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Eggs before Chickens?

Assessing Africa's Livestock Revolution with an Example from Ghana

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ABSTRACT

Nearly 20 years ago, an upsurge in demand for animal-source foods in developing countries was recognized as a "Livestock Revolution." The Livestock Revolution resulted in a correspondingly large increase in livestock production in Asia and Latin America. Africa south of the Sahara can be expected to experience similar increases in demand for animal-source foods, but future production trends are uncertain. Highly efficient global producers already supply African markets, and competitiveness in poultry production hinges crucially on access to inexpensive sources of balanced feed rations. This paper analyzes the impacts of adopting restrictive import policies for chicken meat in Ghana, which would be like the policies adopted in Nigeria. A prohibitive tariff stimulates domestic chicken meat production but also imposes significant costs on consumers and encourages illicit trade. However, a substantial poultry industry, producing mostly eggs, will exist independent of the border policy applied to chicken meat, due to the natural protection offered to local producers in the egg subsector. A subsector analysis of an egg production cluster in Ghana highlights the importance of trade links with other West African countries in developing the egg subsector. A focus on feed efficiency, through a mix of domestic production and imports, would benefit the layer industry, provide reasonable indications of prospects for globally competitive chicken meat production, and benefit other industries dependent on competitive feed, notably aquaculture.

Keywords: tariff policy, computable general equilibrium model, Livestock Revolution, poultry, Ghana

JEL Codes: *C68, O13, O24, Q17, Q18*

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1. INTRODUCTION

Nearly 20 years ago, Chris Delgado and co-authors described an upsurge in demand for animal-source foods in developing countries as a "Livestock Revolution" (Delgado 2003; Delgado et al. 1999, 2000; Delgado, Rosegrant, and Meijer 2001). The basic elements of the Livestock Revolution included a rise in consumption of meat and other livestock products, a corresponding increase in livestock production in the developing world, especially in middle-income countries such as Brazil and China, and technological changes in livestock production systems toward greater industrialization and use of cereal-based feeds, with accompanying increases in efficiency. Population growth, urbanization, and rising household incomes, combined with technological change in production, were the driving forces behind the Livestock Revolution (Delgado et al. 1999, 2000).

Having manifested themselves in Asia and Latin America, these same driving forces are currently marshaling in Africa south of the Sahara (SSA). While the exact rates are exceedingly difficult to predict, rapid population growth and rapid urbanization are widely expected in SSA over coming decades. Livestock production technologies are known and mobile (Narrod, Pray, and Tiongco 2008). Prospects for rapid growth in household incomes in SSA are more contentious (Arbache and Page 2010; Rodrik 2016). Nevertheless, it is clear that macroeconomic management has improved dramatically and that overall living conditions and indicators of long-run population-level capabilities, such as educational attainment and rates of child malnutrition, have been improving, providing a basis for optimism with respect to income growth over the long term (Arndt, McKay, and Tarp 2016; Radelet 2010).

In section 2, we show that projections of the Livestock Revolution, made out to 2020 by Delgado et al. (1999), have thus far been strikingly accurate, at least in terms of broad aggregates. Per capita consumption of meat has grown significantly in all regions where household incomes have increased and countries have become more urbanized. Expenditure on meat products is expected to grow in those countries that are now experiencing income growth from a relatively low base, especially in SSA.

Section 2 also addresses production issues. In Asia and Latin America, led by China and Brazil, production followed demand patterns, with rapid growth in livestock production. For Africa, future production trends are far more uncertain. African markets, particularly in urban areas, are already being supplied with meat by highly efficient producers, such as Brazil, via an efficient cold distribution network. Section 3 focuses on the trade policies enacted by Ghana and Nigeria in the face of rising imports of chicken meat in the early 2000s. Given the expanded options for trade as a source of livestock products, African production patterns will depend heavily upon local factors, including endowments, capabilities, and policies.

In light of this dependence on local factors, sections 4 and 5 provide a focused analysis on prospects for poultry production in Ghana. Poultry's enormous efficiency advantages over pork and beef in terms of feed conversion ratios make it relatively low cost and highly attractive to African consumers. Ghana has been at the vanguard of African development from early independence to early adoption of structural adjustment programs to its current status as a functional multiparty democracy. Ghana recently also achieved middle-income-country status, has had a solid economic growth and poverty reduction track record over the past two decades, and is urbanizing rapidly (Arndt, McKay, and Tarp 2016). Hence, the demand-side factors highlighted by Delgado et al. (1999, 2000) and Delgado, Rosegrant, and Meijer (2001) are present in Ghana.

In section 4, we employ a detailed economywide model of Ghana. Similar to a previous application of an economywide model to the poultry sector (Diao 2009), poultry production is divided between layers, which face essentially no import competition, and broilers, which compete directly with imports of frozen meats. Our simulations are dynamic and motivated by Nigeria's decision to impose a ban on poultry imports in 2002.

We find that, even assuming high income elasticities of demand for poultry to 2025, the sector remains small in macroeconomic terms with correspondingly limited impact on macroeconomic aggregates regardless of policies. High or nearly prohibitive tariffs impose costs on Ghanaian consumers, strongly decelerate growth in demand for chicken meat, and provide strong stimulus to the chicken meat

industry. Production of eggs, however, is relatively constant across scenarios, meaning that a significant poultry industry will exist and grow with or without tariff protection. We also find a relatively small impetus to local production for the main feed ingredients—soybean, white maize, and yellow maize—suggesting that high tariffs provide only a limited boost to the feed-grains sector.

Section 5 then focuses on prospects for egg production, using a subsector analysis of a high-production cluster near Ghana's border with Côte d'Ivoire. The analysis, based on qualitative interviews with poultry industry actors, suggests that by maintaining a trade network across the border with input and feed suppliers and consumers, the local egg cluster has nearly doubled its production in five years, and is starting to supply eggs to other countries in West Africa. Continued success will depend on openness to cross-border trade in poultry production inputs and outputs, combined with local investments in services for farmers.

Sections 6 and 7 discuss broad policy implications for SSA and conclude. We argue that the natural protection afforded the layer industry, and the example of a successful high-production cluster already operating in Ghana, makes layers a more promising subsector for Ghana than the broiler industry. It also provides a relatively low-cost and low-risk way to consider whether reasonably competitive chicken meat production has a chance of emerging in Ghana and elsewhere. As competitive feed is a necessary condition for competitive poultry, an initial focus on feed is merited. Competitive feed has the corollary benefit of expanding opportunities in other sectors, such as aquaculture.

2. PREDICTING AND ASSESSING THE LIVESTOCK REVOLUTION

In the late 1990s, Delgado et al. (1999) described the Livestock Revolution as a past, present, and future reality. Pointing to increased meat and milk consumption in the three decades before 2000, they showed that the Livestock Revolution had been taking place in developing countries around the same time that the much better known Green Revolution had led to increased production of cereals such as maize, rice, and wheat. The trends associated with the Livestock Revolution were expected to continue well into the 2000s and 2010s. In this section, we review the Livestock Revolution from the perspectives of demand for animal-source foods in developing countries and growth in livestock production as a supply response.

