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PRO-POOR HPAI RISK REDUCTION

Implications of Avian Flu for Economic Development in Kenya

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Africa/Indonesia Team Working Paper No. 22

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Preface

Since its re-emergence, HPAI H5N1 has attracted considerable public and media attention because the viruses involved have been shown to be capable of producing fatal disease in humans. While there is fear that the virus may mutate into a strain capable of sustained human-to-human transmission, the greatest impact to date has been on the highly diverse poultry industries in affected countries. In response to this, HPAI control measures have so far focused on implementing prevention and eradication measures in poultry populations, with more than 175 million birds culled in Southeast Asia alone.

Until now, significantly less emphasis has been placed on assessing the efficacy of risk reduction measures, including their effects on the livelihoods of smallholder farmers and their families. In order to improve local and global capacity for evidence-based decision making on the control of HPAI (and other diseases with epidemic potential), which inevitably has major social and economic impacts, the UK Department for International Development (DFID) has agreed to fund a collaborative, multidisciplinary HPAI research project for Southeast Asia and Africa.

The specific purpose of the project is to aid decision makers in developing evidence-based, pro-poor HPAI control measures at national and international levels. These control measures should not only be cost-effective and efficient in reducing disease risk, but also protect and enhance livelihoods, particularly those of smallholder producers in developing countries, who are and will remain the majority of livestock producers in these countries for some time to come.

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The views expressed in this report are those of the author and are not necessarily endorsed by or representative of IFPRI, or of the cosponsoring or supporting organizations. This report is intended for discussion. It has not yet undergone editing.

More information

For more information about the project please refer to www.hpai-research.net.

Summary

Kenya is vulnerable to avian flu given its position along migratory bird routes and proximity to other high risk countries. This raises concern about the effect an outbreak could have on economic development. We use a dynamic computable general equilibrium model of Kenya to simulate potential outbreaks of different severities, durations and geographic spreads. Results indicate that even a severe outbreak does not greatly reduce economic growth. It does, however, significantly worsen poverty, because poultry is an important income source for poor farmers and a major food item in consumers' baskets. Avian flu therefore does pose a threat to future development in Kenya. Reducing an outbreak's duration and spatial transmission is found to substantially lower economic losses. However, losses are still incurred when poultry demand falls, even without a confirmed outbreak. Our findings support monitoring poultry production and trade, responding rapidly to possible infections, and improving both farmers' and consumers' awareness of avian flu.

1. Introduction

The rapid spread of highly pathogenic avian influenza since its emergence in China in 1997 has raised concerns over its potential effect on human wellbeing and economic development, especially in low-income countries. Outbreaks of avian flu have already been confirmed in parts of Africa. Moreover, while some African countries have not yet experienced outbreaks, they remain vulnerable, both in terms of susceptibility and potential economic losses. Kenya is one of these vulnerable countries. Many of its neighbors face high risks of infection, including southern Sudan, where outbreaks have already occurred. Illegal cross-border trade may facilitate the transmission of the disease to domestic poultry stocks (Omiti and Okuthe, 2009). Equally important is the fact that Kenya lies along wild bird migratory routes, which may have caused outbreaks in other countries (see You and Diao, 2007). Finally, the threat of avian flu has caused many households, including those in Kenya, to limit their consumption of poultry products. Governments such as Kenya's have also banned poultry imports (Nyaga, 2007; Omiti and Okuthe, 2009). Thus, even without a confirmed outbreak, avian flu may undermine the poultry sector with adverse impacts on agricultural livelihoods. The implications of avian flu for economic growth and poverty is therefore of great concern to countries like Kenya, especially as they consider whether to devote resources to mitigation efforts.

In this paper we estimate the economywide impacts of a potential avian flu outbreak in Kenya. In Section 2 we examine the role of the poultry sector in Kenya's broader economy and for households' livelihoods. Then in Section 3 we develop a dynamic spatial computable general equilibrium (DCGE) model to capture the effects of reduced poultry production and demand on economic growth and poverty. Given the uncertainty surrounding the possible nature of avian flu in Kenya we design a series of simulations that capture different dimensions of an outbreak, including its severity, duration and geographic spread. The results from these simulations are presented in Section 4. The final section summarizes our findings and considers their policy implications.

2. Role of poultry in the Kenyan economy

Structure of the economy

Table 2.1 shows the contributions of different sectors to gross domestic product (GDP) and foreign trade. Agriculture is an important part of the Kenyan economy, accounting for a quarter of total GDP. Food crops form more than half of agricultural production, since maize is the country's main staple. Kenya also has a well established agricultural export sector (mainly tea, sugarcane and coffee). Only limited downstream processing of export crops takes place, which explains their high export intensity and the large share of agriculture in total export earnings.

Table 2.1: Structure of the Kenyan economy

	Share of total (%)				Export	Import
	Total GDP	Agric. GDP	Exports	Imports	Intensity	intensity
Total GDP	100.00	-	100.00	100.00	13.26	23.43
Agriculture	25.97	100.00	26.97	4.87	17.38	7.76
Food crops	14.11	54.34	2.89	4.87	3.36	12.09
Export crops	4.62	17.79	23.15	0.00	86.30	0.00
Livestock	5.63	21.68	0.00	0.00	0.00	0.00
Beef & dairy	3.24	12.49	4.46	0.00	0.00	0.00
Poultry	1.30	4.99	1.86	0.00	0.00	0.00
Other livestock	1.09	4.20	1.68	0.00	0.00	0.00
Fisheries	0.47	1.80	0.93	0.00	38.83	0.00
Forestry	1.14	4.39	0.00	0.00	0.00	0.00
Industry	18.02	-	25.27	81.02	10.98	46.07
Mining	0.76	-	2.14	0.00	31.27	0.00
Manufacturing	10.95	-	23.13	81.02	17.00	59.74
Food processing	3.11	-	2.29	9.41	4.37	30.92
Other manufactures	2.57	-	3.96	11.61	18.91	54.56
Other industries	6.31	-	0.00	0.00	0.00	0.00
Services	56.01	-	47.76	14.12	12.95	6.63

Source: Author's calculations using the 2007 Kenyan social accounting matrix (Thurlow, 2008).
Note: 'Export intensity' is the share of exports in total domestic output; 'Import intensity' is the share of imports in total domestic demand.

Livestock generates about five percent of total GDP or one fifth of agricultural GDP. The sector is dominated by cattle and dairy. Poultry, by contrast, is a fairly small subsector generating 1.3 percent of national GDP. Few livestock products are imported or exported, such that, in our analysis, we assume that poultry is effectively non-traded. This is also consistent with the government's banning of poultry imports following the recent global outbreak of avian flu (Omiti and Okuthe, 2009).

