i>0.566</i>	<i>1.000</i>	<i>0.60</i>	<i>20</i>	<i>8.485</i>	<i>1.000</i>
Mauritania	0.02	1	4.2	0.010	0.017	0.03	18	0.263	0.031
Sierra Leone	0.40	2	4.9	0.361	0.639	0.60	20	5.421	0.639
Guinea	0.40	2	6.2	0.321	0.568	0.60	20	4.819	0.568
Mali	0.03	2	10.9	0.018	0.032	0.04	19	0.230	0.027
Senegal	0.03	1	15.1	0.008	0.014	0.09	49	1.135	0.134
Cote d'Ivoire	0.06	2	30.9	0.022	0.038	0.14	44	1.108	0.131
Kenya	0.01	1	44.1	0.002	0.003	0.05	8	0.060	0.007
Ghana	0.35	2	47.9	0.101	0.179	0.57	53	4.365	0.514
Morocco	0.03	2	104.4	0.006	0.010	0.15	41	0.602	0.071
South Africa	0.01	2	350.6	0.001	0.002	0.09	46	0.221	0.026
Belgium	0.05	1	508.1	0.002	0.004	0.10	13	0.058	0.007
Nigeria	0.11	2	522.6	0.010	0.017	0.18	52	0.409	0.048
UK	0.25	1	2,522.3	0.005	0.009	0.29	17	0.098	0.012
France	0.03	1	2,734.9	0.001	0.001	0.06	33	0.038	0.004
Germany	0.01	1	3,634.8	0.000	0.0003	0.04	20	0.013	0.002
USA	0.01	1	16,800.0	0.000	0.0001	0.15	18	0.021	0.002

Note: Raw index is the product of the probability of a seeded case and the number of cases if seeded. The scaled index is the raw index divided by GDP%, which proxies for the quality of the health system (to be able to contain the spread of cases), but with diminishing marginal returns.

Appendix 2: Modeling the Economic Impact on West Africa

Introduction

The medium term estimates of the economic implications of the Ebola outbreak in West Africa are based on simulations using the World Bank's dynamic computable general equilibrium (CGE) model called LINKAGE. A CGE model uses economic data and a set of behavioral equations to estimate how an economy might react to changes in policy, technology or other factors. The model is benchmarked to a starting year dataset that covers the whole economy, tracking the inter-linkages between sectors through input-output or inter-industry transaction flow tables, various sources of demand such as intermediate demand of enterprises and final demand of households, government and investment. It also models the behavior of producers through profit-maximizing production functions. Finally, it simulates foreign demand and supply by including equations explaining bilateral trade flows.

The analysis using a CGE model starts from the development of a baseline with a set of exogenous variables and parameters (population, productivity growth, and elasticities). Then the counterfactual policy scenario is formulated by changing some exogenous variables or policy parameters. Finally, the impact of a counterfactual scenario is assessed by looking at deviations of endogenous variables (i.e., those variables that are not fixed or user-specified) from their baseline levels (e.g., GDP, investment, savings, trade flows, sectoral output, employment, wages, household (HH) consumption, welfare, and relative prices).

CGE models are best thought of as tools used for understanding the implications of different scenarios. Thanks to their rich structure they capture complex inter-linkages between sectors and countries. However, they cannot track the short term dynamics of an economy; and by focusing only on the developments in the real sphere of the economy, they cannot be used as forecasting tools. The CGE models cannot be tested for statistical accuracy of a forecast in the same way that econometric models can be. In short, these are tools for scenario building, not for forecasting.

Methodology

This section covers the main features of LINKAGE, while a full description is provided in a technical paper by van der Mensbrugghe (2011) and van der Mensbrugghe (2013). The current version of LINKAGE largely relies on release 8.1 of the GTAP database (Global Trade Analysis Program 2014). The data include social accounting matrices and bilateral trade flows for 134 countries/regions and 57 sectors. For computational and analytical purposes, the version employed in this study includes 12 countries/regions and 6 sectors. For the detailed regions see Table 4 below. The data base is benchmarked to 2007; we update it to 2013 replicating the key macroeconomic aggregates (GDP growth, investment, and current account).

The core specification of the model replicates largely a standard global CGE model.¹⁶ Production is specified as a series of nested constant elasticity of substitution (CES) functions for the various inputs—

¹⁶ Other well-known models in this class include the GTAP model (Hertel 1998) and CEPII's Mirage (Decreux and Valin 2007).

unskilled and skilled labor, capital, land, natural resources (sector-specific), energy and other material inputs. The structure of the CES nest characterizes the substitution and complementary relations across inputs. LINKAGE uses a vintage structure of production that allows for putty-semi putty capital. This means that capital can be either old or new, with new capital being more substitutable with other factors. This implies that countries with relatively high rates of investment, such as China, will tend to have more flexible economies as their share of new capital tends to be higher than in countries with relatively low rates of investment. In the labor market in the baseline we assume full employment, and allow for internal migration even though there is no international migration. Aggregate land supply follows a logistic curve with an absolute maximum available supply calibrated to IIASA (International Institute for Applied Systems Analysis) data.

Table 4: Region and Sector Compositions in LINKAGE model

<i>Regions</i>	<i>Rest of Western Africa</i>
High income countries	Benin
United States of America	Burkina Faso
EU27 and EFTA	Cabo Verde
China	Cameroon
India	Côte d'Ivoire
Less developed countries	The Gambia
Ghana	Guinea
Nigeria	Guinea-Bissau
Senegal	Liberia
<i>Rest of Western Africa</i>	Mali
South Africa	Mauritania
Rest of Africa	Niger
	Sierra Leone
	Togo
<i>Sectors</i>	
Agriculture	
Natural resources	
Trade	
Manufacturing	
Transport	
Services	

Source: World Bank.

