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**Animal-sourced Food Revolutions and Their Implications for Prices,
Consumption, and Nutrition in Low- and Middle-Income Countries**

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Abstract

Livestock and aquaculture are increasingly regarded as high-priority sectors for nutrition-sensitive agricultural development in low- and middle-income countries, as well as for income and job generation. One key question is whether increases in animal-sourced food (ASF) production—driven by extensification and/or intensification—translate into improvements in consumption through lower real ASF prices, either in absolute terms, or relative to a counterfactual. This study first examines the theoretical issues around whether real ASF prices should fall in response to production growth, focusing on the key how tradable an ASF commodity is. Fresh ASF products tend to be highly perishable and are therefore hypothesized to have their prices largely set by domestic production and marketing conditions. However, we argue that there is a continuum of tradability that makes these predictions complicated, as well as consumer preferences around substitutability between perishable and non-perishable products such as fresh milk and powdered milk. The study then reviews existing cross-sectional evidence on the relationship between relative caloric prices of ASFs and their consumption. While low incomes are a primary constraint on improving ASF consumption, high ASF prices are an important secondary constraint that explain a sizable share of cross-country variation in ASF consumption. Finally, we review existing country-specific evidence and generate novel cross-country evidence on whether countries that experience rapid growth in ASF production see declines in real ASF prices. Production growth in poultry meat and eggs results in sizable real price declines, while for dairy the association is negative but imprecise, perhaps because of the tradability of dairy powder making these relationships more heterogeneous. These findings support the conclusion that growth in ASF production can make ASFs more affordable in LMICs, though economic, environmental and “one health” challenges need closer consideration. A priority for future research is in-depth economic simulation analyses to provide a more structural explanation of the stylizing facts uncovered in this study, and to assess the prospective impacts of specific ASF investments or policies.

Keywords: Animal-sourced foods; livestock; aquaculture; nutrition; nutrition-sensitive agriculture

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1. Introduction

Livestock and aquaculture are increasingly regarded as high-priority sectors for nutrition-sensitive agricultural development in low- and middle-income countries (LMICs) (Adesogan et al., 2020; Dror and Allen, 2011; Headey, Hirvonen and Hoddinott, 2018; Khonje and Qaim, 2024; Leroy and Frongillo, 2007), as well as for income and job generation (Herrero et al., 2016). In the 1990s and 2000s, IFPRI researchers coined the phrase “the livestock revolution” to describe the rapid growth in production and trade of livestock products within LMICs, including agricultural powerhouses such as Brazil, India, Thailand and China (Delgado et al., 2000; Delgado, 2003; Narrod, Pray and Tiongco, 2008). In the 2000s, it also became clear that there were “blue revolutions” taking place in LMIC aquaculture sectors, particularly in Southeast Asia, including Bangladesh and parts of India such as Andhra Pradesh (Béné et al., 2015; Belton et al. 2017; Hicks et al., 2019; Rashid, Minot and Lemma, 2019).

Most of the research on livestock and blue revolutions focused on the contributions of these revolutions to national economic growth, job creation and poverty reduction, as well as the growing importance of south-south trade in animal sourced foods. However, in the past decade or so there has been a dramatic increase in evidence on how ASFs can contribute to nutrition-sensitive agricultural development. Malnutrition in all its forms is highly costly, but malnutrition in early childhood is particularly damaging for a child’s physical and cognitive development, as well as their future earnings and the economy at large (Black et al., 2013; Hoddinott et al., 2013a). As a result, nutritional investments in early childhood are widely estimated to yield extremely high returns, including by the Copenhagen Consensus (Hoddinott, Rosegrant and Torero, 2013b).

However, there are no silver bullets for solving the multidimensional and multisectoral problem of malnutrition, and interventions must be delivered through multiple sectors, including agriculture (Ruel and Alderman, 2013). A key barrier to improving diets in LMICs is lack of affordability of nutrient-dense foods specifically (Headey and Alderman, 2019) and healthy balanced diets overall (Herforth et al., 2020; FAO et al., 2022; Hirvonen et al., 2020). Balanced healthy diets clearly require consumption of a wide variety of fresh foods across the full range of healthy food groups, including fruits, vegetables, legumes and nuts. However, ASFs also play a critical role in good nutrition, especially in improving nutritional status of the most nutritionally vulnerable populations in LMICs, such as infants and young children, pregnant and lactating mothers and women and girls in general (Dror and Allen, 2011; Headey et al., 2023; Headey et al., 2018; Neumann, Harris and Rogers, 2002; Zaharia et al., 2021).

In this paper the overarching question is whether agricultural production growth—i.e., livestock and aquaculture revolutions—can lead to sustained reductions in real consumer

prices of ASF products. Among ASFs, any significant discussion of beef or sheep/goat products are excluded due to lack of data availability, as well as the undesirable environmental consequences of beef production especially.

The remainder of the paper is structured around the following three questions:

1. Why are ASFs so important for nutrition-sensitive agri-food policies?
2. What does the existing cross-country evidence tell us about the connections between ASF production levels, relative ASF prices and consumption?
3. In cross-country panel data, do long run changes in ASF production predict changes in real ASF prices?

The concluding section reflects on these findings, discussing policy implications, and priority areas for future research. It includes a discussion of the limitations and challenges of increasing ASF production, including environmental, health and economic risks, as well as priority areas for future policy-relevant research on the economic and nutritional impacts of ASF agri-food system investments.

2. Background: Why are ASFs so important for nutrition-sensitive agri-food policies?

While the nutritional and public health importance of ASFs in high income countries is debated—with red meat being a risk factor for various non-communicable diseases—the importance of ASFs to eliminating malnutrition in LMICs is far less controversial (Dror and Allen, 2011; Headey et al., 2023; Murphy and Allen, 2003).

2.1 The nutritional importance of ASFs

LMIC populations suffer multiple forms of malnutrition, including a wide range of micronutrient deficiencies, but also macronutrient deficiencies (calories, fats and proteins). Since ASFs provide high-quality protein, they are often labelled “protein foods” in food-based dietary guidelines because of their rich amino acid profiles. There are nine essential amino acids that must be obtained from food, and deficiency in any single amino acid constitutes a limiting factor for building proteins. In almost any diet, ASFs play a critical role in providing a complete combination of amino acids. Cow’s milk, for example, has the highest amino acid adjusted protein score of any food in the world. While the extent of population-wide protein malnutrition is disputed, infants and young children with small stomachs undoubtedly need protein-dense foods, although ASFs also provide young children with much needed calories and healthy fats (FAO/WHO/UNU, 2007).