Kenya is one of Africa's more industrialized countries, with almost a fifth of total GDP generated in the non-mining industrial sector. However, the nonagricultural economy is dominated by services, especially retail trade, transport and government. Table 2.2 shows the regional distribution of sectors. Nairobi is clearly the center of Kenya's economy, generating almost a third of GDP. Although the capital city does have some agriculture, including poultry, it is small relative to the metropolitan area's nonagricultural base. Accordingly, in our analysis we will include Nairobi's agriculture as part of Central province, including those households that rely intensively on farm incomes.

Table 2.2: Regional structure of the Kenyan economy

	Population (1000s)	Farm pop. share (%)	Share of national total (%) Total GDP	Agric. GDP	Poultry GDP
Kenya	35,367	75.78	100.00	100.00	100.00
Central	4,382	83.04	13.15	20.08	15.90
Coast	3,263	61.58	10.17	8.29	17.82
Eastern	5,817	92.70	10.47	18.89	16.28
Nairobi	2,722	-	30.85	-	-
Northeastern	1,106	62.55	0.55	1.62	-
Nyanza	5,053	85.68	11.20	17.72	12.27
Rift Valley	8,690	76.59	18.67	24.30	23.53
Western	4,335	94.21	4.94	9.09	14.20

Source: Author's calculations using the 2005/06 Integrated Household Budget Survey and the 2007 Kenyan social accounting matrix (Thurlow, 2008).

Note: 'Export intensity' is the share of exports in total domestic output; 'Import intensity' is the share of imports in total domestic demand. Poultry production is zero in Northeastern and Nairobi provinces because the subsector is a very small share of total production in these regions and so is excluded from our analysis.

Poultry and household livelihoods

Despite Kenya's large industrial and service sectors, most households depend heavily on agriculture for their livelihoods. Indeed, more than three quarters of households earn some farm income. Many non-farm households are also linked to agriculture, such as rural traders and transporters. Poultry plays an important role in the agricultural economy. Kenya has around 34 million chickens of which four fifths are indigenous breeds reared in farmers' backyards (Nyaga, 2007). Three quarters of rural farm households keep indigenous chickens, which uses little labor time and requires few inputs, apart from maize-based animal feeds.

Although backyard production dominates poultry, there is also a large commercial sector, mostly located near the countries' urban centers. These businesses keep large flocks of broilers and layers and produce around 16 million day-old chicks each year. However, compared to indigenous chicken farming, few Kenyans are employed in the commercial poultry sector. This implies that the impact of avian flu on employment and livelihoods is likely to arise via effects on indigenous breeds and locally produced poultry feed. Furthermore, even though the largest commercial poultry company employs a contract system to produce broilers, the farmers involved are large-scale owning 3,000-12,000 birds per farm (Nyaga, 2007). Changes in these farmers' income are therefore unlikely to influence poverty. However, it may affect national income, and so both backyard and commercial poultry are included in our analysis.

The top part of Table 2.3 shows that, on average, there are 1.23 birds for each farm household member in Kenya. Per capita poultry ownership is higher amongst higher income households, with less than one bird per household member in the lowest quintile and over two birds per member in the highest quintile. Per capita poultry ownership is highest in the Coastal province.

Table 2.3: Poultry stocks, incomes and consumption shares by expenditure quintile

	All farm households	Farm household per capita expenditure quintiles				
		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
	Average number of birds per farm household member					
Kenya	1.23	0.89	1.17	1.41	1.37	2.19
Central	1.54	0.87	0.94	0.86	1.86	2.75
Coast	1.87	2.08	2.81	4.38	2.56	5.57
Eastern	1.07	0.67	0.88	1.23	1.23	1.79
Nyanza	1.03	0.47	0.95	1.26	0.99	1.83
Rift Valley	1.25	0.78	1.02	1.59	1.23	1.99
Western	1.23	1.20	1.29	0.89	1.46	1.55
	Poultry income share in total farm household income (%)					
Kenya	0.69	2.04	1.89	1.43	0.84	0.23
Central	0.90	1.83	1.31	0.92	1.17	0.67
Coast	2.62	3.65	3.89	3.01	0.91	1.79
Eastern	0.99	1.46	1.21	1.61	1.03	0.47
Nyanza	0.00	0.00	0.00	0.00	0.00	0.00
Rift Valley	0.00	0.00	0.00	0.00	0.00	0.00
Western	0.82	0.86	1.32	1.20	0.53	0.64
	Share of poultry in total household consumption expenditure (%)					
Kenya	2.80	2.04	2.84	3.30	3.15	2.67
Central	2.08	1.64	0.23	1.32	1.73	2.54
Coast	3.80	3.71	6.97	5.97	3.59	2.92
Eastern	2.43	0.80	2.24	2.38	3.01	2.54
Nairobi	2.38	0.00	2.76	0.00	0.72	2.49
Northeastern	0.17	0.22	0.71	0.00	0.00	0.00
Nyanza	4.76	3.43	4.01	5.22	6.45	3.99
Rift Valley	1.67	0.69	0.84	1.98	1.25	2.07
Western	6.11	3.39	6.25	6.49	8.03	5.21

Source: Author's calculations using the 2005/06 Integrated Household Budget Survey, and the 2007 Kenyan social accounting matrix (Thurlow, 2008).

Note: Farm households include those with and without poultry. Poultry stocks and incomes are zero in Northeastern and Nairobi provinces because the subsector is a very small share of these regions' total production and so is excluded from our analysis.

The second part of the table shows the contribution of poultry revenues to total incomes. On average, poultry income generates 0.69 percent of farmers' incomes.[1] Despite their larger poultry ownership, higher-income farmers are, at the national-level, equally dependent on poultry incomes as are lower-income farmers. This is because crop revenues and off-farm earnings become more important income-sources as farm incomes rise. Indeed, the contribution of poultry to household incomes in some provinces is highest in the lower and middle parts of the income distribution, thus justifying concerns about avian flu's potential impact on household poverty.

The third part of Table 2.3 shows the shares of poultry in total household consumption expenditure. On average, 2.8 percent of consumer spending is on poultry.[2] This share is highest in the middle of the income distribution, and in Coast, Nyanza and Western provinces. It is much lower in the Northeastern province, where poultry production is negligible and consumers rely more on other forms of livestock.

In summary, even though the poultry sector is only a small part of the economy, almost all farmers are connected to poultry production, either by rearing backyard chickens, producing maize for poultry feed, or by consuming poultry products. There is also a large commercial poultry sector that contributes to national income and satisfies most urban areas' consumer demand. However, it is smallholders' livelihoods that are likely to be most affected by avian flu since they rely more heavily on poultry incomes. In the next section we develop an economywide model that captures the structure of the poultry sector and estimates the potential impact of avian flu on national and household-level incomes.

