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Economywide Impact of Avian Flu in Nigeria – A Dynamic CGE Model Analysis

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Key Findings

- Although supply and demand shocks significantly affect income from poultry production, the effects of such shocks on household incomes are limited due to the low share that poultry production contributes to households' total incomes.
- The overall effect of HPAI on the Nigerian economy and on poverty is likely to be small, but the indirect effect is larger than the direct effect.

Since its emergence in Africa in 2006, the highly pathogenic avian influenza (HPAI) virus of the H5N1 subtype has spread rapidly to poultry farms in several countries, including Burkina Faso, Cameroon, Ghana, Niger, and Nigeria (FAO 2006; OIE 2006). In February 2006, Kaduna state in Nigeria was the first of 36 states to report the infection of poultry by H5N1 (Monne et al. 2008). By April 2006, more than 325,000 chickens in Nigeria alone were identified as having H5N1 virus; of these, 223,000 died of H5N1 infection and the rest were slaughtered as a control measure (You and Diao 2007). Since 2006, the infection has spread to 22 states in Nigeria (Monne et al. 2008), and there was recently one confirmed case in humans in the southern state of Lagos in February 2007 (Monne et al. 2008). Though the last outbreak occurred in October 2007, the spread of HPAI poses a challenge to the poultry industry in Nigeria (You and Diao 2007).

Based on estimates from the National Bureau of Statistics (NBS) in Nigeria, since 2000, the poultry subsector in Nigeria grew at 5.9 percent per year, reaching a population of 150 million in 2005 until the appearance of HPAI in 2006 (Nigeria, NBS 2006). Since then, a significant reduction in the poultry trading activities (imports and exports) has been observed in Nigeria (Uzochukwu Obi et al. 2008). Outbreaks of HPAI undoubtedly pose serious consequences on the livelihood of many poor households, disrupting an important source of cash income for producers and a source of protein for consumers' diets. Moreover, HPAI can threaten the advancement of women, as raising poultry has become an important channel for women in countries to develop assets or income because entry costs are low and the work can be integrated with their domestic responsibilities (You and Diao 2007).

This paper focuses on the economywide impact of the HPAI outbreak in Nigeria. The primary goal of this paper is to assess the economywide potential impact of an avian flu outbreak in Nigeria, which can provide helpful information for designing a pro-poor HPAI risk-reduction strategy. Towards this, a dynamic computable general equilibrium (CGE) model and a social accounting matrix (SAM) were used to assess the economywide impact of HPAI outbreaks in Nigeria.

According to the SAM, poultry is a small subsector in the Nigerian economy, accounting for 1.2 percent of the agricultural gross domestic product (GDP) and 0.4 percent of the total GDP. Approximately 96 percent of poultry-producing households are small scale, producing less than 50 birds, and collectively only produce less than a quarter of the national poultry production.

Brief Description of the Model and Data Used

Existing CGE models are not useful for assessing the impact of HPAI mainly because they are highly aggregated (spatially). The model employed for this study was a new dynamic CGE model for Nigeria (Diao et al. 2009). The new model captured trade-offs and synergies from accelerating growth in various agricultural subsectors, as well as the economic interlinkages between agriculture and the rest of the economy. The examined agricultural crops fell into four broad groups: (i) cereal crops, which were separated into five crops: rice, wheat, maize, sorghum, and millet; (ii) root crops, such as cassava, yam, cocoyam, Irish potatoes, and sweet potatoes; (iii) other food crops, which individually included plantain, beans, groundnuts, soybeans, other oil crops, groundnuts, and vegetables and fruits for domestic use; and (iv) high-value export-oriented crops, which were composed of cocoa, coffee, cotton, oil palm, vegetable and fruit for export, sugar, tobacco, cashew nut, other nuts, rubber, and others.

Poultry as a production activity was identified in this dynamic CGE model, which also identified three other primary livestock subsectors, namely cattle, goat and sheep, and other livestock. To complete the agricultural sector, the model also included forestry and fisheries. The dynamic CGE model also captured regional heterogeneity. In this model, rural agricultural production was disaggregated across six zones in Nigeria, wherein representative farmers produced different crops and livestock production across zones. Therefore, the model was calibrated to the initial agricultural structure at the zonal level.