The assumptions on productivity growth are complex. Different approaches are adapted to three broad sectors: agriculture, manufacturing and services. Agricultural productivity is assumed to be factor-neutral and exogenous and is set to estimates from empirical studies (Martin and Mitra 2001). Productivity in manufacturing and services is labor-augmenting and skill-neutral but sector-biased. The productivity growth assumptions in manufacturing and services are country-specific and based on past trends in productivity growth. Following the broad findings of earlier researchers (Bosworth and Collins 2007), we assume that productivity growth in manufacturing is about 2 percentage points faster than in services.

Demand by each domestic agent is specified at the so-called Armington level, i.e. demand for a bundle of domestically produced and imported goods. Armington demand is aggregated across all agents and allocated at the national level between domestic production and imports by region of origin. A top level CES nest first allocates aggregate (or Armington) demand between domestic production and an aggregate import bundle. A second level nest then allocates aggregate imports across the model's different regions thus generating a bilateral trade flow matrix. Each bilateral flow is associated with three price wedges. The first distinguishes producer prices from the FOB ("free-on-board") price (an export tax and/or subsidy). The second distinguishes the FOB price from the CIF (cost, insurance, and freight) price (an international trade and transportation margin). And the third distinguishes the CIF price from the user price (an import tariff).

Government derives its income from various taxes: sales, excise, import duties, export, production, factors and direct taxes. Investment revenues come from household, government and net foreign savings. Government and investment expenditure are based on CES functions.

The standard scenario incorporates three closure rules. Typically government expenditures are held constant as a share of GDP, fiscal balance is exogenous while direct taxes adjust to cover any changes in the revenues to keep the fiscal balance at the exogenous level. The second closure rule determines the investment savings balance. Households save a portion of their income with the average propensity to save influenced by demographics and economic growth. Government savings and foreign savings are exogenous in the current specification. As a result, investment is savings driven and the total amount of savings depends on household savings, with the price of investment goods being determined also by demand for investment. The last closure determines the external balance. In the current application we fix the foreign savings and therefore the trade balance. Therefore changes in trade flows will result in shifts in the real exchange rate.

The model characterizes a few key dynamics. Population growth is based on the medium fertility variant of the UN's population projections. Labor force growth is equated to the growth of the working age population – defined here as the demographic cohort between 15 and 64 years of age. Investment is equated to total savings. Household savings are a function of income growth and demographic dependency ratios, with savings rising as incomes rise and dependency ratios decline. Thus countries that have declining youth dependency rates tend to see a rise in savings. This will eventually be offset by countries that have a rising share of elderly in their population which will result in a fall of savings. Capital accumulation is then equated to the previous period's (depreciated) capital stock plus investment. Productivity growth in the baseline is 'calibrated' to achieve the growth rates for the baseline scenario as in the IMF World Economic Outlook data base up for 2014 and 2015. These productivity growth rates remain fixed in the counterfactual scenarios.

Capturing the economic impact of Ebola

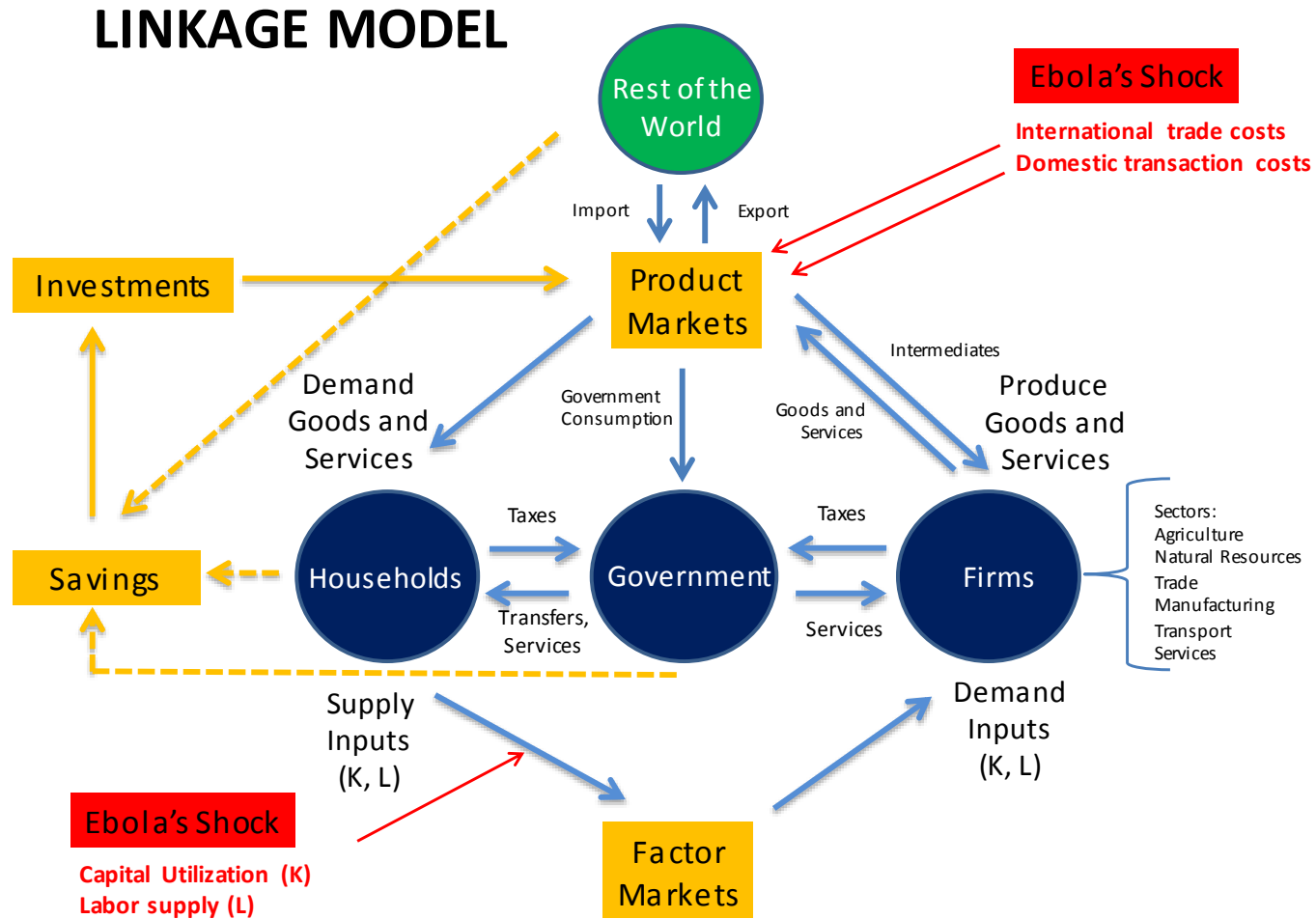
We develop three scenarios. The baseline (no Ebola) replicates the IMF/WB forecast for 2014 and 2015 constructed before the emergence of Ebola. We replicate the GDP, investment and current account numbers for these years. To study the impact of Ebola we analyze two scenarios: Low Ebola and High Ebola. These are based on the probabilities of international spread of Ebola from Gomes, et al. (2014) with