[1] This is smaller than poultry's contribution to total GDP because the government receives foreign capital (e.g., donor funds) some of which is (directly or indirectly) transferred to households (e.g., pensions and social security).

[2] This is larger than poultry's contribution to total GDP because poultry in non-traded and households use their income for other non-consumption purposes (e.g., taxes and saving).

3. Modeling the economywide impacts of Avian Flu

The DCGE model used in this paper captures Kenya's detailed economic structure. This class of economic models is often used to examine external shocks in low income countries, such as droughts, world price changes, and human and animal illness. Their strength is their ability to explicitly measure structural linkages between producers, households and the government, while also accounting for resource constraints and the role these play in determining product and factor prices. These models do, however, depend on their underlying assumptions and the quality of the data used to calibrate them. This section explains the workings of the Kenyan DCGE model and the data used to calibrate it.

The core general equilibrium model

Table 3.1 presents the equations of a simple model illustrating how changes in poultry production and demand affect economic growth and household incomes in our analysis. The model is recursive dynamic and so can be separated into a static 'within-period' component wherein producers and consumers maximize profits and utility, and a dynamic 'between-period' component wherein the model is updated based on demographic trends and previous period results, thereby reflecting changes in population, labor supply, and the accumulation of capital and technology.

In the static component of the model, producers in each sector *s* and region *r* produce a level of output *Q* in time period *t* by employing the factors of production *F* under constant returns to scale (exogenous productivity α) and fixed production technologies (fixed factor shares δ) (eq. [1]). Profit maximization implies that factor payments *W* are equal to average production revenues (eq. [2]). Labor and land supply *S* and capital supply *K* are fixed within a given time period, implying full employment of factor resources. Land and labor market equilibrium is defined at the regional level, so land and labor is mobile across sectors but wages and rental rates vary by region (eq. [6]). National capital market equilibrium implies that capital is mobile across both sectors and regions, and earns a national rental rate (i.e., regional capital returns are equalized) (eq. [7]).

Factor incomes are distributed to households in each region using fixed income shares based on households' initial factor endowments θ (eq. [3]). Total household incomes *Y* are then either saved (based on marginal propensities to save υ) or spent on consumption *D* (according to marginal budget shares β) (eq. [4]). Savings are collected in a national savings pool and used to finance investment demand *I* (i.e., savings-driven investment closure) (eq. [5]). Finally, a single price *P* equilibrates demand and supply in national product markets, thus avoiding the need to model interregional trade (eq. [8]).

The model's variables and parameters are calibrated to observed data from a regional social accounting matrix that captures the initial equilibrium structure of the Kenyan economy in 2007 (Thurlow, 2008). Parameters are then adjusted over time to reflect demographic and economic changes and the model is re-solved for a series of new equilibriums for the 8-year period 2007-2015. Three dynamic adjustments occur between periods: changes in land and labor supply; capital accumulation; and technical change.

Table 3.1: Simple CGE Model Equations

Production function	$Q_{srt} = \alpha_{srt} \cdot \prod_f F_{fsrt}^{\delta_{fsr}}$		(1)
Factor payments	$W_{frt} \cdot \sum_s F_{fsrt} = \sum_s \delta_{fsr} \cdot P_{st} \cdot Q_{srt}$		(2)
Household income	$Y_{hrt} = \sum_{fs} \theta_{hf} \cdot W_{frt} \cdot F_{fsrt}$		(3)
Consumption demand	$P_{st} \cdot D_{hsrt} = \beta_{hsr} \cdot (1 - \upsilon_{hr}) \cdot Y_{hrt}$		(4)
Investment demand	$P_{st} \cdot I_{st} = \rho_s \cdot \sum_{hr} \upsilon_{hr} \cdot Y_{hrt}$		(5)
Labor and land equilibrium	$\sum_s F_{fsrt} = S_{frt}$	*f is land and labor*	(6)
Capital equilibrium	$\sum_{rs} F_{fsrt} = K_{ft} \quad and \quad W_{frt} = W_{fr't}$	*f is capital*	(7)
Product market equilibrium	$\sum_{hr} D_{hsrt} + I_{st} = \sum_r Q_{srt}$		(8)
Labor and land supply	$S_{frt} = S_{frt-1} \cdot (1 + \sigma_{fr})$	*f is land and labor*	(9)
Capital accumulation	$K_{ft} = K_{ft-1} \cdot (1 - \pi) + \sum_s \frac{P_{st-1} \cdot I_{st-1}}{\kappa}$	*f is capital*	(10)
Technical change	$\alpha_{srt} = \alpha_{srt-1} \cdot (1 + \gamma_{srt})$		(11)

Subscripts
- *f* Factor groups (land, labor and capital)
- *h* Household groups
- *r* Regions (provinces)
- *s* Economic sectors
- *t* Time periods

Exogenous parameters
- α Production shift parameter (factor productivity)
- β Household average budget share
- δ Factor input share parameter
- θ Household share of factor income
- ρ Investment commodity expenditure share
- υ Household marginal propensity to save
- *γ* Hicks neutral rate of technical change

Exogenous parameters (continued)
- κ Base price per unit of capital stock
- π Capital depreciation rate
- σ Labor and land supply growth rate

Endogenous variables
- *D* Household consumption demand quantity
- *F* Factor demand quantity
- *I* Investment demand quantity
- *K* National capital supply
- *S* Regional labor and land supply
- *P* Commodity price
- *Q* Output quantity
- *W* Average factor return
- *Y* Total household income

Between periods the model is updated to reflect long-term growth rates in labor and land supply S captured by the parameter σ (eq. [9]). For capital supply K, the model endogenously determines the national rate of accumulation (eq. [10]). The level of investment I from the previous period is converted into new capital stock using a fixed capital price κ. This is added to previous capital stocks after applying a fixed rate of depreciation π. New capital is endogenously allocated to regions and sectors so as to equalize capital returns. Finally, the model captures total factor productivity through the production function's shift parameter α. The rate of technical change γ is determined exogenously [eq. (11)].

Extensions in the full Kenya DCGE model

The simple model above illustrates how we link changes in sector production to economic growth and household incomes. However, the full Kenya model drops many of the assumptions implicit in this simplified model (see Lofgren et al., 2002; Thurlow, 2005). Constant elasticity of substitution production functions replace Cobb-Douglas functions in order to allow factor substitution based on relative factor prices (i.e., δ is no longer fixed). The full model identifies 53 sectors (see Table 3.2) each of which is disaggregated across the country's eight provinces. Intermediate demand in each sector, which was excluded from the simple model, is now determined by fixed technology coefficients (i.e., Leontief). Based on the 2004/05 Kenya Integrated Household Budget Survey (IHBS), labor markets in each region are further segmented across three skill groups: (1) high-skilled professionals and managers; (2) semi-skilled technicians and sales staff; and (3) remaining low-skilled workers, such as farmers. Agricultural land and livestock capital is mobile across sectors within regions, but cannot be reallocated to other regions. Poultry capital is separated from other livestock sectors and earns sector-specific returns. Nonagricultural capital is also sector/region-specific. However, new capital from past investment is allocated across regions/sectors according to profit rate differentials under a "putty-clay" specification.