However, ASFs are not just “proteins”: they are rich in multiple micronutrients. Moreover, ASF micronutrients are highly bioavailable, meaning they are far more easily absorbed by the body than vegetal-based micronutrients. Some key micronutrients, such as B12, can

essentially only be found in ASFs, while ASFs also have high levels of highly bioavailable iron (except dairy), as well as zinc and other key micronutrients (Dror and Allen, 2011; Murphy and Allen, 2003). ASFs should therefore be thought of as both protein-rich foods *and* multiple micronutrient-rich foods.

The evidence on the importance of ASFs for healthy growth in early childhood in LMICs is now highly compelling. While there are a handful of experiments providing ASFs to infants (Eaton et al., 2019; Iannotti et al., 2017; Stewart et al., 2019; Tang et al., 2014), most of the research comes from observational studies or quasi-experimental studies designed to reduce the confounding association of ASF consumption with greater socioeconomic status (i.e., ASFs tend to be income-elastic goods, demand for which rises as incomes grow). A widely cited multi-country study on ASFs and child stunting analyzed data from 113,000 children from 42 LMICS (Headey et al., 2018), and found that children who consumed two types of ASFs per day were around 7 percentage points less likely to be stunted than children who did not consume any ASFs. They also found that the strongest predictor of stunting reduction was consumption of dairy products, which – in addition to their high-quality protein and micronutrients – also contain a growth-stimulating hormone called IGF-1. Further research on dairy and child nutrition likewise confirms its exceptionally strong association with linear growth in young children, while a handful of studies also suggest impacts on cognitive development and schooling outcomes as well. For a review, see Headey et al. (2023).

2.2 Economic rationales for nutrition-sensitive ASF policies and investments

These are nutritional rationales for having a special interest in ASF consumption for improving nutrition in LMICs, but why should economic development of ASF sectors be prioritized for nutrition? In principle, income transfers and/or nutritional education might suffice to significantly improve ASF consumption in LMICs given that ASFs are income-elastic foods, making agricultural interventions superfluous. The reality is more complex, however, because poor people also live in poor food environments characterized by high prices of ASFs (Headey and Alderman, 2019; Headey et al., 2019). In sub-Saharan Africa and much of Asia, 100 calories of ASFs like eggs or dairy can be anywhere between 5 and 20 times more expensive than 100 calories of starchy staples like rice or maize (Headey and Alderman, 2019). Metrics on the cost of healthy diets also shows that ASFs can comprise as much as 40% of the cost of a recommended diet (FAO et al., 2022; Headey et al., 2024b; Herforth et al., 2022; Hirvonen et al., 2020; Mahrt et al., 2019; Raghunathan, Headey and Herforth, 2020), and that daily healthy diet costs far exceed household food budgets for large sections of LMIC population. In those circumstances, a typical social cash transfer of say \$15 per household per month will do little to improve household diets in a context of such high prices of ASFs and other nutrient-dense foods (Headey et al.,

2024b). Hence a key nutritional policy goal should be to identify interventions that *can* cost-effectively reduce the prices of ASFs economywide.

There are three broadly defined options for reducing prices.

The first is some kind of price subsidy, implicit or explicit. Across-the-board price subsidies for ASFs are likely to be undesirable because: (a) wealthy households who do not typically need higher ASF consumption would still financially benefit from the subsidy (an error of targeting inclusion); (b) across-the-board subsidies could be fiscally expensive; and (c) LMIC food markets are highly informal, so it is likely that ASFs subsidies would not directly benefit the poorest and most malnourished populations (note that the same would be true of ASF tax exemptions, like value added tax). More targeted subsidies, such as school meal programs or free/subsidized meals for young children are a better bet because they can more directly target nutritionally vulnerable populations – though very few programs target children under the age of 2 years, who are most in needs of nutrient-dense ASFs for physical and cognitive development. Moreover, these programs can provide a marketing outlet for local ASF producers. In Thailand in the 1990s, for example, school milk programs purchased 40% of national milk production, which played an important role in developing the national dairy industry (Heaver and Kachondam, 2002; Smitasiri and Chotiboriboon, 2003).

The second option is trade reforms that either reduce tariff or non-tariff barriers on imported ASFs or tax or restrict ASF exports. Reducing barriers to ASF imports could be desirable in circumstances where a country has little or no comparative advantage in domestic ASF production, but LMICs vary greatly in which ASFs they can productively and profitably produce. For example, dairy production at scale in hot and humid tropical climates will often not be profitable—in much of Africa, tsetse fly is especially prohibitive to dairy and cattle production—which suggests that liberalization of dairy imports could help improve nutrition in many LMICs (Liu, Liang and Kevin Chen, 2023). Likewise, access to water bodies is obviously a necessary condition for capture fisheries, as is water availability for aquaculture. Countries with little physical capacity to produce ASFs clearly require imports, while at the opposite end of the spectrum are countries with comparative advantages that leave them self-sufficient and potentially net exporters of ASFs. Finally, in between are countries with some potential for ASF production that are unlikely to be fully self-sufficient. In these countries, imports can play a role but will compete against domestic production. In such countries, judicious trade policies need to find the right balance between protecting and developing domestic ASF sectors whilst allowing imports to help boost domestic consumption of ASFs. Vietnam's dairy sector is just such an example, since it uses variable tariffs to augment domestic production rather than displace it, thereby protecting domestic consumers but allowing imports to add to domestic supply

(Headey et al., 2024a). Finally, there are some circumstances where imports and trade policies may have little or no role to play in helping increase ASF consumption because some ASFs are not long-distance tradable (e.g., eggs, fresh milk).

The third option is the main subject of this study: expanding the production of ASFs to create reductions in real consumer prices of ASFs—i.e., the livestock or aquaculture revolutions widely researched in agricultural economics, in particular. Whether or not ASF production growth translates into real price reductions for consumers (as well as producers) depends on how tradable an ASF product is: can a given ASF be easily and cost-effectively imported or exported? If ASF products can be imported at relatively low cost to provide consumers with close substitutes for domestically produced ASFs, and if there are no prohibitively high tariff or non-tariff barriers in place, then domestic production growth would have no impact on real prices—it would only crowd out imports.¹ Likewise, if an LMIC can produce ASFs that are competitive in international markets, then ASFs exports may also limit the real domestic price reductions from any production growth. Hence a highly export-focused livestock revolution may benefit farmers and other ASF value chain actors but provide limited benefits to consumers through price reductions.