Consumption of Livestock Products

In terms of meat consumption, the Livestock Revolution can be considered in two phases, a first phase running from the early 1980s to 2000, and a second phase during the period 2000–2020. Phase one of the Livestock Revolution was driven almost entirely by East Asia (mainly China) and to a lesser extent, Latin America (mainly Brazil). In the period 1983–1997, per capita annual meat consumption in China rose from 16 to 43 kilograms. For comparison, meat consumption in SSA stagnated at 10 kilograms over the same period (Delgado 2003), albeit with some variation across countries. By 2000, meat consumption in the developing world was growing three times faster than meat consumption in the developed world. Growth in pork and poultry consumption was particularly significant, representing about three-quarters of the increased consumption (Delgado 2003).

Delgado et al. (1999) used the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) to project trends in the consumption of animal-source foods to the year 2020. The model predicted increasing consumption of livestock products in the developing world with chicken meat growing most rapidly and eventually leading the other main sources of meat (beef and pork) as a protein source. However, the growth rates from 2000 to 2020 were expected to be slower, about half those of the two preceding decades, mainly because much progress had already been made and the baseline was higher by 1993.

Nevertheless, the expected consumption trends were strongly positive for all the major livestock products (poultry, pork, beef, other meat, milk) and in all regions of the developing world. As in prior decades, consumption of chicken meat was expected to grow the fastest, by 3.1 percent annually on average, while pork and beef consumption would grow by 2.8 percent. Per capita meat consumption was expected to double in China, increase by 30 percent in Latin America, and increase slightly in SSA, keeping pace with expected (rapid) population growth.

Table 2.1 shows trends in meat consumption per capita for major regions as well as forecasts by Delgado et al. (1999) to 2020. The IMPACT model predictions are strikingly on target when compared with trends in meat consumption to date as reported by the Organization for Economic Co-operation and Development and the Food and Agriculture Organization of the United Nations (OECD/FAO 2016). China's meat consumption has not yet reached the projected 60 kilograms per capita predicted by the model, but it was 50 kilograms per capita in 2015, a 52 percent increase over the 1993 per capita consumption figure of 33 kilograms. At 56 kilograms per capita, consumption in Latin America, driven by high demand in countries such as Argentina, Brazil, and Uruguay, has nearly reached the 2020 projected consumption of 59 kilograms per capita. Consistent with projections, meat consumption in Africa south of the Sahara has not grown anywhere near as dramatically since the late 1990s, averaging 11 kilograms per capita in 2015 compared with 10 kilograms in 1993.

Table 2.1 Meat consumption (kg per capita) in selected developing regions, 1983, 1993, 2015, and 2020

Country/ Region	Meat consumption (kg per capita), 1983	Meat consumption (kg per capita), 1993	Meat consumption (kg per capita), 2015	Meat consumption (kg per capita), 2020 (projected in 1999/2003)
China	16	33	50	60
Latin America	40	46	56	59
SSA	10	9	11	11
Developing world	14	21	27	30

Source: Data derived from OECD/FAO (2016) and projections by Delgado (2003) and Delgado et al. (1999).
Note: kg = kilograms; SSA = Africa south of the Sahara.

Overall, Table 2.1 indicates that demand-side growth is relatively predictable, meaning that projections should not be dismissed. Recent projections suggest that meat consumption will grow by 35 percent in SSA over the next decade (OECD/FAO 2016). Although Table 2.1 illustrates that per capita meat consumption in SSA substantially lags other major regions of the world, a combination of rapid population growth, rapid urbanization, and rapid income growth can be expected to lead to rapid growth in demand for livestock products.

This growth will be abetted by the switch to more modern food retail systems in SSA. Modern retail improves the handling and availability of perishable livestock products. As modern retail systems develop, one of the items they tend to offer consumers is fresh meat (Reardon and Hopkins 2006). In China's diet transition during 1989–1997, higher-income households recorded increases in their intake of animal-source foods that were three times higher than the increases recorded among lower-income households (Popkin 2003). This prediction holds in West African countries. Urban households spend more on food, and as incomes rise, food expenditure changes in favor of more expenditure on animal-source foods over time (Zhou and Staatz 2016). In projections over the years 2010–2040, Zhou and Staatz estimate that expenditure on meat in West Africa could grow four times faster in urban areas than in rural areas, with implications for supply.

Livestock Production and Trade in Meat Products

The rapid rise in demand for livestock products was the main driving force behind the Livestock Revolution. In response, livestock producers stepped up production, and by the late 1990s livestock production was also growing faster in the developing world than in the developed world. The IMPACT model predicted that the meat production ratio for developing versus developed countries would rise to 60:40 by 2020 (Delgado et al. 1999; Delgado, Rosegrant, and Meijer 2001). By 2006, developing countries were already producing 55 percent of global chicken meat (Windhorst 2006).

While demand for livestock products was the main driver of the Livestock Revolution, supply-side factors have also played a role. Two key aspects of the expansion in livestock production were the

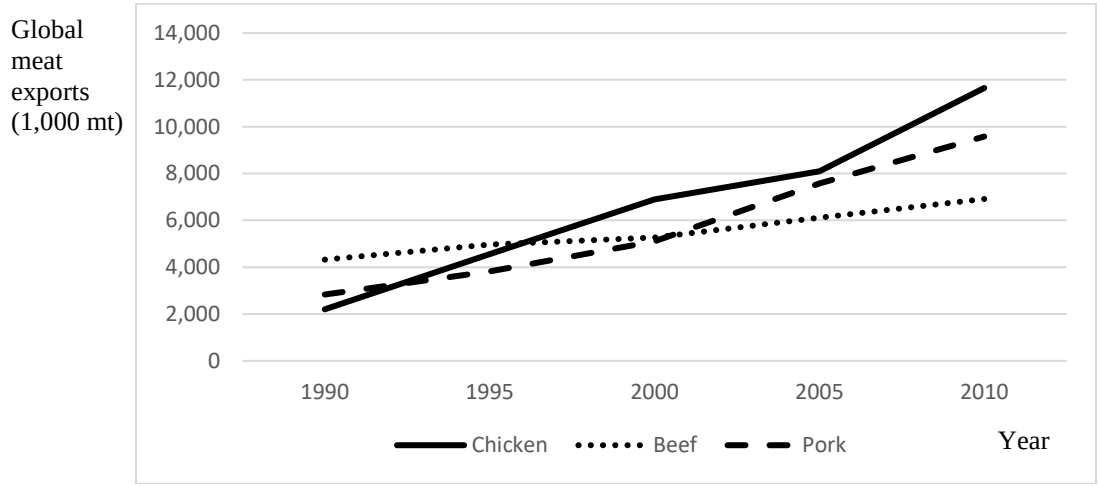
cereal requirements for livestock feed and consolidation of production to take advantage of scale economies. Relative to other meats, poultry is remarkably efficient in terms of the amount of feed required to produce one kilogram of animal weight, known as the feed conversion ratio. For efficient operations at an international level, this feed conversion ratio is about 1.7 for chicken meat (broilers) compared with about 3.0 for pork and more than 10.0 for beef (Tolkamp et al. 2010). Poultry's efficient feed conversion has made it the fastest-growing livestock product.