Table 3.2: Sectors, factors and regions in the Kenya DCGE model

Agriculture (24)	Maize; wheat; rice; sorghum; millet; cassava; other roots (incl. sweet potatoes); pulses (incl. mixed beans); oil seed crops (incl. sesame, groundnuts); fruits; vegetables; cotton; sugarcane; coffee; tea; tobacco; other crops (incl. pyrethrum); cattle; dairy; poultry; sheep & goats; other livestock (incl. pigs); fisheries; and forestry
Industry (19)	Mining; meat & fish processing; grain milling; sugar processing; other food processing; beverages & tobacco; textiles & clothing; leather & footwear; wood products (excl. furniture); printing & publishing; petroleum products; other chemical products (incl. plastics); non-metallic minerals (incl. glass); metal products (incl. aluminum); machinery; other manufacturing (incl. furniture); electricity; water; and construction
Services (10)	Wholesale & retail trade services; hotels & catering; transport services; communication services; financial services; business & real estate; community & other private services; government administration and services; education; and health
Factors (8)	High-skilled labor; semi-skilled labor; low-skilled labor; agricultural land; agricultural capital; nonagricultural capital; livestock stocks; and poultry stocks
Provinces (8)	Central; Coast; Eastern; Nairobi; Northeastern; Nyanza; Rift Valley; and Western

The full model still assumes national product markets. However, international trade is captured by allowing production and consumption to shift imperfectly between domestic and foreign markets, depending on the relative prices of imports, exports and domestic goods. Since Kenya is a small economy, world prices are assumed to be fixed and the current account balance is maintained by a flexible real exchange rate (i.e., a price index of tradable-to-nontradable goods). Production and trade elasticities are from Dimaranan (2006).

Households maximize a Stone-Geary utility function such that a linear expenditure system determines consumption with non-unitary income elasticities. Households in each region are disaggregated across farm/nonfarm groups and by per capita expenditure quintiles, giving a total of 75 representative household groupings. These household groups pay taxes to the government based on fixed direct and indirect tax rates. Tax revenues finance exogenous recurrent spending, resulting in an endogenous fiscal deficit. The full Kenya DCGE model captures the detailed sector and labor market structure of Kenya's economy and the linkages between production, employment and household incomes. The model used in our analysis has already been applied in Kenya (see Thurlow and Benin, 2008; Thurlow et al. 2007) and to address avian flu in Ghana and Nigeria (see Diao 2009; Diao et al. 2009).

Avian flu simulations

Two consequences of avian flu are captured in the DCGE model. First, an outbreak of avian flu results in the culling of poultry stocks, which reduces the productive capacity of the poultry sector. This production-side shock is captured in the model by reducing poultry capital F (eq. [1]) and productivity growth γ for poultry farmers (eq. [11]). When poultry production declines in the avian flu simulations it releases labor to work in other non-poultry sectors. Falling poultry production will therefore affect household incomes in the model via three channels: (1) direct losses in agricultural revenues for poultry farmers; (2) indirect effects from changes in economywide factor returns; and (3) changes in consumer prices, including that of poultry.

The second consequence of avian flu is reduced consumer demand for poultry products. This is captured by reducing the share of disposable incomes that households spend on poultry (i.e., β in eq. [4]) and then proportionally increasing demand for non-poultry products. The effect of reduced poultry demand on household incomes is not easily predicted, since it is effectively a transfer of demand from one product to another. Poultry farmers will be adversely affected by falling prices and lower returns to their agricultural resources, causing them to shift resources into other activities to offset falling agricultural revenues. This will, however, increase non-poultry production and reduce non-poultry products' prices, thus benefiting other household groups in the model. The net effect will depend on the economic structure and income distribution of the Kenyan economy. In our analysis we are able to isolate the effects of production and demand-side shocks.

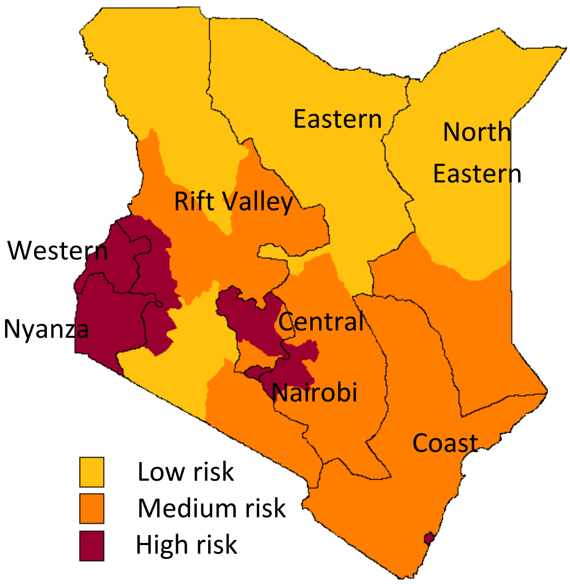
There is considerable uncertainty surrounding the scale and nature of a potential avian flu outbreak in Kenya. As shown in Table 3.3, we run a range of simulations capturing three dimensions of an outbreak: (1) the *severity* of production losses and demand response; (2) the *duration* of over which these losses take place; and (3) the geographic *spread* of infected areas. To capture different severities, we model a 15 and 30 percent annual decline in poultry production and demand starting in 2010. For reporting purposes we shall call these 'minor' and 'major' severities. The duration over which annual declines take place varies from one to three years (i.e., 2010, 2010-11 and 2010-2012). During these outbreaks of different durations, poultry production and demand declines by either 15 or 30 percent each year, thus compounding economic losses. There are six possible combinations of simulations based on different severities and durations of a potential outbreak.