The model includes 24 households that were aggregated from the 2003-2004 Nigerian Living Standards Survey (NLSS) for the six zones by the rural and urban location. The rural households were distinguished according to the poultry production, i.e., a group of rural households without poultry production, a group of small poultry farmers with poultry less than or equal to 50 birds, and a large group of poultry farmers with more than 50 birds. The dynamic CGE model was further linked to a microsimulation module in which all sample households in the NLSS were included. In this formulation of macro-to-micro linkages, changes in representative households' consumption and prices in the dynamic CGE model were passed down to their corresponding sample households in the microsimulation module.

The Model Scenarios

Table 1 below presents the scenarios for the simulations in the model.

Table 1. Summary of the CGE model scenarios

Scenarios	Assumptions imposed	Targeted direct impact
Base run	Exogenous growth in population, land, productivity	GDP, agricultural domestic product (AgGDP) growth rates similar to those in 1995–2007
Scenario 1	Lowering capital stock and productivity in live poultry, poultry meat, and egg production in 2010; other assumptions same as in base run	Reducing poultry and egg production by 10 percent from base run's 2010
Scenario 2	Lowering capital stock and productivity in live poultry, poultry meat, and egg production in 2010 and 2011; other assumptions same as in base run	Reducing poultry and egg production by 10 percent from base run's 2010–2011
Scenario 3	Lowering capital stock and productivity in live poultry, poultry meat, and egg production in 2010–2012; other assumptions same as in base run	Reducing poultry and egg production by 10 percent from base run's 2010–2012
Scenario 4	Lowering marginal budget share for poultry and egg consumption in demand function in 2010; other assumptions same as in base run	Reducing poultry and egg demand by 10 percent from base run's 2010
Scenario 5	Lowering marginal budget share for poultry and egg consumption in demand function in 2010 and 2011; other assumptions same as in base run	Reducing poultry and egg demand by 10 percent from base run's 2010–2011
Scenario 6	Lowering marginal budget share for poultry and egg consumption in demand function in 2010-2012; other assumptions same as in base run	Reducing poultry and egg demand by 10 percent from base run's 2010–2012
Scenario 7	Combined assumptions in Scenarios 1 and 4	
Scenario 8	Combined assumptions in Scenarios 2 and 5	
Scenario 9	Combined assumptions in Scenarios 3 and 6	

Results from the Simulation

Differential Impact of Supply and Demand Shocks on Poultry Prices

Given that poultry and poultry product imports account for a small portion of poultry consumption in Nigeria, according to the model, when production falls by 10 percent, consumption declines in a similar fashion. This is also true for demand shocks, which cause domestic poultry production to fall by a similar range. However, the price effects are quite different between the initial shocks from the supply side and the demand side. When poultry demand has to be reduced involuntarily due to a lack of supply in domestic markets (with limited opportunities to increase imports rapidly when an outbreak occurs) and not due to changes in consumers' own preferences, poultry prices rise sharply. If the poultry supply shock lasts for only 1 year (year 2010) and production growth recovers to its base-run level (from the lowered level in 2010), poultry prices rise by 33 percent in the shocked year (2010) and continue to rise to 34-35 percent in the following years, all compared with the base run's price in the same year. If a similar supply shock lasts for 2-3 years, domestic prices for poultry can be 70 to 115 percent higher than the same year's price in the base run. The main reasons for such a strong price response are the lack of rapid import replacement and the high income elasticity for poultry in consumers' demand.

In contrast with the supply shock in which poultry prices rise sharply, according to the model, the direct shock on poultry demand causes prices for poultry to fall. However, the declines in poultry prices are much more modest, ranging between 2.4 and 6.0 percent, compared with the prices in the base run. The reason is that the model assumes poultry producers can respond to the market demand quickly such that labor and intermediate inputs, other than poultry capital, can be reallocated into other agricultural production.

Demand Shocks Dominate the Impact of HPAI on Revenue from Poultry Production

With 10 percent of the supply declining in 1 year, poultry production revenue actually increases by 20 percent due to sharp rises in poultry prices in the domestic market. Poultry revenue further increases by 40 to 58 percent when the supply shock lasts for 2-3 years. However, when poultry production is forced to contract due to a lack of domestic demand (which falls by 10 percent compared with the base run), poultry revenue falls more than the declines in the quantity of production because of a lowered domestic price for the reduced level of poultry production. Under the worst-case scenario, in which demand falls for 3 years, the revenue due to poultry production declines by 30 percent in the third year.