In reality, however, many ASFs in LMICs are not highly tradable, for various reasons:

1. Many ASFs have inherently low storability or transportability – important examples include fresh dairy products/milk, eggs and to some extent even meat or live animals. Storability and transportability are admittedly not fixed parameters because they can be improved with technologies such as improved transport, storage and processing. Table 1 gives a typology of the inherent storability and tradability of different ASF products. In some instances, these improvements in storability and transportability are only marginal—for example, there is still scarcely any long distance (blue water) trade in eggs or fresh milk—while in other instances processing of products is transformative, such as in the massive international trade in frozen poultry or fish, in milk powder, and in dried, smoked, canned or frozen fish. With dairy products, it is important to note that fresh milk is a hyper-perishable product that will typically spoil in just 3 hours after milking, making timely collection, storage and processing of milk a major challenge in rural LMIC geographies (Headey et al., 2024a).
2. In some instances, international (imported) ASF products are not perfect substitutes for local products. For example, while dairy powder is a widely traded good internationally, many consumers in countries such as India or Kenya would have a strong preference for domestically produced fresh milk. Admittedly, these

¹ Indeed, that production growth might be difficult to achieve in the first place given that the national ASF sector in any given LMIC is likely much less productive than international trading partners.

preferences are not necessarily fixed over time. Milk products and milk markets are changing rapidly in India, for example, and throughout Southeast Asia what is perceived as “fresh milk” is often a mix of local milk and reconstituted imported milk powder.

3. LMIC governments often have strong political and economic incentives to protect domestic ASF producers, and hence impose both tariff and non-tariff barriers to prevent ASF imports. Thus, ASFs in some countries are “non-tradable” for political economy reasons.

Table 1. A stylized typology of the variation in the storability and transportability of different ASF food types

	Low storability & transportability	Medium storability & transportability	Highly storability & transportability
Dairy	Fresh milk (hyper-perishable)	Cheese, butter, yoghurt	Powdered milk; UHT (long-life) milk
Eggs	Fresh eggs	Boiled eggs	Egg powder (ingredient)
Poultry	Fresh meat	Chilled meat, live animals, dried/cured	Frozen meat, Tinned meat
Fish	Fresh fish	Chilled fish	Frozen, dried, smoked, tinned

Of course, even if ASF production growth will reduce real ASF prices in many circumstances, it does not necessarily follow that ASF investments are high-return investments. The literature on ASF revolutions is clearly biased towards success stories, but there are also likely many countries that have pushed for ASF revolutions but not yet succeeded. Mixed success in ASF investments and strategies would not be surprising. ASF sectors are very diverse in terms of their production technologies, including their agro-climatic conditionalities. For example, the original livestock revolution literature focused heavily on poultry (Narrod et al., 2008; Narrod, Tiongco and Costales, 2007), in part because modern intensive poultry systems are characterized by: (1) well-established and high adaptable technologies in terms of animal genetics, feed composition, vaccinations, and management practices; and (2) steep economies of scale, resulting in huge productivity gains as production transitions from backyard poultry systems at one extreme to massive poultry “factories” at the other (Morris, Beesabathuni and Headey, 2018). Poultry production is also not especially climate sensitive.

In contrast, dairy productivity is much lower in hotter and more humid climates and high-yielding cattle varieties from temperate European climates are highly vulnerable to tropical diseases (Headey et al., 2024a). This does not mean dairy productivity growth is impossible in tropical climates—far from it, as countries like Vietnam, Thailand, India and China have shown—but it does present additional financial and policy challenges for both the private sector and the public sector. Likewise, aquaculture requires suitable terrain and water requirements.

In summary, agro-climatic conditions matter substantially for some ASFs, and will be an important determinant of economic potential and comparative advantage. Some African countries, for example, have strong comparative advantage and economic potential in aquaculture, but not in dairy, and could instead import dairy products to further dietary diversification.

2.3 Hypotheses

Based on the theory and typology described above, the following hypotheses on the relationships between production growth in different ASF sectors and subsequent real price changes are proposed:

Hypothesis 1 - EGGS: Due to steep economies of scale in egg/layer production, and high perishability of eggs and limited tradability, production growth in the layer industry will result in steep decline in real prices of eggs.

Hypothesis 2 - POULTRY MEAT: Although there are steep economies of scale in poultry meat (broiler) production, price reductions for poultry meat will depend on trade barriers and costs (protection), preferences for local vs imported meat, and preferences for chilled over frozen meat. Hence, real prices of poultry products may not decline as substantially as prices of eggs would from analogous production changes.

Hypothesis 3 - DAIRY: Because of more limited scale economies in dairy, climate constraints and the coordination, collection and processing challenges that emerge from milk's hyper-perishability, we hypothesize that there will inevitably be fewer countries that are national dairy success stories. However, for countries that do achieve rapid production growth, the change in real prices will depend on whether consumers treat imported milk powder products as a close substitute for domestic milk, and on whether dairy exports emerge as an important outlet market for domestic production.

Hypothesis 4 - AQUACULTURE: While there is no widely available cross-country data on fish prices, aquaculture growth will likely reduce the real prices of aquaculture products, especially relatively to non-aquaculture fish/seafood products that have natural limits and economic barriers to sustained production growth. How much prices reduce will partly

depend on whether export markets emerge for aquaculture products, as well as demand-side factors like preferences for fresh versus capture fish products.

3. Cross-country patterns in ASF consumption and ASF prices

This section examines cross-country comparisons of ASF consumption as well as ASF prices to understand regional patterns of ASF consumption and prices. For price comparisons the relative caloric price indicators developed by Headey and Alderman (2019) are used. These indicators compare how expensive different types of ASF calories are relative to starch staple calories like rice, wheat or maize, and thus measure how economically attractive or unattractive it is for consumers to diversify consumption away from staples into a given ASF.

3.1 Regional differences in ASF consumption

Table 2 reports average consumption per capita in grams per day of various ASFs by region, drawing on Food Balance Sheet data from FAOSTAT (FAO, 2025). These data come with two important limitations: (1) this is an indicator of ASF calories available for consumption rather than actual consumption; (2) FAOSTAT data are quite low quality in lower income countries especially where national statistical capacity is weaker.

Bearing those caveats in mind, Table 2 shows that in the higher income regions of South America, Central Asia and Eastern Asia, the average person is estimated to consume around 50 grams of ASF protein per day. In North Africa and South Asia this falls to 26 and 21 grams, respectively, while in much of sub-Saharan Africa it falls to as low as 10-12 grams per day. These consumption levels are obviously strongly correlated with per capita income, but there are nevertheless interesting patterns in the data in terms of which ASFs are more commonly consumed. For example, in South America and Central Asia, meat, eggs and dairy are all widely consumed but fish and seafood are not, while in Eastern and Southeastern Asia fish and seafood consumption is much higher than other regions. And uniquely, although South Asia has low ASF consumption overall, dairy is a very important ASF, with consumption at 11.7 grams per day, which is more than half the total ASF consumption in that region (21.3 grams). Much of this high dairy consumption in South Asia is driven by India, where a third of the population do not eat meat or eggs but do consume milk (i.e., lacto-vegetarian).