Poultry production has also benefited from improved technologies in breeding day-old chicks that have ensured faster growth and lower mortality (Narrod, Pray, and Tiongco 2008). By the late 1990s, farmers in developed countries had already demonstrated the significant scale economies achievable in livestock production (Martinez 2002), and as technologies were being transferred to the emerging producers in the developing world (Narrod, Pray, and Tiongco 2008), this scaling up process was replicated in developing countries. Scaling up included increases in the average size of farms (number of animals held on the farm at any time) and, with the benefit of technology, increases in the rate at which livestock products could be harvested from farms. Both aspects of scaling up contributed to increasing sales of livestock products.

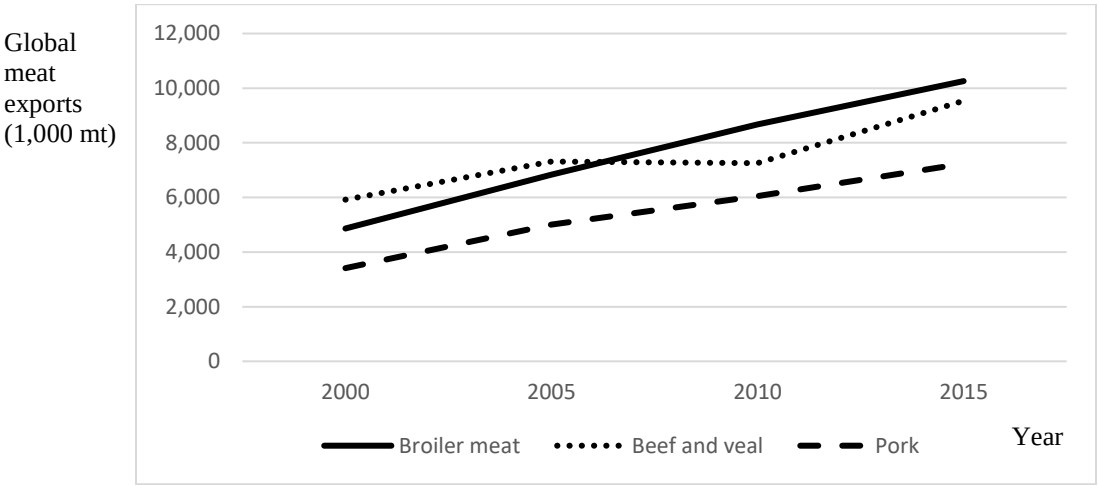
Improved feeding via access to high-quality feed ingredients and improved technology in terms of breeds, pharmaceutical products to combat disease, and improved production and processing technologies have led to two key outcomes in global poultry production. First, production became heavily industrial, with more and more birds housed in larger farms. The move toward intensive production has been typically accompanied by clustering of farms around processing centers, and vertical coordination of the broiler production process with meat processing (Martinez 2002; Steinfeld, Wassenaar, and Jutzi 2006). This process started in developed countries such as the United States in the 1970s, as improvements in cold storage and transport made it more efficient to transport processed meat to markets than to transport live birds from farms to processing plants (Martinez 2002), and has now occurred in parts of the developing world.

Second, along with improved production, international trade in chicken meat has expanded rapidly. Figures 2.1(a) and 2.1(b) illustrate this phenomenon using data from the United Nations food and agriculture database (FAO 2017) and the U.S. Department of Agriculture (USDA 2003, 2009, 2010, 2017). The key point these graphs illustrate is that chicken meat has led the growth in meat exports over the past two or three decades. Figure 2.1(a) shows that in 1990, the quantity of beef exported (4,323,000 metric tons) was nearly double the quantity of chicken meat exported (2,201,000 metric tons). By 2010, the tables had turned, with the quantity of chicken meat exports (11,654,000 metric tons) now far exceeding beef exports (6,913,000 metric tons). Figure 2.1(a) also shows that chicken meat exports exceeded pork exports, another fast-growing export product, in the 1990s. Figure 2.1(b), which uses slightly different measures of the meat types, also shows similar movements and indicates that the trends have continued in more recent years.

Figure 2.1 Global trends in meat exports



(a) Global meat exports (1,000 mt), 1990-2010



(b) Global meat exports (1,000 mt), 2000-2015

Source: Derived from data from FAO (2017) for (a) and USDA (2003, 2009, 2010, 2017) for (b).
Note: mt = metric tons. For (a) beef includes cattle, beef and veal meat, pork includes pork and pig meat. For (b) weights are in carcass weight equivalent. For 2015, Albania, Armenia, Congo (Brazzaville), Gabon, Georgia, Ghana, Jamaica, North Korea, Kyrgyzstan, Moldova, Switzerland and Trinidad and Tobago are excluded. Chicken legs are excluded.

Two additional points should be emphasized regarding the trends in poultry production and trade. The first point is the widespread availability of inexpensive, frozen chicken meat imports as an alternative to locally produced chicken meat in developing countries. Export forecasts (not shown in Figure 2.1) indicate that increasing production from the major poultry exporters, such as Brazil, would lead to a record 11.2 million metric tons of broiler meat exports in 2017 (USDA 2017). Remarkable growth in

chicken meat trade has, in the past, taken place despite tariff and nontariff trade barriers (Josling, Orden, and Roberts 2001).

A second, related point is the emergence of large poultry producers in Asia and Latin America that are focused on producing meat for export to both the developed world and developing countries, including SSA. Differences in demand patterns are potentially one of the drivers of this trade. Developed countries demand mainly chicken breasts while SSA demands mainly chicken thighs and backs. This demand complementarity drives trade and potentially serves as a source of comparative advantage for large producers, who are increasingly located in former developing countries. As recounted by Windhorst (2006), the top 10 producers included only two developing countries in the 1970s, but by the mid-2000s five developing countries were in the top 10 producers, with China and Brazil in the top three following the United States. In the past decade, Brazil has surpassed the United States as the leading exporter of chicken meat.

The focus of these new leaders in the poultry industry is on the export market (Mcleod, Thieme, and Mack 2009). The share of domestic consumption in a country's production is an indication of this export focus. For example, Brazil's and Thailand's domestic consumption in 2017 was 69 percent and 60 percent of their production, respectively, while the shares for the European Union (EU) and the United States were 95 percent and 84 percent, respectively.[1] The next section considers the implications of these global trends for meeting the growing demand for chicken meat in SSA with particular focus on Ghana and Nigeria.

[1] The shares are based on authors' calculations from USDA (2017) data.