Differential Impact of HPAI on Rural Income by Zone

Table 2. Changes in the rural household income by zones and household groups under Scenarios 3 and 6 (% change from the base run in the same year)

	10% of supply decline in 2010-12			10% of demand decline in 2010-12		
	2010	2011	2012	2010	2011	2012
South-south, no poultry	0.0	0.1	0.1	0.0	-0.1	-0.1
South-south, with poultry < 50	-0.1	-0.3	-0.5	-0.1	-0.3	-0.4
South-south, with poultry > 50	-1.1	-2.9	-5.0	-1.8	-3.5	-5.1
Southeast, no poultry	0.0	0.0	0.0	0.0	0.0	0.0
Southeast, with poultry < 50	0.0	0.0	0.0	0.0	0.0	0.0
Southeast, with poultry > 50	-0.2	-0.5	-0.9	-0.3	-0.6	-0.8
Southwest, no poultry	0.0	0.0	0.0	0.0	-0.1	-0.1
Southwest, with poultry < 50	0.0	0.0	-0.1	-0.1	-0.2	-0.2
Southwest, with poultry > 50	-1.1	-2.9	-5.0	-1.8	-3.5	-5.1
North-center, no poultry	0.0	0.0	0.0	0.0	0.0	0.0
North-center, with poultry < 50	0.0	0.0	0.0	-0.1	-0.1	-0.1
North-center, with poultry > 50	-1.3	-3.3	-5.7	-2.0	-3.9	-5.7
Northeast, no poultry	0.0	-0.1	-0.2	0.0	0.0	0.0
Northeast, with poultry < 50	0.0	-0.1	-0.1	0.0	0.0	0.0
Northeast, with poultry > 50	-0.5	-1.2	-1.9	-0.6	-1.2	-1.8
Northwest, no poultry	0.0	0.0	0.0	0.0	-0.1	-0.1
Northwest, with poultry < 50	0.0	0.0	-0.1	0.0	-0.1	-0.1
Northwest, with poultry > 50	-0.6	-1.5	-2.6	-0.9	-1.8	-2.6

Source: Nigeria DCGE model simulation results

A cross-zone comparison by the type of household groups by the size of poultry production shows that the households engaged in large-scale poultry production are affected more than the small-scale producers are. Moreover, the large-scale poultry farmers the North-center zone are affected the most, as their income falls by 5.7 percent in the third year (2012) in both supply and demand shock scenarios (compared with the base run). This indicates that poultry income accounts for a larger share of total income for some rural households in the North-center zone, though about one third of the national poultry production is actually concentrated in the Southeast zone (among the households engaged in large-scale poultry production households), while only 12 percent of national poultry is produced by households engaged in large-scale poultry production in the North-center zone.

Indirect Effects of HPAI Outbreaks on Other Agricultural Sectors

Since poultry production is a very small subsector in the Nigerian economy dominated by small-scale producers with backyard production systems, the amount of agricultural inputs used in poultry production is very low. The data compiled for the SAM shows that agricultural products used as intermediate inputs in poultry production (excluding poultry itself) account for only 1.32 percent of the gross value of poultry output. Among these agricultural products, maize is the most important, but still only accounts for 0.8 percent of the gross value of poultry output. Because traditional poultry production does not apply many inputs from other agricultural sectors, the production linkage of poultry and other agricultural activities is weak, and it is unlikely to cause any significant impact of HPAI on other agricultural production when poultry production or demand falls by 10 percent in a year.

Besides linkages in the production process, the model also captures the consumption linkages. At the given level of income, when poultry prices increase due to supply shortages in the market, consumers have to spend more income on consuming fewer poultry products than before. Thus, income spent on other food consumption is limited and consumption of some other agricultural products may fall. After investigating production and consumption linkages, the model demonstrates that while both linkages are weak in the case of the poultry sector in Nigeria, consumption linkages seem to be relatively stronger (Table 3).