lower probabilities defining Low Ebola and higher probabilities defining High Ebola: These two scenarios are described in detail in Appendix 2. In both scenarios the outbreak of Ebola spreads to some extent to other countries in West Africa.

The impact of Ebola has been translated into two channels. The first channel is through reduction of factors of production: lower labor supply growth rates and capital underutilization. The first, direct effect on the labor force consists of workers being ill, dying, or caring for the ill. While tragic, this amounts to a relatively small proportion of the labor force. The much larger shock comes from workers staying at home for fear of exposure to Ebola or because businesses reduce capacity and force workers to take unpaid leave. At the same time capital remains underutilized. This is similarly due to closures or reduction of capacity of operations of factories and businesses. The decline of availability of factors reduces productive capacity of the economy and results in the drop of output and household income.

The second channel is through increased transport and transaction costs in domestic and foreign trade. Increased domestic and international trade and transaction margins are due to inspections, market and road closures, border closures, etc. These will lower the prices that domestic producers receive for their products and services net of transaction costs and will increase the prices of imports on the domestic market. Increased domestic transaction costs in domestic trade lead to efficiency losses and reduce the income of domestic producers. These two channels combined account for the full impact of Ebola (see Figure 10). These two channels of impacts are likely to result in lower trade, investment, output, household income and consumption, as well as worsening of terms of trade, all of which are endogenous in the simulations.

Figure 10: How the LINKAGE model works



Source: World Bank.

The assumptions regarding reduction of factors of production and international and domestic transaction costs for the West Africa region are presented in Table 5. All of those effects are then scaled according to the probability of having a case and the likely number of cases, as explained in Appendix 2. In the Low Ebola case, labor force growth drops from 2.3% to 2.1% in 2014 due to mortality, morbidity (a small fraction) in addition to a shock due to aversion behavior. The shock is moderate because labor force growth is assumed to have been normal for the first nine months of 2014. In 2015, the growth rate returns to normal (off a smaller base due to the shock in 2014). In the High Ebola case, the shock is more pronounced due to a more rapid spread of the outbreak to other countries in the region, and it continues into 2015. Capital utilization follows a similar pattern in both scenarios. Finally, aversion behavior – individuals avoiding markets or traveling across borders – is captured in the “trade and transaction margins”, with a moderate shock in the second half of 2014 but then a return to normal in 2015 in the Low Ebola case. In the High Ebola case, the shock is more pronounced in 2014 and then continues into the first half of 2015.

We report the results of the simulations for West Africa as a whole (see Table 6). In the baseline, the GDP of West Africa would have been expected to grow by 6.7% in 2014 and by 6.4% in 2015. Furthermore, transaction costs remain at the 2013 level and exports were projected to increase by 7.7% in 2014 and by 9% in 2015.

In Low Ebola, when the outbreak is contained relatively quickly, the impact on the economy is quite limited (see Table 6). The growth rate in 2014 slows down by 0.3 percentage point, but it recovers in 2015 when Ebola is under control for most of the year. With lower income, households’ savings decline and there is less funding for investment. Indeed, investment declines by 0.1 percentage point relative to the baseline value of 2014. Producers lose part of the value of their products due to increased trade and transport margins, which – coupled with lower output – lead to a reduction of the volume of exports relative to the baseline by 2 percentage points (see Table 6, columns 2 and 4). The forgone output due to lower GDP growth rate is approximately US\$2.2 billion in 2013 dollars (see last row of Table 6).¹⁷ When output recovers in the second half of 2015 and transaction costs return to the baseline level, exports expand to reach similar volume as in the baseline, but the GDP is now increasing from a lower base (due to a drop in 2014)¹⁸ and the output volume in 2015 in the Low Ebola scenario is still US\$1.6 billion below the baseline level (see Figure 11).¹⁹

¹⁷ This value refers to the difference between the estimated GDP in the baseline scenario (no Ebola) compared to the Low Ebola scenario.