Table 3.3: Different dimensions of a simulated avian flu outbreak

Severity (2 levels)	Minor (15 percent annual decline in poultry production and demand) Major (30 percent annual decline in poultry production and demand)
Duration (3 levels)	1 year (2010) 2 years (2010-2011) 3 years (2010-2012)
Spread (3 levels)	Localized (high risk districts only) Extensive (high and medium risk districts) Nationwide (all districts)

Finally, a third dimension of an outbreak is its geographic spread. Different parts of Kenya have different vulnerabilities to avian flu based on, for example, their proximity to migratory bird routes or neighboring countries. This is captured by a district-level avian flu risk index estimated by xxx (2009) (see Figure 3.1). To capture different spreads of an outbreak, we run each of the six severity/duration combinations assuming (1) a 'localized' outbreak only in high risk districts; (2) a more 'extensive' outbreak covering both high and medium risk districts; and (3) a 'nationwide' outbreak covering all districts. Since the DCGE model is disaggregated by province, we weighted poultry production shocks by district-level populations to derive province-level shocks.

Figure 3.1: District-level avian flu risk index



Source: Author's calculation using the avian flu risk index from xxx (2009).
Note: Minimum risk indices are used in the figure. Low risk index values range from 80-100; medium risk from 100-120; and high risk from 120-140.

In summary, the DCGE model captures the economywide impact of a potential avian flu outbreak, including its impact on both economic growth and household incomes. The model is calibrated to the most recent social accounting matrix and household budget survey and captures the detailed economic structure of the Kenyan economy. Finally, since it is impossible to predict the actual severity, duration and spread of a potential outbreak, we run a number of simulations in our analysis to estimate economic losses across a wide range of possible outbreak scenarios.

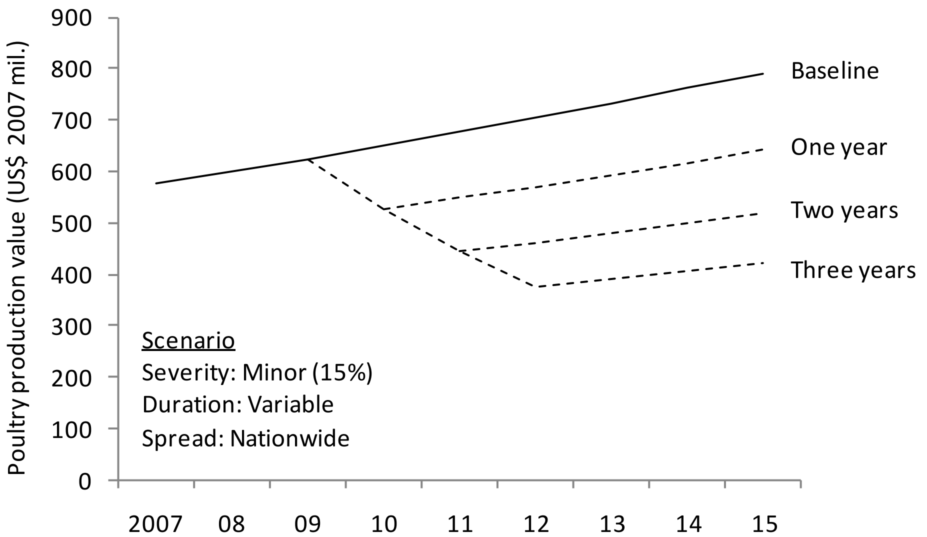
4. Simulation results

To estimate the economic impact of avian flu we first simulate a baseline scenario without an outbreak. This baseline scenario draws on recent growth and demographic trends. We assume that labor supply, population and agricultural land expand at two percent per year during 2007-2015. Poultry and non-poultry livestock stocks also grow at two percent annually. Agricultural and nonagricultural total factor productivity (TFP) grows at one and three percent respectively, thus reflecting agriculture's weaker performance in recent years (see Thurlow and Benin, 2008). Under these assumptions, total GDP growth averages about five percent per year. It should be noted that the baseline only provides us with a counterfactual and so does not influence our conclusions. Starting from this baseline, we reduce poultry production and demand in order to simulate an avian flu outbreak of varying dimensions.

Different dimensions of an outbreak

To account for uncertainty, we model outbreaks that vary on their severity, duration and spread (see Table 3.3). To illustrate these dimensions we first report the impact of avian flu on the real value of poultry production. Figure 4.1 shows the impact of a minor nationwide outbreak of different durations (i.e., one that reduces poultry production and demand by 15 percent each year). In the baseline scenario, poultry production continues to grow throughout the 2007-2015 period. However, in the one-year duration scenario, production falls in 2010. Production then grows again in subsequent years, albeit from a lower base. This reflects the culling of poultry stocks and the recovery period after an outbreak. In the two- and three-year duration scenarios, production continues to fall until 2011 and 2012, respectively. Thus the decline in poultry stocks and production is significantly larger when the duration of an outbreak is lengthened.

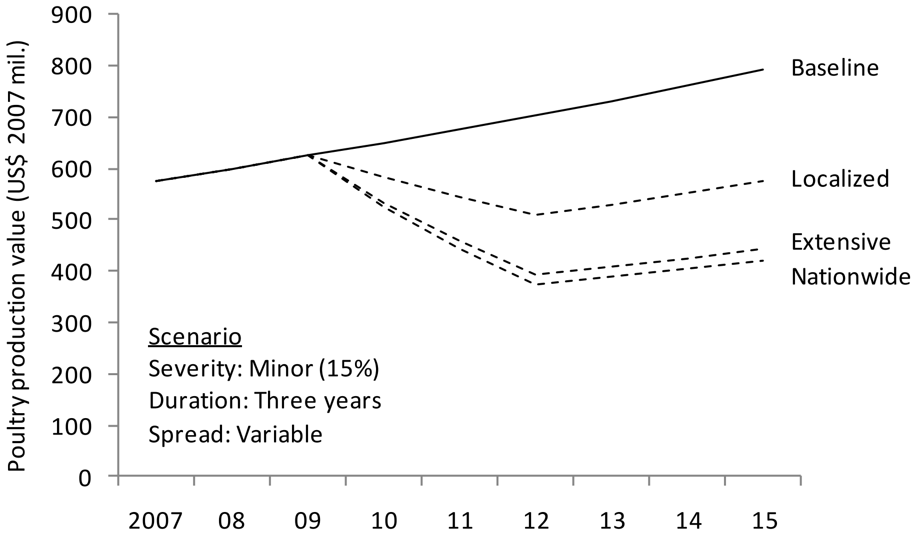
Figure 4.1: Poultry production under avian flu scenarios with variable durations



Source: Results from the Kenya DCGE and microsimulation model.
Notes: Impact of the combined production and demand scenario on the real value of poultry production (measured in 2007 prices).

Figure 4.2 again shows the impact of a minor outbreak. However, in this figure we vary its geographic spread rather than duration, which we fix at three-years. In a 'localized' outbreak only certain areas of the country are affected, including all of Nyanza and Western provinces and most of Central province (i.e., high risk districts shown in Figure 3.1). Even though avian flu is concentrated during a localized outbreak, the fall in poultry production is still significant because the affected districts account for about half of national poultry production (see Table 2.2). Production losses are larger under an 'extensive' outbreak, which now also includes the Coast province and large portions of the remaining provinces (i.e., both high and medium risk districts). Finally, there is only a small additional loss incurred when an extensive outbreak becomes nationwide, because none of low risk districts are major poultry producing areas (i.e., the northern parts of the Rift Valley and Northeast provinces).