3. GHANA AND NIGERIA: ALTERNATIVE POLICY RESPONSES TO CHICKEN MEAT IMPORTS

Ghana and Nigeria represent two different responses to the increase in deep-sea imports of frozen chicken meat over the past 20 years. Ghana applied and quickly revoked a 40 percent tariff in 2003, and since then has allowed imports, maintaining a 20 percent tariff until the adoption of the ECOWAS Common External Tariff of 35 percent in 2016. Nigeria, in contrast, banned imports of chicken meat in 2002. Clearly, Ghana and Nigeria took different paths in their trade policy responses to imports in the early 2000s, when the Livestock Revolution was in full swing.

Not surprisingly, Ghana and Nigeria have seen divergent results since taking their policy stances in response to the influx of chicken meat imports.[2] The two countries had similar levels of poultry consumption in the late 1990s, with the annual average consumption for Nigeria in 1995–1999 being slightly higher, at 1.32 kilograms per capita, than Ghana's annual average consumption of 1.26 kilograms per capita. About 15 years later, poultry consumption in Ghana averaged 6.66 kilograms per capita annually (2011–2015), nearly eight times the annual average for Nigeria, whose consumption had contracted to 0.85 kilogram per capita. In comparison, the average consumption of chicken meat increased across SSA from 1.37 kilograms per capita in 1995–1999 to 2.40 kilograms per capita in 2011–2015.

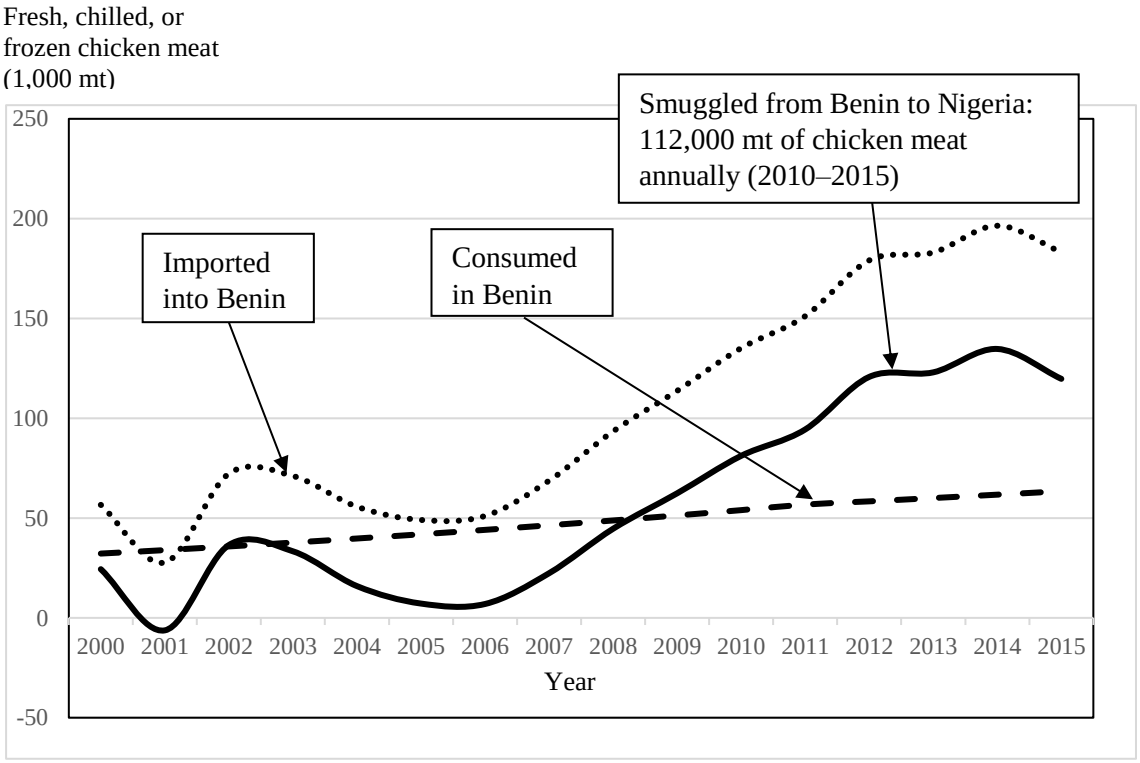
The contraction in demand for chicken meat on a per capita basis in Nigeria occurred despite a commodity-price-related consumption boom from about 2003 to 2014, rapid rates of urbanization, and reasonably strong evidence of smuggling of imported frozen chicken meat into Nigeria via Benin. In particular, United Nations Comtrade data indicate a surge in frozen chicken meat imports into Benin just as official Nigerian imports decline to effectively zero (UN 2017).

In Figure 3.1 we depict the following trends in Benin's chicken meat trade from 2000 to 2015: estimated imports of chicken meat, estimated local consumption in Benin, and the remainder representing

[2] Poultry consumption estimates in this section are based on authors' calculations using data provided in OECD/FAO (2016).

likely volumes of chicken meat smuggled into Nigeria. Figure 3.1 indicates that the volume of imports into Benin greatly surpasses levels that could plausibly be consumed by the local population, and therefore a considerable share of Benin's chicken meat imports are re-exported across Nigeria's border with Benin. We estimate that 112,000 metric tons of chicken meat imported into Benin was smuggled into Nigeria annually from 2010 to 2015.

Figure 3.1 Estimated volumes of informal cross-border trade (smuggling) of chicken meat from Benin into Nigeria



Source: Authors' estimates based on United Nations commodity trading database (UN 2017) data for imports, and FAO (2005) for consumption trends for Benin..
Note: mt = metric tons. Extrapolations for Benin consumption follow Ghana consumption trends.

The trends in Ghana are essentially the inverse. Although Ghana has seen a marked increase in demand for chicken meat, local broiler production has declined or stagnated over the period, and now consists almost entirely of seasonal production (Amanor-Boadu, Nti, and Ross 2016). The bulk of the rising consumption of chicken meat in Ghana comes from deep-sea imports from countries such as Brazil, EU countries, and the United States. Ghana has become the third largest importer of chicken meat in

Africa. A widely held view in policy discussions in the Ghanaian government is that domestic production can be increased either through trade measures (tariffs) or nontrade measures (such as direct input subsidies).

4. MODELING TRADE POLICY IN POULTRY FOR GHANA

Economywide Model

To examine border policy alternatives for Ghana, we develop a dynamic recursive computable general equilibrium (CGE) model called the Ghana Applied General Equilibrium (GAGE) model. GAGE is a variant of the International Food Policy Research Institute (IFPRI) model described in Lofgren et al. (2002) and Thurlow, Zhu, and Diao (2012). It is a descendant of the class of CGE models introduced by Dervis, de Melo, and Robinson (1982).

CGE models, such as GAGE, are useful for counterfactual analysis as they provide a simulation laboratory of the economy. The model is based on a social accounting matrix (SAM), which captures all transactions and transfers in the economy, and with the rest of the world, at a specific point in time, thus providing useful insights on the direct and indirect linkages within the economy. Behavioral equations in the model capture the decision-making process of agents and allow them to respond to shocks in the system. Structural equations and closure rules ensure macroeconomic consistency between incomes and expenditures within the model and are used to describe the functioning of the economy. These include the behavior of exchange rates, investment, government savings, and prices and quantities of commodities and factors of production. The dynamic recursive nature of the model allows for an assessment over time as investment is turned into capital endogenously in a putty-clay fashion, that is, investment in period t is turned into capital and allocated to sectors in period $t + 1$. The sector capital allocation is determined by the initial share of aggregate capital income, the capital depreciation rate, and period t sectoral profit-rate differentials.