Table 2. Average consumption per capita in grams per day of various ASFs by region, stratified by above average (green) or below average (orange) ASF protein consumption

	All ASFs	Meat	Eggs	Dairy*	Fish & Seafood
South America	59.1	37.7	3.9	12.6	2.8
Central Asia	50.0	21.3	3.3	22.0	1.1
Northern Africa	26.1	11.8	1.4	8.0	3.8
Eastern Asia	53.8	29.8	6.9	3.6	11.7
Western Asia	35.3	18.2	2.3	12.0	1.9
Southern Asia	21.3	4.9	1.4	11.7	2.9
Southeastern Asia	31.8	13.3	4.0	1.8	11.5
Southern Africa	34.6	23.9	1.6	4.6	1.5
Eastern Africa	12.0	5.3	0.3	4.2	1.5
Central Africa	11.2	6.7	0.2	0.8	2.5
Western Africa	10.4	4.9	0.6	1.3	3.0

Below average
Above average

Source: Authors' estimates from FAO (2025).

Table 3 shows ASF consumption patterns for the most nutritionally-vulnerable demographic, infants and children aged 6-23 months, drawing on Demographic Health Survey data from 59 LMICs. ASF consumption is low for most foods in most regions, except for Latin America, Eastern Europe and Central Asia, and the Middle East and North Africa. In these latter regions, roughly two-thirds of children consumed dairy in the past 24 hours, and quite large shares consumed meat or eggs (but not fish). In Southeast Asia, dairy consumption is lower, but almost a third of children consumed fish, meat and/or eggs in the previous 24 hours, suggesting non-dairy ASF consumption is high in this region. In most other regions, either dairy or fish is the dominant ASF. In India, dairy is dominant with 51% of children consuming dairy in the past 24 hours and much smaller shares consuming eggs (14%), meat (6%) or fish (5%). In contrast, while dairy and eggs are relatively important in Bangladesh, fish is the most common ASF (37%).

In sub-Saharan Africa the picture is also complex. Dairy is dominant in the East African highlands (e.g., Ethiopia, Kenya, Uganda, Rwanda) but dairy is also consumed in other East African countries (28%) along with fish (21%) and meat (21%). However, in Western and Central Africa fish is clearly more prevalent, being twice as commonly consumed as meat and more common than dairy or eggs also. These results are consistent with the importance of agro-ecology in shaping dairy production and consumption in Africa, since the relatively temperate East African highlands have a much less burdensome disease environment for dairy production.

Table 3. The share of children 6-23 months of age consuming various ASFs in the past 24 hours in 59 LMICs, grouped by region

	Fish	Meat	Eggs	Dairy	Primary ASF?
Western Africa	26%	13%	13%	23%	FISH
Central Africa	32%	16%	9%	14%	FISH
East African highlands	6%	7%	10%	37%	DAIRY
East Africa, other	21%	21%	15%	28%	MIXED
South Asia	7%	8%	17%	49%	DAIRY
Bangladesh	37%	13%	25%	28%	FISH
India	5%	6%	14%	51%	DAIRY
Southeast Asia	32%	30%	31%	18%	FISH/MEAT
Latin America	9%	51%	41%	57%	DAIRY
Eastern Europe & Central Asia*	4%	38%	37%	66%	DAIRY
Middle East & North Africa*	8%	21%	27%	67%	DAIRY

Source: Author's construction from Demographic Health Survey data (ICF-International, 2026).

3.2 Cross-country variations in the relative caloric prices of ASFs

Are cross-country differences in ASF consumption levels explained by price differences? Measuring cross-country price differences is not easy because exchange rates do not easily capture cost of living differences. However, Headey and Alderman (2019) derived a novel price measure that circumvents exchange rate complications and provides a neat way of measuring how costly it is for poor people to diversify away from starchy staples: the relative caloric price. In any given country, this measure is simply the ratio of the price of a given ASF calorie relative to the price of a starchy staple calorie. So, a relative caloric price of 10 for eggs, means that egg calories are 10 times as expensive as starchy staple calories.

Results from their study for ASFs are reported in the heat map in Table 4, with darker shades denoting more expensive foods. The results show interesting patterns consistent with the consumption patterns observed in Tables 2 and 3. For example, the first column shows that milk calories are 9 to 10 times more expensive than starchy staple calories in sub-Saharan Africa, where milk consumption is very low.

Table 4. Headey and Alderman's (2019) estimates of the relative caloric prices of various ASFs, by World Bank income levels and regions

	Milk	Other dairy	Eggs	White meat	Red meat, unproc.	Red meat, proc.	Fish & seafood
All countries (N=176)	3.84	6.93	5.54	5.42	3.07	11.51	6.00
High income (N=64)	1.93	2.46	2.60	3.91	3.07	7.50	5.65
Upper middle (N=44)	2.72	6.25	4.46	3.54	2.68	9.34	4.31
Lower middle (N=41)	4.55	9.40	6.65	6.98	3.30	14.89	6.90
Low income (N=27)	10.45	8.53	11.66	9.97	3.72	15.26	10.20
Europe (N=39)	2.11	2.73	3.42	4.09	3.38	7.76	5.84
North America & Australasia (N=6)	1.48	1.76	1.72	1.85	2.00	5.92	6.47
Latin America & Caribbean (N=38)	2.30	3.73	3.22	2.74	2.92	3.63	5.36
Middle East & North Africa (N=18)	4.27	3.94	5.34	5.05	5.09	12.90	5.30
Central Asia (N=6)	3.80	4.89	4.66	4.47	3.58	8.29	8.27
China (N=1)	2.51	7.74	4.79	3.72	2.01	11.47	3.55
Other East Asia (N=5)	2.59	3.64	2.25	6.18	4.83	7.92	4.53
South-East Asia (N=10)	6.68	11.24	8.24	5.79	3.85	14.02	4.92
India (N=1)	2.77	9.29	5.32	7.10	2.28	12.77	6.99
Other South Asia (N=6)	3.97	12.51	5.79	7.02	4.77	22.42	10.19
Eastern & Southern Africa (N=19)	9.14	7.77	9.16	9.51	3.15	12.06	10.27
Western & Central Africa (N=27)	10.00	7.72	12.93	9.35	3.79	22.09	6.61
LEGEND	Very cheap: RCP<2		Cheap: RCP of 2-4		Expensive: RCP of 4-8		Very expensive: RCP>8

Source: Headey and Alderman (2018).