Figure 4.2: Poultry production under avian flu scenarios with variable geographic spreads



Source: Results from the Kenya DCGE and microsimulation model.
Notes: Impact of the combined production and demand scenario on the real value of poultry production (measured in 2007 prices).

The above two figures underline the uncertainty surrounding a potential avian flu outbreak. Table 4.1 summarizes the impact on poultry production for all dimensions of an outbreak. As was shown in Figure 4.1, a one-year nationwide outbreak reduces total poultry production by between 19.0 and 36.5 percent depending on its severity. It should be noted that the overall impact is larger than the separate production or demand-side shocks because these compound each other causing poultry production to fall by more than 15 or 30 percent in a minor or major outbreak, respectively. Similarly, lengthening the duration of an outbreak leads to less than proportional reductions in production, since the *absolute* size of the percentage-based shocks becomes smaller in subsequent years. However, the model results clearly indicate that increasing the severity, duration and geographic spread of an outbreak leads to significantly larger declines in poultry production. This underlines the importance of responding rapidly to an outbreak in order to limit the disease's transmission to other farmers and provinces.

Table 4.1: Deviation in national poultry production from baseline in 2015 (%)

Severity of Outbreak	Spread of outbreak	Duration of outbreak One year	Two years	Three years
Minor (15%)	Localized	-10.51	-19.61	-27.52
	Extensive	-17.72	-32.27	-44.22
	Nationwide	-18.97	-34.34	-46.80
Major (30%)	Localized	-20.46	-35.61	-47.04
	Extensive	-34.15	-56.52	-71.21
	Nationwide	-36.47	-59.64	-74.36

Source: Results from the Kenya DCGE and microsimulation model.
Notes: Impact of the combined production and demand scenario on the real value of poultry production (measured in 2007 prices).

Economywide losses and growth-effects

In the previous section we presented the direct impact of avian flu on poultry production. However, an outbreak will also affect non-poultry sectors via a number of transmission channels. For example, declining production will reduce poultry farmers' incomes and hence their demand for non-poultry consumer products. Similarly, by reducing the size of poultry farming, avian flu will lower upstream demand for animal feeds, thereby affecting maize farmers. Conversely, when poultry stocks are culled, poultry farmers will reallocate productive resources (i.e., labor) to non-poultry activities, such as crop farming and off-farm employment. As a result, avian flu may actually expand production in non-poultry sectors. It is necessary to account for all indirect sector linkages and factor market adjustments when estimating economywide losses.

Table 4.2 reports estimated losses in total GDP caused by outbreaks of different dimensions. The DCGE model estimates that a minor one-year localized outbreak reduces total baseline GDP by US$39 million (measured in 2007 prices). These losses increase under lengthier and more severe outbreaks. For instance, a major three-year nationwide outbreak generates economywide losses of US$248 million. It is worth noting that the estimated losses are measured only after the economy has had time to adjust. This implies that farmers have had sufficient time to reallocate resources to non-poultry sectors, and that labor working in commercial poultry businesses have had sufficient time to find new jobs. In reality, there may be a short-term adjustment period following an outbreak. However, since very little labor is used for backyard poultry rearing, and since this is where most of the economic losses occur, it is likely that any adjustment costs will be small compared to the medium-term losses reported in the table.

Table 4.2: Total economic losses due to avian flu (US$ million)

Severity of outbreak	Spread of outbreak	Duration of outbreak		
		One year	Two years	Three years
Minor (15%)	Localized	-38.7	-71.4	-99.0
	Extensive	-61.4	-111.1	-151.3
	Nationwide	-65.2	-117.3	-158.9
Major (30%)	Localized	-76.0	-130.8	-170.8
	Extensive	-118.8	-194.6	-241.6
	Nationwide	-125.7	-203.0	-248.4

Source: Results from the Kenya DCGE and microsimulation model.
Notes: Impact of the combined production and demand scenario on the real value of total GDP in 2015 (measured in 2007 prices).

Economic losses are not evenly distributed across provinces. This is evident in Table 4.3, which reports changes in provincial GDP following a three-year avian flu outbreak. Not surprisingly, the province facing the largest economic losses varies according to the geographic spread of the outbreak. In a localized outbreak, the largest losses occur in the high risk Nyanza, Western and Central provinces. The Rift Valley also experiences large losses despite being at a more moderate risk level. This is because the Rift Valley is a large province and a significant share of its population resides in high risk districts (see Figure 3.1). By contrast, Eastern province is largely unaffected by a localized outbreak since none of the province's districts are at high risk. However, large losses are experienced in this province during an 'extensive' outbreak, when medium risk districts are affected. Finally, Nairobi benefits slightly from an avian flu outbreak. This is primarily because falling demand for poultry leads to some increase in demand for non-food products, which benefits Nairobi's large nonagricultural economy (see Table 2.2).

Table 4.3: Total economic losses due to a three-year avian flu outbreak (US$ million)

	Minor outbreak (15%)			Major outbreak (30%)		
	Localized	Extensive	Nationwide	Localized	Extensive	Nationwide
Kenya	-99.0	-151.3	-158.9	-170.85	-241.64	-248.42
Central	-19.7	-25.3	-24.9	-33.74	-39.43	-38.40
Coast	-8.8	-29.9	-29.6	-17.05	-47.17	-46.51
Eastern	-1.9	-20.6	-21.4	-4.91	-32.82	-33.46
Nairobi	-1.5	0.9	1.4	-3.22	0.21	0.65
Northeastern	0.1	0.0	0.0	0.13	-0.15	-0.27
Nyanza	-19.6	-17.8	-17.3	-31.47	-27.14	-25.80
Rift Valley	-21.6	-33.7	-42.5	-39.41	-56.98	-67.33
Western	-26.0	-24.8	-24.6	-41.17	-38.17	-37.30

Source: Results from the Kenya DCGE and microsimulation model.
Notes: Impact of the combined production and demand scenario on the real value of total GDP in 2015 (measured in 2007 prices).

In summary, avian flu could cost the Kenyan economy between US$38 and US$248 million depending on the scale and duration of an outbreak. However, these impacts remain very small relative to the overall size of the economy. For instance, even a major three-year nationwide outbreak would only reduce the country's average annual total GDP growth rate by 0.12 percentage points during 2009-2015. Thus, while potential economic losses caused by avian flu are significant, it is unlikely that an outbreak would have a severe detrimental effect on economic growth in Kenya.