¹⁸ This is the reason why the GDP growth rate (in percentage points) in 2015 is higher in Low Ebola than in the baseline scenario (see “growth rebound” in Figure 11).

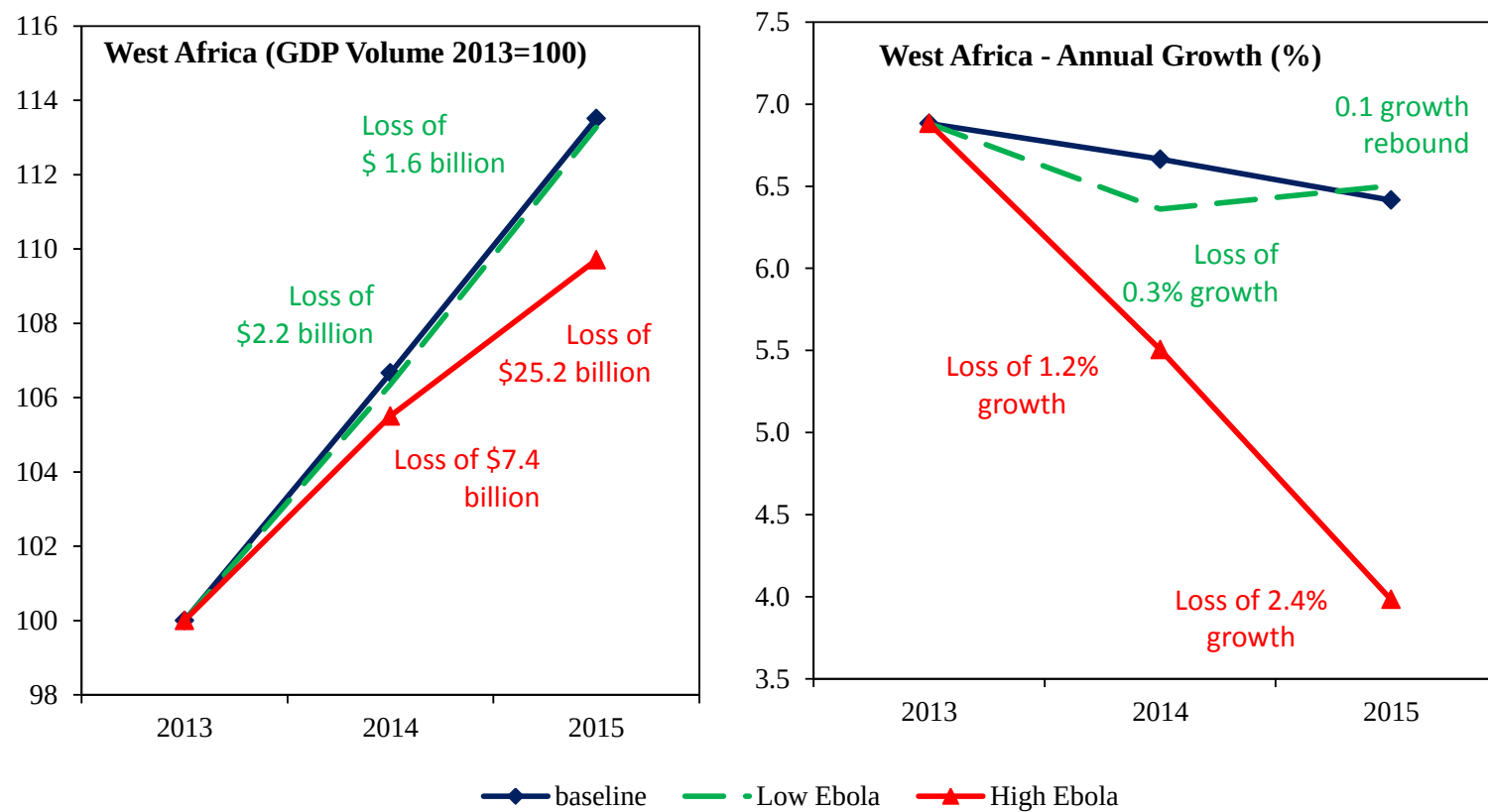
¹⁹ The level of GDP (volumes) in the Low Ebola scenario is lower than the baseline projection.

Table 5: Assumptions about changes in factor availability as compared to the baseline (percentage point deviations)

<i>Variables</i>	<i>Baseline</i>		<i>Low Ebola</i>		<i>High Ebola</i>	
	<i>2014</i>	<i>2015</i>	<i>2014</i>	<i>2015</i>	<i>2014</i>	<i>2015</i>
Labor force growth rates	2.3	2.3	2.2	2.3	1.7	0.9
Capital utilization	100	100	99.2	99.9	97.7	95.6
Trade and transaction margins*	100	100	102	100	115	110*

Source: World Bank staff projections based on LINKAGE model. Note: * refers to international trade and domestic transaction margins. The increase of trade and transaction margins shown above refers to the Rest of West Africa regional aggregate, while the impacts are scaled for Ghana, Senegal and Nigeria.

Figure 11: GDP volume and growth rates in the Baseline, Low Ebola and High Ebola scenarios



Source: World Bank staff calculations using LINKAGE.

With a large expansion of the outbreak and Ebola spreading to other countries within the region (accounting for 83% of GDP of West Africa in 2013), there is a more significant reduction of labor and utilization of capital. In addition, transaction costs increase by a further 3 percentage points and the impact on exports and imports is much more significant. Exports growth would be over 5 percentage points lower in 2014 in the High Ebola scenario compared to the baseline. Exports recover in 2015, but their volume remains significantly below their baseline value in 2014. The GDP growth rate declines to 4.1% in 2014. This is the value of the GDP growth rate for the West Africa region as a whole, which indicates that for the countries directly affected by Ebola outbreak the economic decline is likely to be much more significant. Building on the assumptions in Gomes, et al. (2014), we model the five countries²⁰ most likely to have an Ebola outbreak, assuming the disease does not travel beyond those.