In contrast, milk calories are just 2.77 times as expensive as starchy staples in India, where milk consumption is unusually high relative to the India's low levels of income. Conversely, fish prices are low in Southeast Asia – where consumption is high – and relatively low in sub-Saharan Africa where fish is often the most commonly consumed ASF for young children. But another key takeaway is that ASFs are generally much cheaper in relative terms in high-income countries than they are in low-income countries – a difference that could be explained by the massive productivity differences in ASF production between low- and high-income countries.

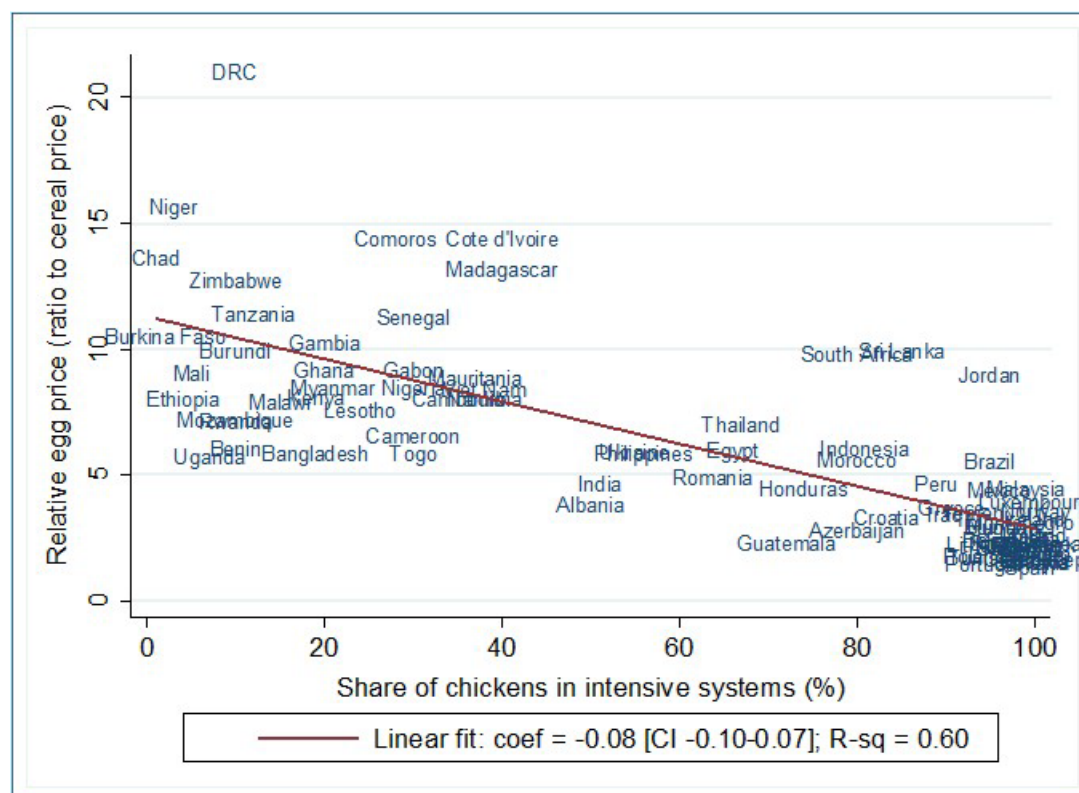
Headey and Alderman (2019) also show that relative caloric prices are powerful predictors of cross-country differences in children's ASF consumption, after controlling for per capita

income. For example, cross-country differences in egg prices explain around 20% of the difference in egg consumption among children 6-23 months of age. They also show that ASFs prices are strongly negatively correlated with stunting prevalence, especially dairy prices.

While these associations are all correlations rather than causal evidence, cross-country patterns in relative prices do make economic sense. As noted above, dairy production in most of sub-Saharan Africa is highly constrained by livestock diseases, particularly tsetse fly, and hot and humid climates, and it is striking how expensive dairy products are in this region. Conversely, large parts of Southeast Asia are highly suited to both capture fisheries and aquaculture, and fish and seafood products are cheap in this region.

Another study examined prices and production technologies for eggs specifically (Morris et al., 2018) and uncovers a strong association between the share of chickens in intensive production systems and the relative caloric prices of eggs (Figure 1). This is only an association not evidence of direct causation, because the intensiveness of poultry production systems is not exogenous as private poultry investors respond to growing demand. Nevertheless, some countries have also taken actions to promote the commercial poultry sector (Mehta and Nambiar, 2007; Narrod et al., 2008; Narrod et al., 2007).

Figure 1. The relative caloric price of eggs versus the share of chickens in intensive production systems



Source: Morris et al. (2018).

In summary, cross-country differences in ASF consumption levels are indeed highly correlated with relative caloric price differences in ASFs.

4. Panel data and time series evidence on changes in real ASF prices

While the previous section provided evidence hinting at connections between production/productivity and relative prices, this section more directly examines whether *changes* in ASF production lead to *changes* in real ASF prices. This section starts with a cross-country regression analysis of changes in real prices as a function of changes in production, for eggs, poultry meat and milk. It then turns to a review of evidence on changes in real ASF prices from the “natural experiment” of Myanmar, which began to liberalize its economy in the mid-2000s after 50-plus years of inward-looking protectionism, which led to rapid expansion and commercialization of a variety of ASF sectors, including aquaculture.