Household welfare and poverty-effects

Even though the impact of avian flu on national income is small, it has large negative consequences at the household-level, especially amongst certain population groups. Table 4.4 reports changes in average annual per capita growth in equivalent variation, which is a household welfare measure that controls for changes in prices. As mentioned above, a major three-year nationwide outbreak reduces the national GDP growth rate by only 0.12 percentage points per year. However, the impact on per capita equivalent variation growth is larger at 0.41 percentage points (see the top part of Table 4.4). This is because poultry contributes a larger share to household incomes than it does to national GDP (see Tables 2.1 and 2.3). Welfare losses are also larger for farm households, although these losses also vary considerably depending on the scale and duration of an outbreak.

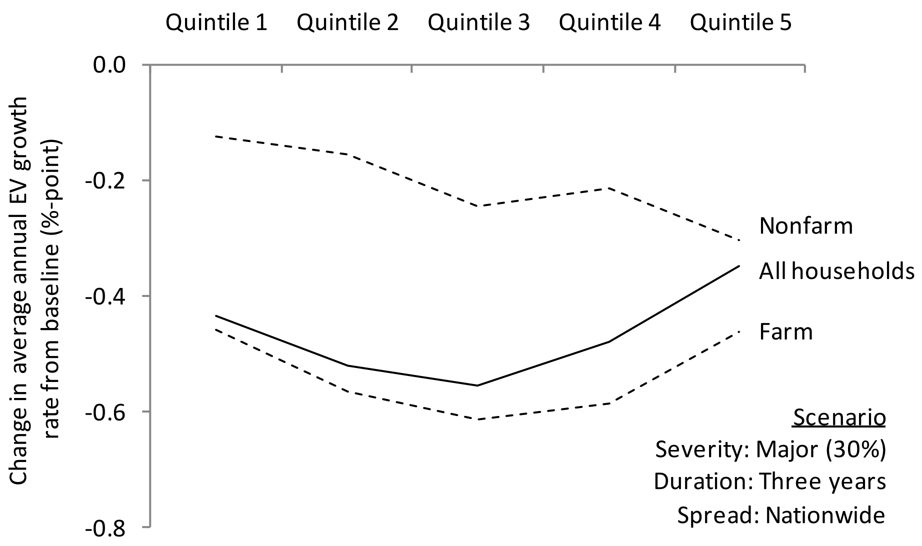
Table 4.4: Deviation in average annual per capita equivalent variation from Baseline due to avian flu (%-point)

Severity of Outbreak	Spread of outbreak	Duration of outbreak		
		One year	Two years	Three years
		All households		
Minor (15%)	Localized	-0.02	-0.04	-0.06
	Extensive	-0.04	-0.09	-0.14
	Nationwide	-0.05	-0.10	-0.16
Major (30%)	Localized	-0.04	-0.08	-0.11
	Extensive	-0.09	-0.21	-0.35
	Nationwide	-0.11	-0.24	-0.41
		Farm households		
Minor (15%)	Localized	-0.04	-0.08	-0.11
	Extensive	-0.07	-0.14	-0.21
	Nationwide	-0.07	-0.15	-0.23
Major (30%)	Localized	-0.08	-0.15	-0.20
	Extensive	-0.15	-0.30	-0.47
	Nationwide	-0.16	-0.33	-0.54
		Nonfarm households		
Minor (15%)	Localized	0.00	0.00	0.00
	Extensive	-0.02	-0.04	-0.07
	Nationwide	-0.02	-0.05	-0.09
Major (30%)	Localized	0.00	0.00	-0.01
	Extensive	-0.04	-0.11	-0.23
	Nationwide	-0.05	-0.14	-0.29

Source: Results from the Kenya DCGE and microsimulation model.
Notes: Impact of the combined production and demand scenario on households' real annual equivalent variation growth rate during 2009-2015.Equivalent variation is a welfare measure controlling for changes in prices.

Avian flu affects Kenya's income distribution. Figure 4.3 shows the impact of a major three-year nationwide outbreak on household welfare across per capita expenditure quintiles. The solid curved line in the figure indicates that households in the middle of the income distribution (i.e., quintile 3) are most vulnerable to welfare losses caused by avian flu. This is because these households are most reliant on poultry incomes (see middle part of Table 2.2). By contrast, higher-income nonfarm households are more affected than lower-income nonfarm households because they spend a larger share of their disposable incomes on poultry products (see bottom part of Table 2.2). However, despite these distributional variations, the model results indicate that all income quintiles and both farm and nonfarm households would be adversely affected by an avian flu outbreak.

Figure 4.3: Deviation in national household equivalent variation by expenditure quintile



Source: Results from the Kenya DCGE and microsimulation model.
Notes: Equivalent variation is a welfare measure controlling for prices.

The DCGE model is linked top-down to the 2005/06 household survey. This means that changes in real per capita consumption for each household group in the model are passed down to their corresponding households in the survey, where poverty is calculated. This is the 'micro-simulation' component of the model. Table 4.5 reports changes in the final year poverty headcount rate from the baseline scenario caused by avian flu.[3] Under a major three-year nationwide outbreak the national poverty headcount increases by 1.15 percentage points. This reflects the welfare losses experienced by households near the poverty line (i.e., quintile 2 in Figure 4.2). Given a two percent annual population increase, Kenya's total population is projected to reach 41.4 million people by 2015. Thus, the increase in the final year poverty rate by 1.15 percentage points is equivalent to an additional 478,000 people living below the poverty line as a result of a severe and lengthy outbreak of avian flu (see bottom part of Table 4.5). Thus, while avian flu would only have a small detrimental effect on national economic growth, its implications for household welfare and poverty could be far more pronounced.

[3] The poverty headcount is the share of Kenya's total population with per consumption levels below the national poverty line. In 2005/06, 47 percent of Kenya's population was classified as 'poor'. This falls to 35 percent by 2015 in our modeled baseline scenario, which projects real per capita GDP growth of around three percent per year.