The production of beef and goat/sheep meat were also included in the model. However, there seems to be no difference in the changes of production and consumption for these two products under both supply and demand shocks.

Table 3. Changes in the production and consumption of selected agricultural products under Scenarios 3 and 6 (% change from the base run in the same year)

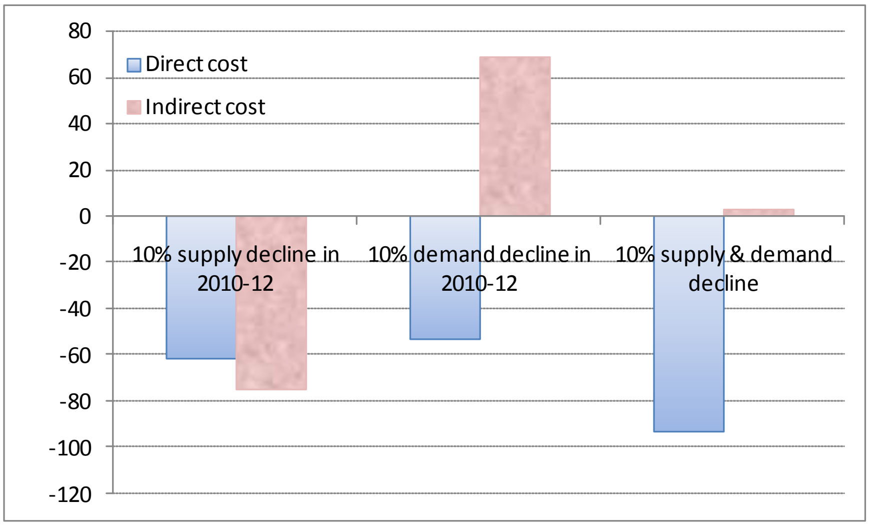
	10% of supply decline in 2010-12			10% of demand decline in 2010-12		
	2010	2011	2012	2010	2011	2012
Maize						
production	-0.15	-0.31	-0.48	0.24	0.47	0.70
consumption	-0.19	-0.40	-0.62	0.25	0.50	0.74
Sorghum						
production	-0.12	-0.25	-0.38	0.16	0.32	0.48
consumption	-0.14	-0.28	-0.44	0.17	0.35	0.51
Beef						
production	-0.07	-0.15	-0.24	0.43	0.81	1.15
consumption	-0.07	-0.15	-0.24	0.43	0.81	1.15
Goat/sheep meat						
production	-0.18	-0.37	-0.57	0.44	0.85	1.22
consumption	-0.18	-0.37	-0.57	0.44	0.85	1.22

Source: Nigeria dynamic CGE model simulation results

Assessing the Macroeconomic Effects of HPAI Outbreaks

In total, according to the model, the direct effect of a decline in poultry production costs the Nigerian economy about 20-61 billion Nigerian Naira measured as total GDP. The indirect effect through production and consumption linkages is about 24-76 billion Nigerian Naira (measured also as total GDP) when poultry production declines by 10 percent between 2010 and 2012, both from the GDP level in the base run's same year (Figure 1). That the indirect cost is higher than the direct cost further emphasizes the importance of assessing the economywide impact of HPAI outbreaks.

Figure 1. Direct and indirect cost of a possible HPAI outbreak to the Nigerian economy (measured as the difference in GDP in billion Nigerian Naira from the base run's 2012)