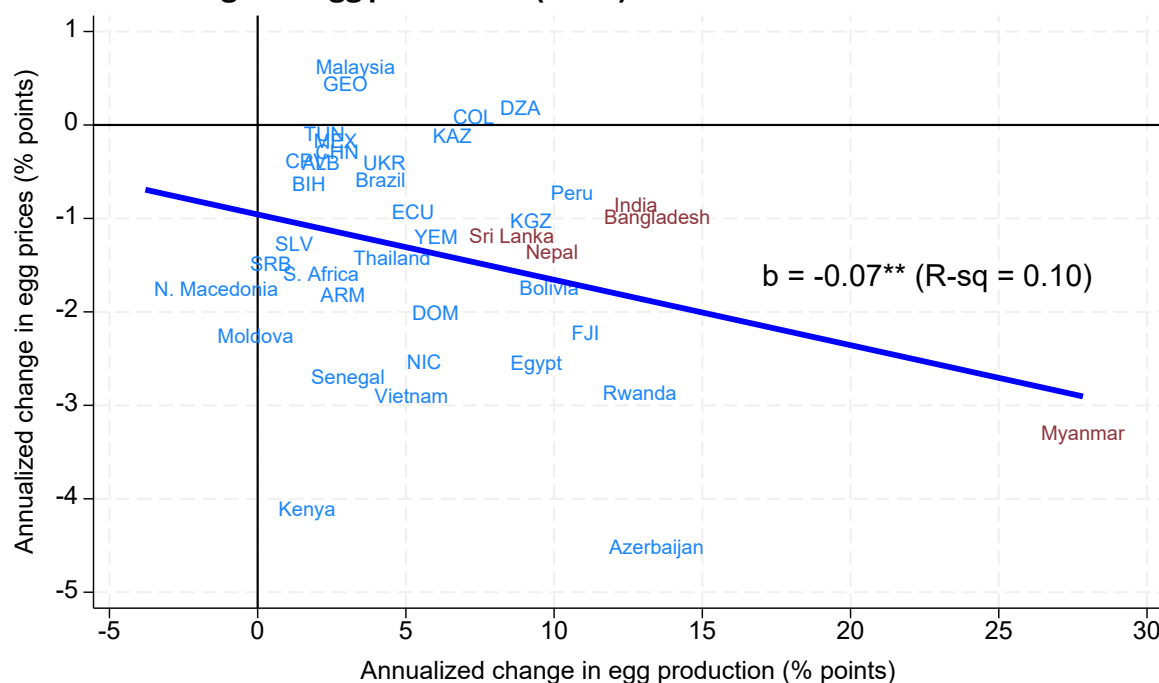
4.1 Cross-country evidence on ASF production growth and changes in real ASF prices

Do increases in ASF production lead to decreases in real prices? The main constraint to test this is a paucity of data because most countries do not publicly release commodity

level consumer price data. To circumvent this, we use FAO (2025) producer price data for poultry meat, eggs and dairy, all deflated by GDP deflators to produce real price changes. While consumer prices would be preferable from a consumption perspective, the reality is that producer and consumer prices almost invariably move closely together. The data in question cover 2000 to 2023 to show long-term changes in production and prices. However, because of uneven data coverage, different countries have “episodes” of different lengths, so annualized changes in both production and prices are measured. Moreover, the data was extensively cleaned to exclude obvious outliers.

Figure 2 reports results for changes in egg production and prices for 39 countries. Eggs are one of the least tradable commodities, so it is not surprising to see a strong negative gradient that is statistically significant at the 5% level. The slope coefficient implies that a 10% increase in egg production per year would predict a 0.7 percentage point reduction in real egg prices per year. There is also a diverse array of countries that achieved sizable growth in egg production over this period, the most notable being the aforementioned Myanmar example. India, Bangladesh, Nepal and Sri Lanka also had high growth rates, suggesting a livestock revolution in South Asia over this period, as did Azerbaijan and Rwanda.

Figure 2. A scatter plot and regression fit of annualized changes in egg prices against annualized changes in egg production (N=39)

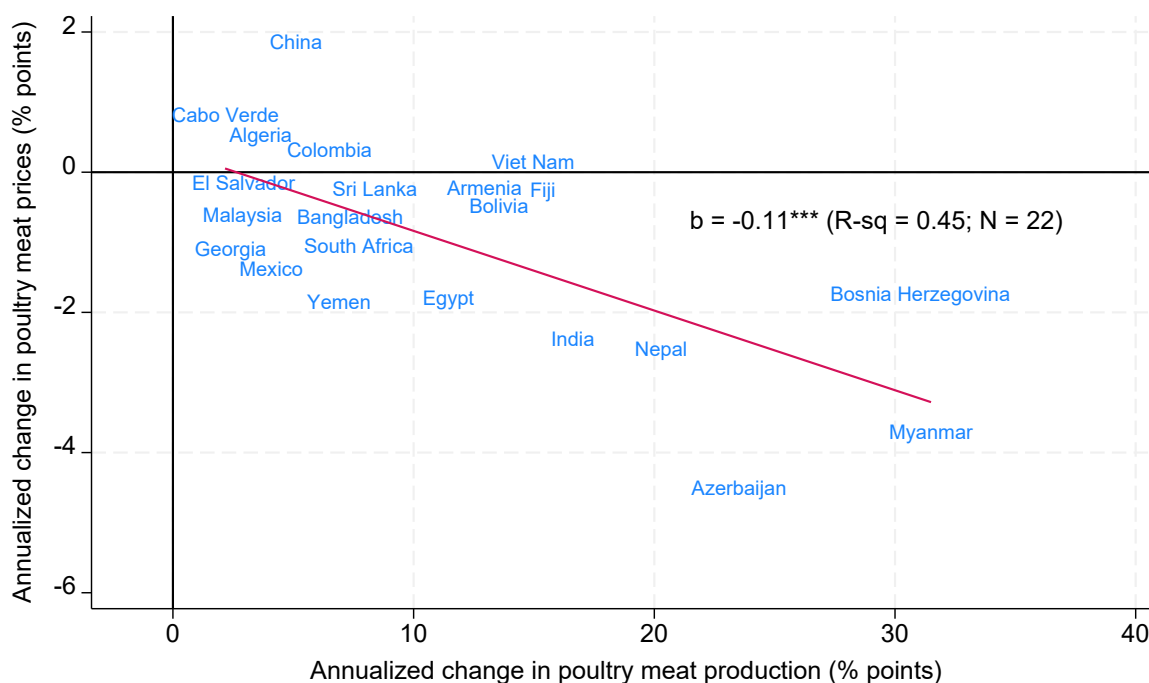


Source: Author’s estimates from FAOSTAT data (FAO 2025).

Figure 3 reports the same type of graph and regression for poultry meat, but from a smaller sample. Here the regression fit is even stronger and the slope coefficient is even more steep and highly statistically significant, again suggesting that production growth in poultry leads to falling real prices.