The resulting slower growth rate results in a drop of output worth US\$7.35 in 2014. The output continues to grow at a much slower rate in 2015 than in the Baseline case, leading to a further loss of US\$ 25.2billion.²¹ Overall, in the High Ebola scenario the GDP of West Africa is only 10% higher than its 2013 level by the end of 2015, while in the absence of Ebola it would have been 19% higher (see Table 6, columns 3 and 7). In addition to the immeasurable costs of lives lost, the loss of income in High Ebola could take years to recover.

Table 6: Annual GDP growth rates in the baseline and the Low Ebola and High Ebola scenarios (percent)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Baseline			Low Ebola		High Ebola	
	2013	2014	2015	2014	2015	2014	2015
Investment	100	107.7	117.5	107.6	120.6	104.4	106.3
Price of exports*		100	100	98.5	100	96.4	93.3
Exports	100	109.6	119.3	107.6	119.2	104.0	105.7
GDP Volume	100	106.7	113.5	106.4	113.3	105.6	109.9
GDP annual growth rates	6.9	6.7	6.4	6.4	6.5	5.6	4.1
GDP (2013 USD billion)	709.3	756.6	805.2	754.4	803.5	749.3	779.9
USD billion GDP lost	-	-	-	2.2	1.6	7.35	25.2

Source: World Bank staff projections based on LINKAGE model. Note: * refers to price of exports net of transaction costs.

With swift international action Ebola can be contained and not only thousands of precious lives could be saved but also economic cost for the region could be limited. If the outbreak is not contained the economic costs could run into billions of USD in forgone output (up to \$33 billion), so acting fast not only saves precious lives, but our estimates indicate that spending even billions of dollars to contain the spread would be cost effective.

²⁰ These are Ghana, Nigeria, Senegal, South Africa and the rest of Africa.

²¹ These values (loss of US\$7.35 billion in 2014 and US\$25.2 billion in 2015) refer to the difference between the estimated GDP in the High Ebola scenario compared to the baseline scenario (no Ebola), for the respective years.

As already stated in the introduction, these scenarios should not be perceived as forecasts. The CGE simulations are simply allowing us to analyze various scenarios in a consistent and coherent framework. Our estimates may even be underestimated as the most recent epidemiological projections indicate that in the worst case scenario the number of cases could reach over one million, and how aversion behavior varies with caseload is not known with precision. This analysis also does not incorporate every possible economic implication of the epidemic. Further, if the fear factor persists and reduces investment and trade for the years to come, the negative growth implications could continue well beyond 2015.

Possible extensions to the modeling work

In further work on this topic we will explore several extensions of the analysis. A number of press articles have indicated that tourism in countries as far as South Africa has been negatively affected by the outbreak. Tourism is relatively small in the core three countries, but for South Africa the drop of tourism activity could have significant implications for economic growth.

Further, we analyzed only one low and one high case scenario. Future work will explore the feasibility of running a number of scenarios to produce a distribution of impacts for West Africa. This analysis has focused on the key macro variables. Given the availability of household surveys for the three core countries, one could estimate the impacts of various scenarios on poverty and income inequality using the micro simulation tool known as the GIDD (Global Income Distribution Dynamics).²²

²² For more information see www.worldbank.org/prospects/GIDD.

Appendix 3: Modeling the Economic Impact on Liberia

This appendix offers a rapid assessment of the possible impact on Liberia's economy of Ebola based on simulations with MAMS, a Computable General Equilibrium (CGE) model developed by the World Bank for analysis of the impact of policy changes and economic shocks in developing countries.²³ The simulations address two alternative Ebola scenarios: a moderate case underpinned by effective policies leading to rapid containment (Low Ebola) and a severe case with an inadequate policy response leading to slow containment (High Ebola). As noted in the main body of the text, in broad outline, the results and the assumptions are similar but not identical to those of the macroeconomic forecasting methods described in World Bank (2014).

The advantage of a model of this type is that it imposes basic economic mechanisms, including markets with flexible prices and the constraints and linkages that are important in any economy: employment of labor and capital and other factors is limited to what is available; production in one sector generates demands for the outputs of downstream sectors and meets the demands of upstream sectors, households, investors, and exporters; private and government incomes from production, taxes and other sources generate demands domestic output and imports; and the spending of the nation as a whole and for each type of agent (the government, firms and households) must be fully financed (by some combination of current incomes, grants, and net borrowing, some of which may come from abroad).

In this application, the results for alternative Ebola scenarios in 2014 and 2015 are compared to a base scenario that reflects the expected development of Liberia's economy before the emergence of Ebola. This comparison assesses the effects of Ebola on country-level macro, sectoral, welfare, and poverty indicators. In sum, a comparison between two possible Ebola scenarios, representing success and failure to contain the epidemic, demonstrate the dramatic importance of making sure that workers can access their places of work and trade can continue without interruptions and excessive transactions costs. This requires that the epidemic be stopped in the very near future.