The dynamic recursive CGE model used here is based on a 2015 national SAM for Ghana, which is modified to include a more detailed poultry sector. Specifically, poultry producers are split into commercial broilers, commercial layers, and traditional layers. Poultry outputs are also disaggregated into chicken meat and eggs. Information from Amanor-Boadu, Nti, and Ross (2016) is used to disaggregate the poultry sector in the SAM. The SAM consists of 56 activities and 58 commodities. It includes eight categories of labor that distinguish between skill level (determined by education) and labor location (rural

versus urban). To further highlight the differences between sectors, we disaggregated capital between sectors—namely crop agriculture, livestock agriculture, mining, and all other. Land is used by the crop agriculture activity. We divided households into 15 representative household groups and represented the quintile income distribution in rural farm, rural nonfarm, and urban households. Other institutions, government, enterprises, and the rest of the world are also represented. Key taxes represented in the SAM include direct taxes on incomes, sales taxes, export tariffs, and import duties.

Simulations

To address the first part of the question for Ghana, we derived descriptive data from value chain studies that have documented production costs, the state of the feed sector, and current prices (Andam et al. 2017; Amanor-Boadu, Nti, and Ross 2016). The GAGE model is used to assess the potential economic and social impacts of a near ban on chicken imports into Ghana by 2025. The dynamic recursive CGE model is run over a 10-year period to develop a baseline growth path, described below. We then impose effectively prohibitive tariffs on chicken meat imports to assess the impact relative to this baseline.

Baseline Growth Path

Table 4.1 presents the structure of the Ghana economy as represented by the 2015 SAM as well as the baseline growth rates used within the CGE model for the 2015–2025 period. Private consumption (C) accounts for around two-thirds of total gross domestic product (GDP), fixed investment (I) and government consumption (G) account for 29 percent and 17 percent, respectively, and net trade (X - M)[3] is negative allowing absorption (C + I + G) to exceed GDP. Ghanaian production is concentrated within the services sector, which accounts for almost half of total GDP (not illustrated in Table 4.1). The agriculture sector is the second largest sector, accounting for almost 20 percent of GDP. Agriculture value-added is concentrated within the crops subsector, which accounts for 80 percent of the sector's total

[3] Definitions are as follows: X = exports and m = imports.

value-added. Mining and manufacturing account for about 6 percent of total GDP each, and utilities (including construction, which is the largest element) account for 18 percent.

Table 4.1 Structure of Ghana's economy and model baseline assumptions

	Share of total GDP, 2015 (percent)	Baseline average annual growth, 2015–2025 (percent)
Total GDP	100.0	5.8
Private consumption	64.6	5.4
Investment	28.7	7.6
Government consumption	16.5	3.5
Exports	30.8	5.9
Imports	-40.6	5.3
Exchange rate index*	1.0	-0.8

Source: 2015 Ghana SAM.
Note: GDP = gross domestic product; SAM = social accounting matrix.
* A positive (negative) value for growth indicates an appreciation (depreciation).

In the baseline scenario, the Ghanaian economy is assumed to grow at an average annualized rate of 5.8 percent between 2015 and 2025, in line with projections by the International Monetary Fund for 2015–2022 (IMF 2017). The structure of the economy does not shift dramatically between 2015 and 2025. On aggregate, labor supply is assumed to increase roughly in line with population growth (~2 percent), although the supply of skilled labor is assumed to grow at a faster pace than unskilled labor as education levels within the economy rise. Total factor productivity across sectors averages around 2.4 percent per annum. The exchange rate depreciates over the model period as foreign aid to the country decreases relative to GDP and the trade deficit narrows, bringing absorption closer in line with GDP.

Model Scenarios and Assumptions

To simulate the impact of a ban on chicken imports into Ghana, the effective import duty on imported chicken is increased gradually over the 10-year period. The effective import duty on chicken is increased to 350 percent by 2025, an effectively prohibitive rate. All other assumptions, including the closure rules, are the same as in the baseline. The closure rules are as follows: the exchange rate adjusts to equilibrate supply and demand for foreign currency while foreign savings remain fixed. The level of investment is

determined by total savings in the economy (that is, private, government, and foreign). Government savings adjust for changes in income and expenditure—all tax rates remain unchanged. The producer price index is used as the model numeraire. All labor and land use in the economy is fully employed and mobile. Capital is allocated via the dynamic recursive processes described earlier under "Economywide Model." Reflecting the structure of Ghana's poultry sector, the market output for the egg subsector is four times the market output for the broiler subsector in the SAM.

Results and Discussion

In Table 4.2, we present results of the model simulations. We show changes in local production, import levels, household expenditure, and the prices of commodities of interest. The main outputs for the poultry sector are broiler meat, eggs, and layer meat (spent layers sold as live birds). We also report the changes for the main poultry feed ingredients—white maize, yellow maize, and soybean.

Table 4.2 Model results

	Base values	No additional trade restrictions			Prohibitive tariff reaching 350% by 2025		
				Local production			
	Quantity (1,000 mt), 2015	Quantity (1,000 mt), 2025	Average annual percentage change, 2015–2025	Percentage change, 2015–2025	Quantity (1,000 mt), 2025	Average annual percentage change, 2015–2025	Percentage change, 2015–2025
Chicken meat	10.5	**25.4**	9.26	142.4	**158.8**	31.26	1417.7
Layer meat	2.7	4.4	5.05	63.7	4.4	5.11	64.7
Eggs	54.7	**89.6**	5.05	63.7	**90.1**	5.11	64.7
White maize	1762.0	2667.9	4.24	51.4	2774.6	4.65	57.5
Yellow maize	50.0	75.7	4.23	51.4	75.8	4.24	51.5
				Imports			
	Quantity (1,000 mt), 2015	Quantity (1,000 mt), 2025	Average annual percentage change, 2015–2025	Percentage change, 2015–2025	Quantity (1,000 mt), 2025	Average annual percentage change, 2015–2025	Percentage change, 2015–2025
Chicken meat	129.7	274.5	7.79	111.7	**3.9**	-29.58	-97.0
Yellow maize	450.0	742.7	5.14	65.1	744.2	5.16	65.4
Soybean	70.0	119.1	5.46	70.1	190.7	10.54	172.4
				Real household expenditure			
	Expenditure, 2015 (in 2015 GHS1m)	Expenditure, 2025 (in 2015 GHS1m)	Average annual percent-age change, 2015–2025	Percentage change, 2015–2025	Expenditure, 2025 (in 2015 GHS1m)	Average annual percentage change, 2015–2025	Percentage change, 2015–2025
Chicken meat	328.5	**796.7**	9.26	142.5	**367.1**	1.12	11.7
Eggs	254.7	397.9	4.56	56.3	395.5	4.50	55.3
Yellow maize	51.9	68.9	2.86	32.6	68.4	2.79	31.7
White maize	322.8	426.0	2.81	32.0	423.2	2.74	31.1