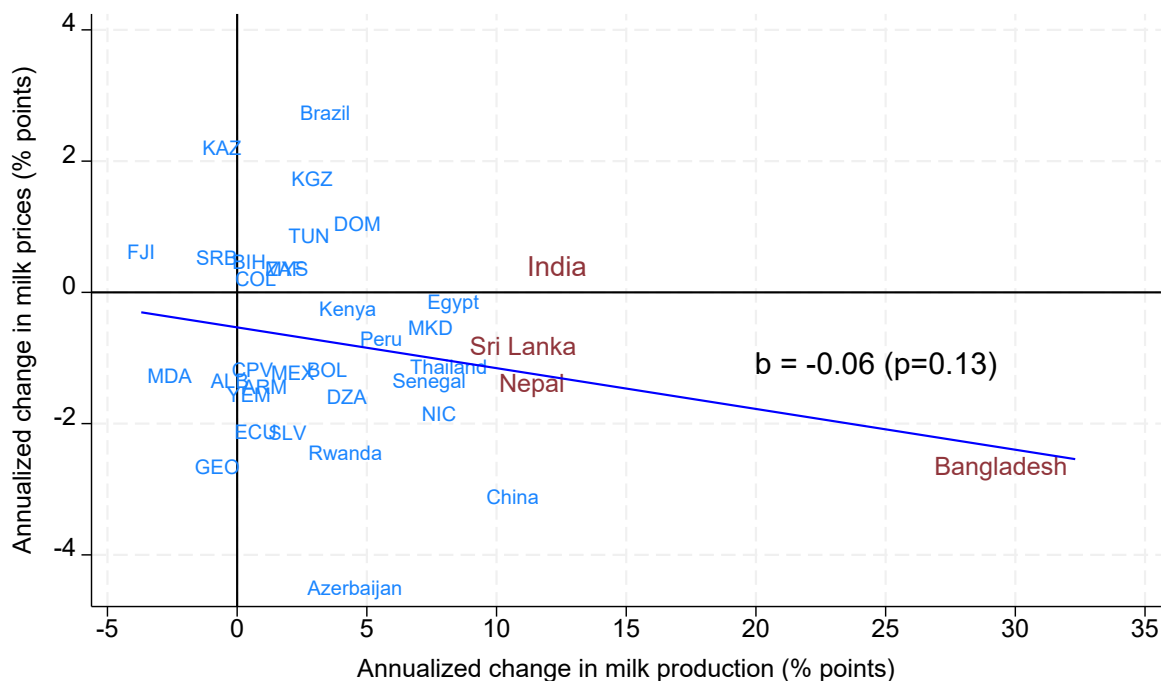
Finally, Figure 4 reports an analogous graph for dairy prices. Here the relationship is weaker and the slope coefficient is marginally insignificant at the 10% level (with a p-value of 0.13). The slope is still negative, however, suggesting that production growth in dairy might often lead to real price declines. However, this weaker relationship is perhaps unsurprising given that milk powder is highly-tradable, such that any effects on changes in production are likely conditioned by changes in net imports.

Figure 3. A scatter plot and regression fit of annualized changes in poultry meat prices against annualized changes in poultry meat production (N=22)



Source: Author's estimates from FAOSTAT data (FAO 2025).

Figure 4. A scatter plot and regression fit of annualized changes in milk prices against annualized changes in milk production (N=35)



Source: Author's estimates from FAOSTAT data (FAO 2025).

In summary, even in small cross-country samples statistically significant results corroborate the hypothesis that increases in ASF production typically lead to reductions in real prices for eggs and poultry meat, with weaker evidence for dairy. This evidence is not ideal because the data are measured with error and producer prices are used in lieu of consumer prices. The results also do not control perfectly for growth in demand or reverse causation, since changes in prices motivate producers to increase or decrease output. However, we note that reverse causation would only attenuate rather than exaggerate the negative associations observed above. Ideally, future research should aim to explore these mechanisms through structural economic simulation models.

4.2 A note on Myanmar's aquaculture and poultry revolutions in the wake of the country's 2008 economic liberalization

While the evidence above provides broad stylized facts across countries, it has limitations. First, we don't know why expansion of ASF production took place in any given country, leading for potential for confounding factors. Second, we did not have any data on fish prices or aquaculture across countries.

To complement the cross-country analysis, we examine the “natural experiment” of Myanmar as an excellent case study for examining the impacts of increases in ASF production on ASF prices, for two reasons:

1. Before the mid-2000s, the country was virtual autarkic with high degrees of protectionism and restrictive internal regulations that greatly inhibited agri-food system commercialization. However, economic liberalization from the mid-2000s onwards (until the military takeover in 2021) allowed for significant agri-food system investment and made it easier to import key inputs for poultry, swine and aquaculture. These processes are extensively documented by Scott et al. (2023), who report the massive expansion of commercial poultry and swine farms around Yangon (the major commercial center) as well as rapid expansion in aquaculture, much of it by smallholders.
2. Myanmar has a diverse diet in which most households consume a variety of ASFs, including ocean fish and riverine fish, poultry meat, eggs and pork, and beef. The only exception is dairy, which is not a major part of the diet nor widely produced. Importantly, then, Myanmar’s liberalization episode provides evidence for multiple commodities, including aquaculture products.

In Figure 2 we report Scott et al. (2023) results from time series data on ASF prices collected by the Myanmar Central Statistical Office (CSO) between April 2008 and February 2018 from retail markets across the country. These are real prices adjusted for inflation using the general consumer price index (also supplied by CSO) and converted to an index where the price of all ASF for April 2008 was equal to 100, with an increase (decrease) of one point in subsequent months equivalent to a 1% increase (decrease) in real price.

One additional important point of note is that price changes reflect changes in both supply and demand. If changes in domestic demand and overseas demand for exported Myanmar ASF products over 2008 and 2017 were identical across products, and if no ASFs were imported, then price changes would solely reflect changes in production. But in reality, there are likely different domestic and external demands that help explain some of the differences in price trends observed in Figure 2. For example, Myanmar exports wild (marine) fish and these exports amounted to 40% of domestic marine fish production in 2008, rising to 55% in 2017 (FAO 2025). Myanmar also sometimes exports beef (cattle) informally to China. However, outside these two food groups, Myanmar virtually has no ASF exports. It also has very limited ASF imports due to high transport costs for importing perishable ASF commodities. As for demand, there is likely some variation in income elasticities for different ASF food groups and individual commodities, though no recent estimates exist for Myanmar, except for different types of fish (Aung et al., 2022). Moreover,