Scenario assumptions

- The analysis looks at the impact of two Ebola scenarios, contrasting them with a base scenario without Ebola.
- The first Ebola scenario, labeled Low Ebola, assumes that an effective policy response is rapidly implemented, by the end of 2014 putting an end to new cases and deaths. As a result, the economic repercussions are kept in check.
- The second Ebola scenario, High Ebola, assumes that the policy response is slow and ineffective, leading to a much larger number of cases and deaths in 2014 as well as additional deaths in 2015 before the virus is contained and defeated. Accordingly, the economic repercussions are much more severe.
- Table 7 summarizes the key assumptions for the two scenarios. The assumptions are based on the fragmentary evidence available at the time of writing this paper. In addition to losses in life, such

²³ Additional information is also found at www.worldbank.org/mams.

evidence indicates that Ebola makes itself felt through multiple economic channels, the most important of which are:

- Labor. Due to fear, controls and restrictions on movement, workers do not go to work, reducing the productive capacity of the economy.
- Mining. Like other sectors, production in mining is reduced. The mining sector is singled out given its importance and the fact that its production and exports depend critically on the presence of expatriates, i.e., not on the general reduction in the labor supply in the economy.
- FDI declines because of added uncertainty about the future and interruptions to international travel and communication.
- Trade (or transactions) costs increase. Such costs arise when goods are brought from the border to domestic demanders (for imports) and from domestic suppliers to the border or to domestic demanders (for exports and sales of domestic output domestically, respectively). These costs increase due to the same forces that keep workers away from their workplaces. In the context of the simulations, they require labor and other inputs and contribute to relatively strong growth for private services. They represent a productivity loss since additional inputs are needed to bring goods to their demanders inside or outside of Liberia's economy, instead of being available for consumption and investment. For the agricultural sectors, these effects are milder since a substantial part of production is consumed by the producers themselves or in the local community, mitigating the impact of higher trade costs.
- Foreign grants. The international community is increasing its aid, especially for health spending to contain Ebola.

Table 7: Key assumptions for MAMS model

	<i>Low Ebola</i>		<i>High Ebola</i>	
	<i>2014</i>	<i>2015</i>	<i>2014</i>	<i>2015</i>
Ebola cases	12,000	0	120,000	30,000
Ebola deaths (3)	6,900	0	69,000	17,000
Labor employment (% decline from BASE in same year) (4)	2.9	0.5	11.3	14.1
Mining resource use (% decline from BASE in same year)	5.7	0.4	16.3	19.1
Foreign Direct Investment (% decline from BASE in same year)	-41.5	-14.7	-41.5	-57.3
Additional export and import trade costs (% of border price) (5)	15.0	0.0	22.5	22.5
Additional domestic trade costs (% of producer price) (6)	17.5	0.0	26.3	26.3
Additional foreign grants (million 2014 US dollars)	47.7	95.4	15.7	31.5

Notes

- 1 Ebola-low and Ebola-high reflect moderate (strong policy) and severe (weak policy) impact scenarios, respectively.
- 2 The years are calendar years.
- 3 The vast majority (in the simulations all) of the deaths afflict persons in working age (15-64 years old)
- 4 The decline in labor force is due to fear and movement restrictions and is in addition to the loss due to death. In the model, this is the decline that is due to a lower labor force participation rate among the population aged 15-64. The labor force is also lower due to Ebola deaths (on preceding line).
- 5 These trade costs reflect use of services to bring goods from the supplier to the border (for exports) and from the border to the domestic demander (for imports). For exports, the added trade costs reduce the price of the producer relative to the border price; for imports, it adds to the price paid by demanders relative to the border price. These cost additions are at base prices; they may be smaller or larger depending on changes in the prices of trade services.
- 6 These trade costs reflect use of services to bring goods from the domestic supplier to the domestic demander. These added trade costs raise the price paid by the demander relative to the price received by the supplier. These cost additions are expressed at base prices; they may be smaller or larger depending on changes in the prices of trade services compared to the base scenario.

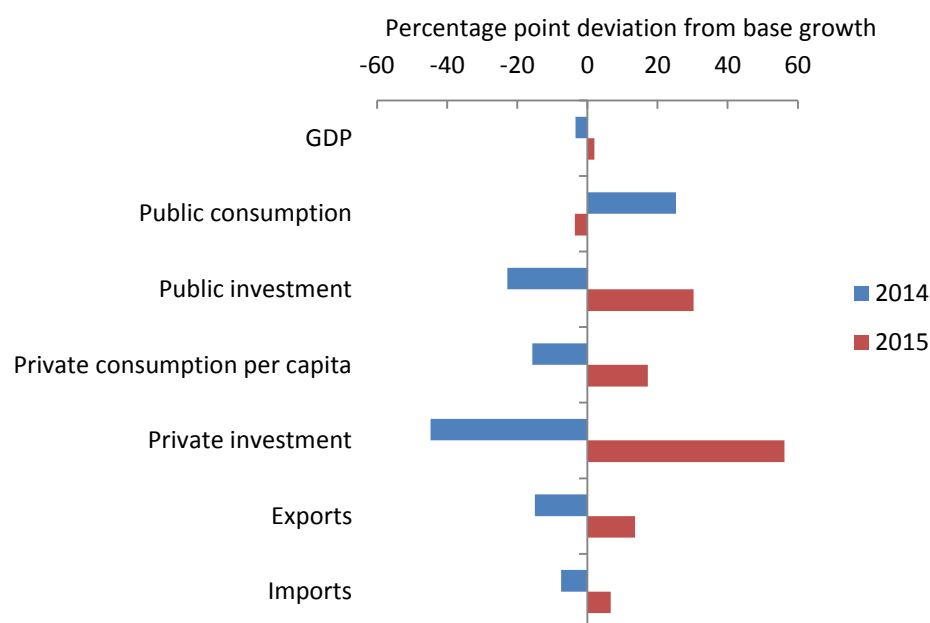
Simulation results

Low Ebola

The growth rates under Low Ebola are compared to the base scenario in Figure 12. In 2014, the impact on several variables is moderate, in part due to the fact that the crisis emerged during the second half of the year. For the government – here broadly defined to include the government-type activities of non-government organizations and other donors – the effects are relatively mild since foreign grants, its major revenue source, increase at the same time as the decline in the economic activities that generate tax revenues is moderate. It is assumed that the government maintains its domestic borrowing unchanged in

real terms (i.e., compared to the base increasing as a share of GDP due to a lower GDP level). In response to the health crisis, the government reallocates spending, compared to the base significantly raising its consumption and reducing its investment. As a result of the decline in the employment of labor, the model predicts a decline in household incomes, savings, and consumption. Coupled with the decline in FDI, lower household savings translate into less financing of private investment.