	Base values	No additional trade restrictions			Prohibitive tariff reaching 350% by 2025		
	Price						
	Price (GHS/kg), 2015	Price (GHS/kg), 2025	Average annual percentage change, 2015–2025	Percentage change, 2015–2025	Price (GHS/kg), 2025	Average annual percentage change, 2015–2025	Percentage change, 2015–2025
Chicken meat	5.0	5.4	0.77	8.0	11.1	8.27	**121.3**
Eggs	7.8	8.2	0.45	4.6	8.1	0.36	3.7
White maize	1.2	1.4	1.43	15.2	1.4	1.42	15.2
Yellow maize	1.5	1.7	1.34	14.2	1.7	1.33	14.2
Soybean	3.3	3.6	0.82	8.5	3.6	0.81	8.4

Source: Ghana Applied General Equilibrium (GAGE) model poultry-sector simulations.
Note: Figures cited in text are in bold type. mt = metric tons; GHS = Ghanaian cedis; GHS1m = 1 million GHS; kg = kilograms.

The main result is that the tariff does lead to increased domestic production that replaces imports in the domestic market. An increase in the import tariff on chickens raises the price of chicken meat by 121 percent by 2025 (Table 4.2, Price section, last column). The quantity of chickens imported decreases to close to zero (3,900 metric tons) by 2025 relative to the baseline scenario. This decrease in imports, along with continued demand for chicken, provides an encouragement for domestic producers to increase their production. Domestic chicken meat production increases sixfold relative to the baseline of no tariff change (Table 4.2, Local production section, compare columns 3 and 6). In contrast, the layer subsector experiences little difference in egg production, and consumption of eggs remains essentially unchanged,[4] with or without the tariff. There are relatively small increases in production of white and yellow maize. Another key result is that due to the increase in the economywide price of chicken meat with the trade restriction, household demand for chicken meat decreases as expenditure drops from 797 Ghana cedis to 367 Ghana cedis (Table 4.2, Real household expenditure section, compare columns 3 and 6).

The model results also indicate the macroeconomic impacts of the tariff. The knock-on impacts of more expensive chicken and increased competition for skilled labor, which drives skilled wages up, result in an overall increase in prices in the economy (consumer price index [CPI]) of 0.8 percent (not shown in Table 4.2). For households, the increase in prices is partially offset by increases in household incomes as employment, the supply of livestock capital, and returns to land increase. Total household welfare measured by real (CPI-deflated) household consumption decreases marginally by 0.11 percent relative to the baseline scenario. Urban households experience larger welfare losses (-0.14 percent) than rural households (-0.03 percent), particularly in the nonpoor quintiles (that is, quintile 3 to 5). Poor urban households experience an increase in welfare (0.09 percent) relative to the baseline scenario as income increases outpace the rise in prices in the economy.

[4] The cross-price elasticity of demand for eggs relative to meat used in the model is a conservative estimate. Egg consumption would likely increase in the restrictive tariff scenario.

The expansion of poultry production within Ghana also leads to a small decline in the poverty headcount rate by 2025, despite the increase in prices. On aggregate the poverty headcount rate decreases marginally by 0.08 percentage point (results not shown in Table 4.2). The decrease in the poverty headcount rate is larger in rural areas than in urban areas. The poverty gap also decreases. The overall dietary diversity score for Ghana decreases marginally when imports are banned, as chicken meat consumption declines relative to baseline.[5] However, the dietary diversity score for poor rural households, particularly farm households, increases slightly as incomes within these households increase because of increased employment and factor returns.

[5] The dietary diversity score is calculated for household groups using food expenditure shares. Diversity is estimated using a cross entropy measure across six food categories (cereals and roots; vegetables; fruits; meat, fish, and eggs; milk and dairy; and pulses and oilseeds) relative to an estimated "ideal" food budget allocation. A more diverse diet is assumed to be associated with improved nutrition outcomes.

5. PROSPECTS FOR EGG PRODUCTION TO SUPPLY REGIONAL MARKETS

The model in the preceding section suggests that Ghana has a fairly resilient layer industry that would maintain its production levels regardless of border policies on meat imports. In this section, we provide a more detailed assessment of the layer industry by focusing on a prolific egg-producing area in Ghana, Dormaa Ahenkro. Dormaa Ahenkro is located close to the border with Côte d'Ivoire, in Ghana's Brong Ahafo Region, and within easy travel distance of Agnibilekrou in Côte d'Ivoire, the location of a large poultry hatchery, Foani Services, which supplies day-old chicks to farmers in Ghana (Figure 5.1).

Figure 5.1 Locations of egg production cluster in Dormaa Ahenkro, Ghana, and layer hatchery in Agnibilekrou, Côte d'Ivoire

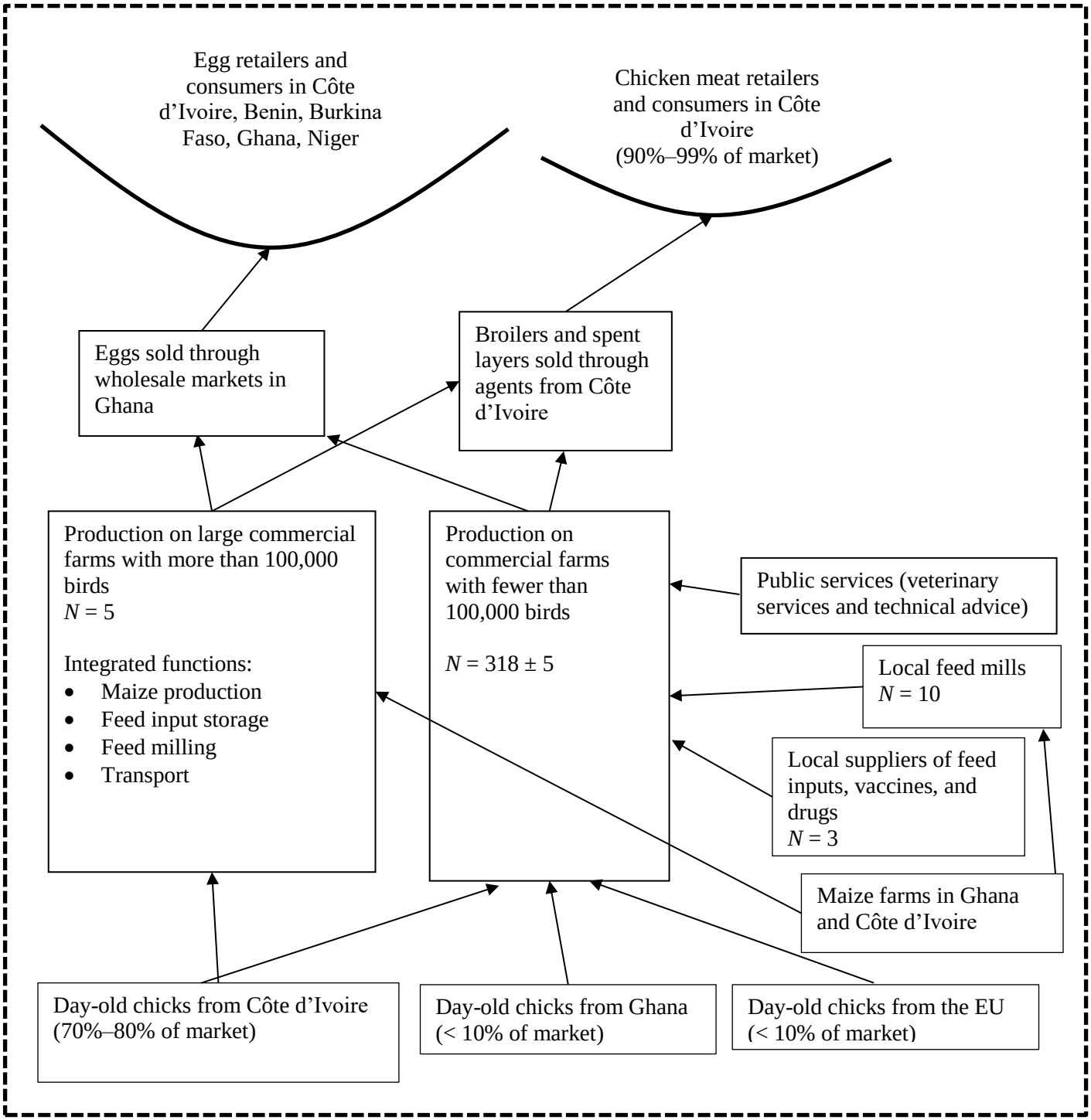
Source: Authors' depiction based on map supplied by Survey Department of Ghana.