Table 4.5: Deviation in household poverty due to avian flu

Severity of Outbreak	Spread of outbreak	Duration of outbreak		
		One year	Two years	Three years
		Deviation in national poverty headcount rate from baseline in 2015 (%-point)		
Minor (15%)	Localized	0.18	0.37	0.54
	Extensive	0.23	0.49	0.64
	Nationwide	0.27	0.52	0.64
Major (30%)	Localized	0.40	0.76	0.90
	Extensive	0.50	0.92	1.10
	Nationwide	0.58	0.93	1.15
		Deviation in national poor population from baseline in 2015 (1000's people)		
Minor (15%)	Localized	74.4	154.0	224.8
	Extensive	95.0	201.9	264.7
	Nationwide	112.9	214.3	264.2
Major (30%)	Localized	165.0	314.4	373.6
	Extensive	206.4	381.6	456.0
	Nationwide	241.7	385.3	477.8

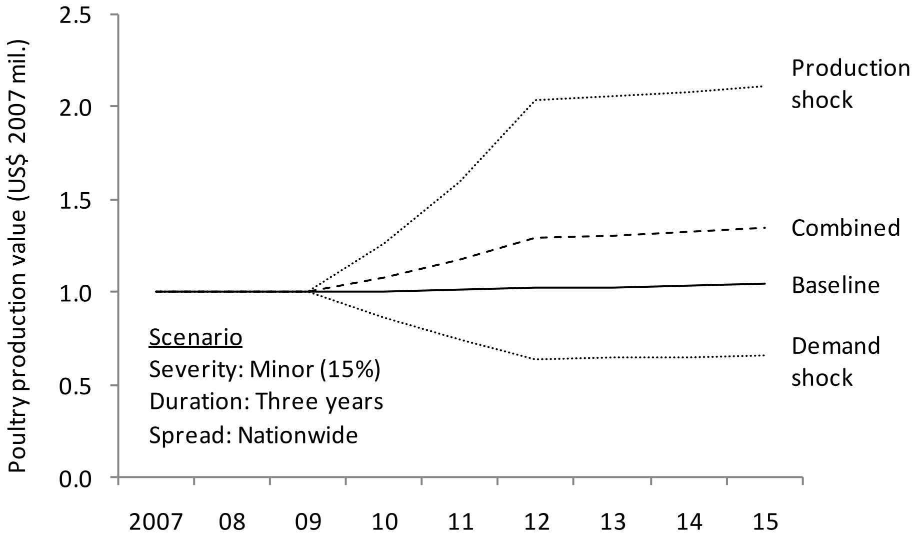
Source: Results from the Kenya DCGE and microsimulation model.
Notes: Initial poverty rates calculated using the 2005/06 Kenya Integrated Household Budget Survey.

Production versus demand shocks

The simulations reported above include both production and demand-side effects of avian flu. However, as Kenya experienced in 2005, it is possible that households will respond to the threat of avian flu by reducing their demand for poultry products, even if an outbreak has not been confirmed (Kimani et al., 2006 cited in Nyaga, 2008). A fall in demand for poultry products produces different outcomes to those reported earlier. Figure 4.4 decomposes changes in poultry market prices caused by production and demand-side shocks. Reducing production without lowering demand causes *real* poultry prices to double under a minor three-year nationwide outbreak. Conversely, reducing demand without culling birds causes an over-supply of poultry products and falling market prices. Lower prices benefit those consumers that continue to eat poultry despite the threat of avian flu. It will, however, reduce agricultural revenues for poultry farmers.

Table 4.6 reports economywide losses for outbreaks of different dimensions. Total GDP falls by far less when only poultry demand falls during an unconfirmed outbreak (i.e., when farmers do not cull poultry stocks). For example, demand-side shocks cause economywide costs equal to US$52 million during a major three-year nationwide outbreak. This is much lower than the US$163 million production-side cost incurred during a similar outbreak. This suggests solely demand-side shocks generate costs equal to about one quarter of the total costs estimated in the combined scenarios reported earlier. These decomposed results clearly indicate that significant economic losses are still incurred if consumers respond to the *threat* of avian flu even if an outbreak has not actually occurred.

Figure 4.4: Poultry prices under production and demand-driven avian flu scenarios



Source: Results from the Kenya DCGE and microsimulation model.

Table 4.6: Total economic losses due to production and demand-side avian flu shocks (US$ million)

Severity of Outbreak	Spread of outbreak	Duration of outbreak		
		One year	Two years	Three years
		Production-side shocks only		
Minor (15%)	Localized	-28.4	-53.7	-76.7
	Extensive	-46.8	-85.3	-117.4
	Nationwide	-49.9	-90.2	-123.1
Major (30%)	Localized	-54.5	-95.1	-126.6
	Extensive	-87.0	-136.9	-163.4
	Nationwide	-92.1	-141.0	-163.3
		Demand-side shocks only		
Minor (15%)	Localized	-10.1	-16.8	-20.9
	Extensive	-13.8	-22.9	-28.4
	Nationwide	-14.3	-23.8	-29.5
Major (30%)	Localized	-20.2	-31.9	-38.0
	Extensive	-27.7	-43.0	-50.8
	Nationwide	-28.8	-44.6	-52.4

Source: Results from the Kenya DCGE and microsimulation model.
Notes: Impact on the real value of total GDP in 2015 (measured in 2007 prices).

5. Conclusions

Although there has not been an outbreak of avian flu in Kenya, the country still remains vulnerable to the disease due to its position along migratory bird routes and its proximity to other high risk countries. This raises concern over impacts that an outbreak could have on economic development. In this study we estimated the implications of avian flu for economic growth and poverty in Kenya. We developed a dynamic spatial CGE model that captures the detailed structure of the Kenyan economy. Given uncertainty about the nature of avian flu, we simulated outbreaks different severities, durations and geographic spreads. We also decomposed avian flu impacts in order to capture possible demand-side responses to the threat of the disease, even when an outbreak does not actually occur.

Model results indicate that the economywide costs of a severe and lengthy outbreak could be as high as US$248 million (measured in 2007 prices). Although this is a substantial economic loss, it is small relative to total national income. Thus, even a severe outbreak of avian flu would not have a large detrimental effect on economic growth. It would, however, have a significant impact on household welfare and poverty. Model results indicate that a severe and prolonged outbreak could increase the number of people living below the poverty line by almost half a million. This would be a major setback for Kenya, where almost half of the population is already considered poor, and where economic growth has so far failed to significantly reduce poverty (Thurlow et al., 2007). In this regard, avian flu does represent a significant threat to future development in Kenya.

Model results indicate that economic losses from avian flu are substantially lower when an outbreak remains localized in high risk districts and when its duration is kept short. This suggests that, when an outbreak occurs, the government and its development partners should respond rapidly to limit the transmission of the disease to farmers in lower risk areas. However, results also indicate that a quarter of economywide losses are still incurred when consumer demand for poultry products falls in response to an unrealized outbreak. Thus, even without a confirmed outbreak, Kenya is still vulnerable to the threat of avian flu and its effect on consumer behavior. Together our findings underline the importance of ongoing efforts to monitor cross-border poultry trade; undertake rapid testing of possible infections; regulate the disposal of infected birds; and improve both farmers and consumers awareness of avian flu. While these measures cannot ensure that an outbreak does not occur, it can greatly reduce the threat that avian flu poses to future development in Kenya.

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