Figure 12: Macroeconomic growth in Liberia under Low Ebola



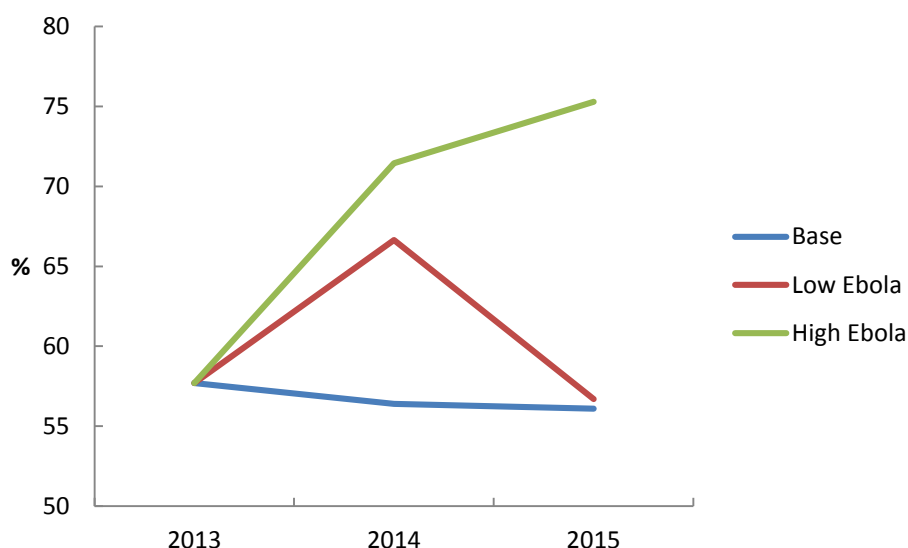
Source: World Bank calculations.

The increase in transaction costs also raises the prices households pay for their consumption items with a more limited increase for locally produced agricultural products. It also discourages exports and imports, even though the effects under this scenario are quite small. In Figure 12, household consumption is measured in per-capita terms to correct for the fact that the population is slightly smaller than under the base scenario. The fact that Liberia suffers from a demographic dividend in reverse (its dependency ratio increases due to Ebola deaths) and a larger share of its population in labor-force age is inactive exacerbates the decline in consumption per capita.

This scenario posits that in 2015, thanks to a successful health intervention, few or no additional Ebola cases or deaths are recorded, and the negative economic shocks of 2014 are mostly reversed; most importantly, lifting restrictions on people's movements makes it possible to most of the labor back into production while trade costs return to normal levels. Moreover, the emergency response is pulled back, reducing public consumption and raising public investment, bringing the economy toward its original trajectory. Still, due to the need for some time to restart the economy, including time lags in production processes in agriculture and elsewhere, lingering uncertainties (affecting mining and FDI), and less investment in 2014, GDP is still below the base level in 2015. The net results of these developments are shown in Figure 12: Most importantly, the changes in public and private investment and household

consumption are reversed, while public consumption, supported by continued aid, remains above the base 2015 level even though its growth has slowed. The impact on households is reflected in Figure 13, which shows the headcount poverty rate under different scenarios: for Ebola-low, the 2015 poverty rate returns to close to the (still substantial) base-year rate.²⁴

Figure 13: Headcount poverty rate under alternative scenarios

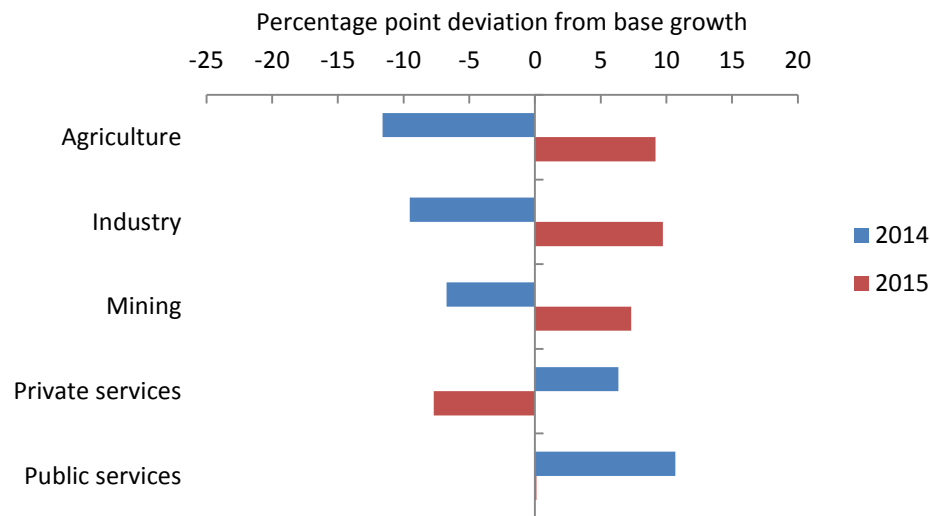


Source: World Bank calculations.