To carry out the assessment, we use the subsector analysis approach proposed by Holtzman (1986) and further elaborated by Haggblade and Gamser (1991). Subsector analyses were originally used to identify opportunities for small- and medium-scale enterprises in developing countries by describing key features of an industry's production system (Haggblade and Gamser 1991). The main output from the analysis is a subsector map.

For our purposes in this paper, subsector mapping provides a convenient way to describe input sources, production levels, producer characteristics, and marketing channels in one figure. Our subsector analysis is based on semi-structured interviews with key informants in Dormaa Ahenkro, including two leaders of the Dormaa Ahenkro poultry farmers' association, four poultry farmers, two input dealers, a feed miller, two egg traders, one egg transporter, a border official, and six local officials of the Ministry of Food and Agriculture (MoFA). We also reviewed records from the offices of MoFA and the poultry farmers' association. Fieldwork was carried out in August 2015.

The resulting subsector map of the Dormaa Ahenkro layer industry is shown in Figure 5.2. The main actors in the Dormaa Ahenkro industry are hatcheries, farmers, feed mills, transporters, agents (mainly from Côte d'Ivoire), egg and meat traders, and consumers in Ghana and Côte d'Ivoire. We identified 318 commercial poultry farms in Dormaa Ahenkro (Figure 5.2). These farms focus on egg production, with seasonal production of broilers for chicken meat. Layers represent about 95 percent of the bird population.

Figure 5.2 Subsector map of poultry industry cluster in Dormaa Ahenkro, Ghana



Source: Authors' construction based on field interviews.
Note: *N* = number of enterprises/producers. Arrows indicate sale of goods and services.

Four points deserve emphasis. First, the analysis highlights the importance of cross-border trade in the development of the egg subsector. A distinctive feature of the Dormaa Ahenkro cluster is that egg producers can take advantage of the proximity to the border with Côte d'Ivoire to purchase inputs (day-old chicks, feed, and vaccines) from Ivorian suppliers. Sources reported that the population of layers on farms in Dormaa Ahenkro has increased rapidly in recent years, and is currently estimated at 3 million layers, close to double the population of 1.8 million in 2011. The eggs are sold mainly in Ghanaian markets, but increasingly, markets outside Ghana are becoming important sources of demand, especially when there is a glut in the Ghanaian market. Transporters carry eggs from Dormaa Ahenkro to all major urban centers in Ghana, and have started moving beyond Ghana to Benin, Burkina Faso, and Niger.

At the end of the egg production cycle, farmers sell a large proportion of their spent layer birds in the Ivorian market. According to the farmers we interviewed, Côte d'Ivoire is a better market for spent layers because of the sale volumes—whereas only a few restaurants in Ghana typically place orders for 1,000 birds at a time, agents from Côte d'Ivoire tend to purchase truckloads of birds by tens of thousands in one transaction. Approximately 99 percent of broilers and 90 percent of layers produced in Dormaa Ahenkro are sold in Côte d'Ivoire.

Secondly, after years of repeated commercial interactions between egg producers in Ghana and input suppliers in Côte d'Ivoire, there is sufficient trust to enter into informal contracts that overcome credit and input constraints to production. For example, an estimated 150 farmers participate in an informal outgrower farming system with Foani Services, the Ivorian hatchery. Participating farmers obtain about 80 percent of their inputs from Foani Services in the form of day-old chicks, feed ingredients, and veterinary drugs. The farmers also benefit from a credit system whereby they receive starting capital, day-old chicks, and feed on credit, with those costs deducted at the end of the laying cycle. A supply of 1,000 birds usually includes feed to last a few weeks, allowing the farmer time to start feed preparation on his or her own. Typically, when birds start laying at around 20 weeks, the farmer can then purchase feed using proceeds from egg sales. At the end of the production cycle, when the loans

from Foani Services have been paid by the farmer, the farm is restocked with a new batch of day-old chicks.

A third feature worth mentioning is that the trade networks have benefited the poultry industries on both sides of the border. On some occasions, when egg supply is low on the Ghana side, typically in April–May, farmers act as sales agents, purchasing eggs from Côte d'Ivoire to be sold through Dormaa Ahenkro in Ghanaian markets. The main by-product from egg production, poultry manure, is sold to maize and cocoa farmers on both sides of the border.

Lastly, the subsector analysis showed that in addition to sourcing input supplies from Côte d'Ivoire, the egg industry has benefited from private and public support services within Ghana. Farmers purchase feed ingredients from three major suppliers in Dormaa Ahenkro—Boris B Farms, Koudjis, and Kumi Global Ventures—and obtain technical advice on feed formulation from the district office of the Veterinary Services Directorate and various input suppliers. The Food and Drugs Authority and the Ghana Standards Authority also provide technical assistance through training workshops. The purchased feed ingredients are often supplemented with on-farm maize production, especially for the larger-scale commercial farms. These larger-scale farmers tend to formulate and mill their own feed, and as such they have warehouses for storage to hedge against price fluctuations for maize and other ingredients. Smaller-scale farmers take their feed inputs to one of 10 commercial feed millers in Dormaa Ahenkro for customized milling.