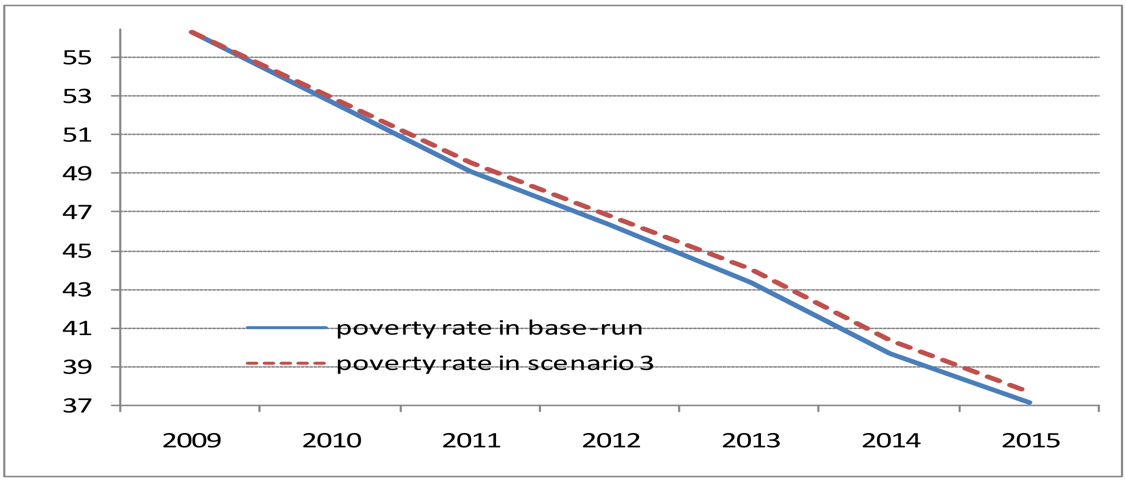
Source: Nigeria dynamic CGE model simulation results

Compared with the growth rate in the base run, the impact of shocks shows that even under the worst-case scenario, the AgGDP annual growth rate only falls by 0.34 percent and 0.17 percent for total GDP. With such a modest change in the growth rate, the cost of the HPAI outbreak is only about

0.7 and 0.5 percent of AgGDP and GDP, respectively, even in the worst year of the worst-case scenario (Scenario 3).

Based on the results from the microsimulation, income for the aggregate households of rural small-scale poultry producers by zones only falls by 0.1-0.4 percent, even in the worst-case scenario. Holding all other conditions as the same in the base run, HPAI outbreaks will make 70,000-145,000 more members of such households become poor between 2010 and 2012 in which an outbreak is assumed to lower poultry production by 10 percent each year.

Figure 2. Poverty rate for rural small-scale poultry producers



Source: Nigeria dynamic CGE model simulation results

Conclusions

In this paper, we developed a dynamic CGE model to assess the economywide impact of HPAI in Nigeria under different scenarios. In the model, using the data drawn from the 2003-2004 NLSS, we disaggregated Nigerian rural households into three groups across six zones according to the size of poultry production at the household level. The newly developed SAM was used as the dataset for the dynamic CGE model. We developed nine scenarios to assess the potential impact of an HPAI outbreak in Nigeria.

Nigeria vigorously protects its poultry markets through tariff and non-tariff barriers. The imports of poultry were further restricted after the 2006 HPAI outbreak in the country and in West Africa as a region. Because of these restrictions, according to the model simulation, the demand for and supply of poultry will change in a similar fashion in the domestic market regardless of which side is exogenously shocked. However, changes in poultry prices are very sensitive depending on whether supply or demand of poultry is directly shocked.

This study is constrained by the subnational disaggregation, as the heterogeneity in HPAI spread disappears once the risk scores are averaged to the zonal level in Nigeria. Hence, the model cannot capture the differential effects at the zonal level due to differences in HPAI outbreak or spread across the six zones. However, the model does capture the differential effects among rural households depending on whether poultry is a part of their livelihood strategy. Since the income deriving from poultry production of small-scale poultry producers is only a fraction of their overall income, an HPAI outbreak will affect such producers' incomes modestly if each zone's small-scale poultry households are treated as a group. The negative income effect on the households engaging in large-scale poultry production as a group at the zonal level is relatively large and their income can fall as much as 5.7 percent in a year (compared with the base run).

Our analysis also quantitatively assessed the economywide costs of HPAI outbreaks and it shows that the overall indirect costs to total GDP, measured in Nigerian Naira, are more than the direct cost of declines in the poultry value-added. By linking the dynamic CGE model with a microsimulation module, we also analyzed the possible poverty effect of HPAI on poultry-producing households. Because poultry accounts for a small portion of these households' total income, declines in poultry income seem not to have a significant poverty effect in the simulations. Under the simulation, about 70,000-145,000 of these household members will fall into poverty when poultry production is lowered by 10 percent for the 3 years. Given the population size of the country, such poverty effects can only slightly raise the poverty rate for the households engaging in small-scale poultry production as a group. However, for individual households, it is still a big challenge if poultry is an important part of their livelihood strategy.

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