Figure 14 shows how growth in sector value-added under Ebola-low deviates from the base scenario. In 2014, the economy shifted temporarily toward higher public and private service production at the expense of agriculture and industry, including mining. In 2015, the opposite happened, bringing the economy closer to initial shares.

²⁴ The poverty calculation assumes that inequality (measured by the Gini coefficient) does not change and that consumption follows a log-normal distribution.

Figure 14: Sector-specific growth under Low Ebola

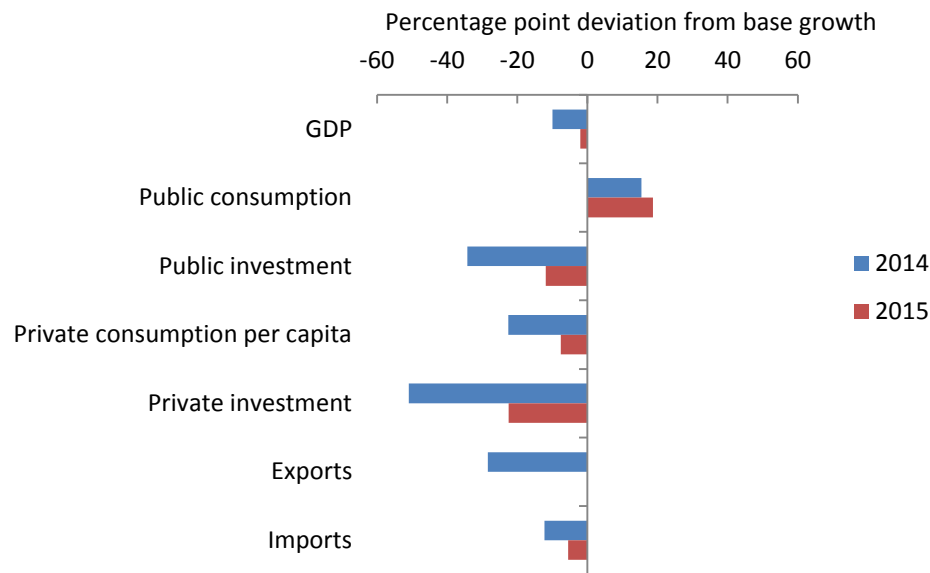


Source: World Bank calculations.

High Ebola

Compared to Low Ebola scenario, the High Ebola scenario demonstrates that, in the absence of a concerted policy response, a much more severe calamity may afflict Liberia and other countries in its neighborhood and beyond. Under this scenario, as the number of cases and deaths spirals out of control in the last few months of 2014, the economy is near collapse, with large-scale withdrawal of labor from production and more severe increases in trade costs, accompanied by very limited aid increases (see Table 7). Figure 15 summarizes the macro consequences. In 2014, due to access to fewer resources, the public investment cut is more dramatic. Household income losses are larger and their purchasing power suffers from the additional increase in trade costs, translating into more dramatic cuts in savings, private investment, and household per-capita consumption. Exports (for mining and other sectors) decline, adding to the need to cut imports due to the decline in FDI and lower grant aid. Only public consumption growth increases compared to the base but is below the level for the Low Ebola scenario.

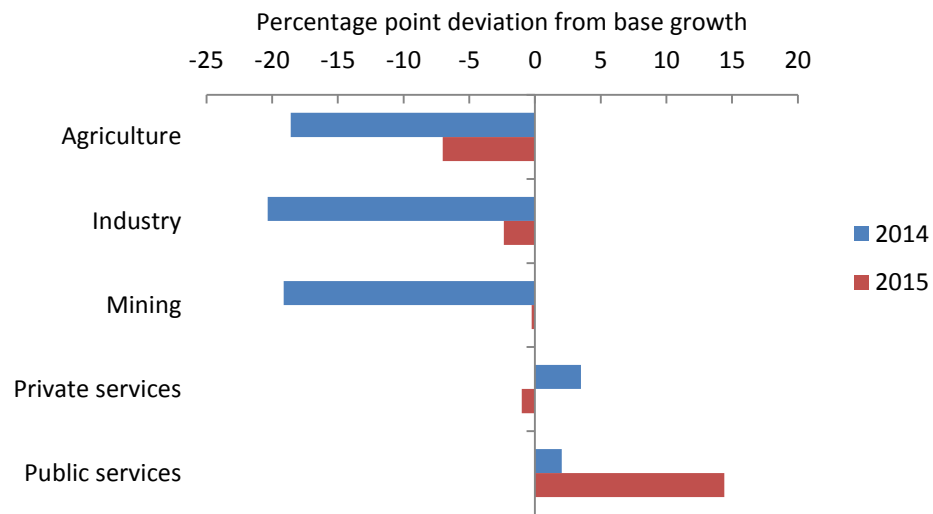
Figure 15: Macroeconomic growth in Liberia under High Ebola



Source: World Bank calculations.

As a result of the failure to put an end to the epidemic during 2014, the crisis becomes more severe in 2015, with continued new Ebola cases and deaths; stronger negative shocks from additional withdrawal of labor from production; further cuts in FDI; continued high trade costs; and only a moderate increase in aid from the international community. The end result is continued growth below base scenario rates for GDP, private and public investment, private consumption, and imports. Exports return to slightly above base growth (after the strong decline in 2014) whereas public consumption, thanks to the aid increase and public investment cut, grows faster than under the base (Figure 15). The continued decline in per-capita household consumption dramatically raises the headcount poverty rate (Figure 13). Growth in sector value-added matches these developments (Figure 16): After the sharp decline in 2014, growth is negative or only moderately positive for all sectors except public services.

Figure 16: Sector-specific growth rates under High Ebola



Source: World Bank calculations.