In conclusion, based on our interviews and subsector mapping exercise, the poultry subsector in Dormaa Ahenkro appears to be thriving, with new entrants coming into the poultry production cycle on a yearly basis, fueled by the proximity to Côte d'Ivoire, which provides access to input and output markets. The larger farms especially have been in existence for decades and mostly report profitable operations. The main constraint to growth of the industry identified by respondents was the unreliable supply of maize. The success of egg production in the Dormaa Ahenkro production cluster has been supported by strong trading relationships between farmers in Dormaa Ahenkro and input suppliers in Côte d'Ivoire, which has facilitated supply of day-old chicks, feed, and other inputs, coupled with the availability of

feed-milling facilities both on-farm for larger-scale farmers and through commercial mills for smaller-scale farmers. The Dormaa Ahenkro cluster has also benefited from a high demand for eggs and spent layer birds. In addition to the Ghanaian market, farmers have had access to additional marketing channels to sell their eggs in Benin, Burkina Faso, Côte d'Ivoire, and Niger.

6. POLICY IMPLICATIONS

Ghanaian policy makers, as well as African policy makers more generally, confront difficult decisions with respect to the incipient Livestock Revolution on the subcontinent. Livestock demand, notably demand for inexpensive protein sources such as poultry, can be expected to grow rapidly, particularly if income growth maintains or accelerates. However, the meat supply response to this demand growth observed in Latin America and Asia seems unlikely to materialize in SSA in the absence of active policy measures. Large, highly efficient producers operating at scale (for example, Brazilian producers) and distributing via an efficient global cold chain to Africa's urban centers, where demand growth is likely to concentrate, imply that African producers will have difficulty competing.

The decision as to whether to enact active policy measures to protect livestock producers from international competition is appropriately viewed through the lens of industrial policy. For Ghana, both sides of the argument of whether to enact significant trade barriers on chicken meat receive some support from the results presented. The pro side can point to large increases in poultry production, limited costs in terms of GDP (as modeled), and a cost incidence that mainly falls upon wealthier segments of society. The con side can point to large reductions in demand for chicken meat and attendant adverse nutritional outcomes, an absence of substantial macroeconomic gains, and very uncertain prospects that significant gains might accrue via the emergence of a globally competitive poultry industry in Ghana.

The uncertainty of becoming globally competitive in chicken meat production is an argument against protection from the standpoint of economic efficiency. Policies should focus on areas where Ghana may have greater comparative advantages, such as egg production, instead of propping up local chicken meat production, which is uncompetitive against the vastly more efficient global value chain that is already in place. Policies to protect livestock producers, such as the tariff considered in this study, will divert resources from more efficient uses and likely have the undesirable consequence of harming Ghana's economic growth.

The con side can also point to a series of factors outside of the model. Specifically, high tariffs on poultry will generate significant incentives for smuggling of chicken meat, likely resulting in some combination of a watering down of the protection afforded to producers, windfall gains to smugglers (and notably corrupt officials), and wasted real resources dedicated to smuggling. As shown by Arndt and van Dunem (2009), Fisman and Wei (2004), and Krueger (1974) among many others, these are not idle concerns. As noted in section 3, significant smuggling appears to have occurred in Nigeria via Benin. High implementation costs or failures of adequate implementation could negatively influence both the incidence and the overall cost of the policy, perhaps very significantly.

For Ghana and many other African countries, the model results do point to a middle path. Egg production is large relative to chicken meat production (at least in Ghana), is a quite similar production process to chicken meat, and is naturally protected due to the difficulties of transporting eggs across borders. As Table 4.2 shows, a substantial poultry industry, producing eggs and some meat, will exist independent of the border policy applied to chicken meat. And as shown in section 5, egg production has already been successful in a cluster of farms near the border with Côte d'Ivoire, crucially by taking advantage of cross-border trading opportunities. This thriving egg sector is now exporting eggs to other West African countries. This situation affords both the poultry industry and the government an opportunity to develop necessary conditions for an internationally competitive poultry sector, by focusing on eggs in the near term. International competitiveness hinges crucially on inexpensive sources of balanced poultry feed rations. In the absence of an inexpensive source of feed, the Ghanaian poultry industry will never achieve international competitiveness, making it a poor choice for an industrial policy focus.

In the Ghanaian case, intelligent initiatives to attempt to reduce feed costs have the added benefit of spilling over to stimulate other livestock sectors such as aquaculture. While Ghana does not manifestly possess endowments that would confer a substantial global advantage in poultry production, the presence of the world's largest man-made lake may confer real advantages in aquaculture production (Ragasa et al.

2017). At a minimum, Ghanaian policy makers should take care to ensure that policies designed to stimulate the poultry industry do not inadvertently set back aquaculture.

7. SUMMARY AND CONCLUSION

The livestock consumption and production trends identified in the Livestock Revolution (Delgado et al. 1999) are yet to be fully realized in SSA, but recent evidence and projections for West Africa (Zhou and Staatz 2016), East Africa (Tschirley et al. 2015), and the continent (OECD/FAO 2016) strongly suggest that the factors required for demand growth are already present. Overall, the Livestock Revolution that unfolded in Asia and Latin America over the past two decades was observed in about 2000 and reasonably accurately predicted to date. On the demand side, there is little reason to believe that demand behavior in SSA will differ, assuming continued or accelerating income growth.

However, it is uncertain that African countries will follow the path of Asian and Latin American countries that saw a surge in production to meet demand. Therefore, a pressing question for African policy makers is to devise ways to take advantage of the rise in consumption of livestock products as a market for small- and large-scale livestock producers, and feed-grain producers. One option is to enact trade barriers to reduce or eliminate imports of frozen meat, with the hope that local producers will fill the gap and meet demand for livestock products. This is the approach Nigeria adopted in 2002 for chicken meat.

As this paper shows for Ghana in the period 2015–2025, adopting such a policy leads to a local supply response, but this is likely to be accompanied by slow growth in demand as the price of chicken meat rises considerably. In addition, a large tariff wedge between domestic and world prices of chicken meat will encourage smuggling, with attendant risks and administrative burdens. All of these impacts—a local supply response, attenuated demand growth for chicken meat, and smuggling of frozen chicken meat—occurred in Nigeria.

Our results also indicate that egg production remains relatively constant with or without a tariff, implying that poultry production would continue to grow, with a focus on layers, even if a prohibitive tariff on meat imports is not in place. In short, the inherent barriers to trade in eggs create a natural “infant industry” niche. Protection of the poultry sector is industrial policy, and those targeted industries afforded

protection are expected to grow up. The natural protection afforded the egg sector potentially offers a low-cost and low-risk opportunity to develop capabilities. Should competitiveness of layers show signs of strong improvement relative to international benchmarks, the case for protection of chicken meat would improve. In the near term, as competitive feed prices are a necessary condition for a globally competitive poultry industry, the focus should be on reducing the cost of feed through a combination of domestic production and imports of ingredients. This focus has the advantage of corollary benefits for other sectors reliant on feed costs, notably aquaculture.

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