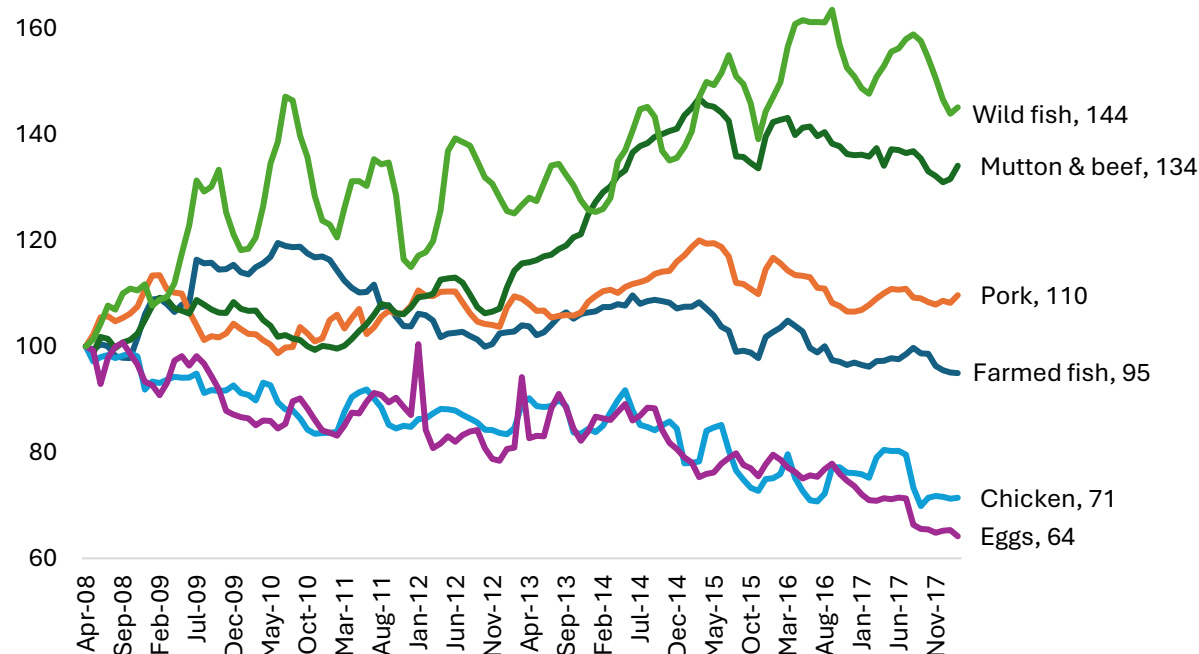
Myanmar's economy grew relatively quickly over 2008-2017, so all of these ASFs would have faced growth in aggregate demand for all ASFs.

Bearing those considerations in mind, Figure 5 shows a dramatic variation in price trends across commodities. The key takeaways are:

1. Real prices of chicken meat and eggs declined rapidly (by 29% and 36% respectively), and by similar magnitudes, reflecting the combination of rapid growth in production—largely due to massive economies of scale in poultry—coupled with the limited tradability of these foods.
2. The price of farmed fish (aquaculture products) declined slightly in real terms (5%) compared to a 44% increase in the price of capture fish. Rapid price increases in capture fish reflect growing export demand, but also the limited capacity to increase marine fishing giving environmental constraints and competition from other marine fleets.
3. Capture fish prices also show marked seasonality in prices because of challenges of capturing fishing during the monsoon months, whereas farmed fish shows no clear evidence of seasonal price fluctuations.
4. Pork prices only increased marginally (10%), consistent with strong production growth.
5. The price of beef increased by 34%, likely reflecting limited production growth coupled with growth in largely informal exports of beef/cattle to China.

In summary, the Myanmar case study is highly consistent with production expansions of “non-tradable” ASF products leading to declining real prices of poultry products, especially, and stable or moderately increasing prices of farmed fish and pork.

Figure 5. Trends in the real consumer prices of various ASFs in Myanmar over a period of rapid economic liberalization: 2008 to 2017



Source: Data are from the Central Statistical Office of Myanmar. The graph replicates the findings of Scott et al. (2023).

5. Discussion: Policy implications and priority areas for further research

ASFs are critically important for improving the nutrition of vulnerable populations in LMICs and also have considerable potential for income generation and job creation. However, the potential of ASF consumption to improve nutrition is currently limited by their high cost in LMICs, where eggs, dairy, meat and fish calories can be anywhere from 5-15 times as expensive as starchy staple calories. Initiatives to reduce real ASF costs for consumers are potentially very important, but not yet well informed by rigorous evidence. This paper therefore sought to explore the linkages between production growth and prices, with a focus on poultry, dairy and aquaculture.

5.1 Key findings on ASF production and prices

Economic theory suggests there would be a relationship between production growth and prices because many nutrient-dense ASFs are highly perishable and cannot cost-effectively be traded long distances, especially in LMIC settings where infrastructure and logistics are poor. With the extreme case of eggs—which are scarcely traded internationally—previous research found an exceptionally strong cross-country association between relative caloric prices of eggs and a metric of poultry

commercialization/intensification, and other studies have observed real declines in aquaculture products due to “Blue Revolutions” in countries such as Bangladesh and Myanmar. This study goes a step further by examining the association between ASF production growth and real price changes in a larger set of LMICs. Consistent with the hypotheses, egg and poultry meat prices are strongly associated with growth in production, while the relationship for dairy production and prices is weaker and likely nuanced by the tradability of milk powder as a substitute for fresh milk.

While these associations have caveats and limitations and need to be examined further—especially in structurally appropriate economic simulation models—they suggest that investments in ASFs sectors can indirectly benefit nutrition through price reductions and increased consumption. The largest benefits would accrue in countries where relative ASF prices are high, which is true of most of sub-Saharan Africa. Poultry is particularly promising because: (1) poultry has such steep economies of scale from a relatively standardized technology bundle (breeds, feed, animal health, etc) that commercialization investments are likely high return provided the market conditions are favorable; and (2) poultry products are almost universally consumed and eggs are highly nutritious and attractive foods for infants and young children. Sizable parts of Africa and Asia also have good scope to increase aquaculture production. Dairy is more nuanced, being conditioned by agro-climatic factors that make its production much more challenging in tropical climates.

5.2 Risks associated with ASF production

While ASF investments are promising, there are still important risks with ASF investments.

Economic risks. The fact that ASF prices are high in many countries does not necessarily mean that ASF investments will be profitable for either the public or the private sector. Many ASFs are highly income elastic, meaning that growth in demand for these products will come from high income growth and urbanization (thick markets). One of the reasons for high ASF prices in many African countries may indeed be weak demand due to low incomes and low-income growth and relatively low levels of urbanization. It is not uncommon in many African countries to observe some amount of ASF commercialization around major cities where the pull factors of agglomeration economies make commercial farms profitable (Minten et al., 2020; Vandercasteelen, Minten and Tamru, 2021). Further geographical expansion of commercial agriculture, however, might be constrained by low incomes and dispersed rural markets that make the production and marketing of perishable products more challenging.

A related risk is prices collapsing if production growth exceeds demand, as well as price volatility related to seasonal imbalances between supply and demand. The downside of

highly perishable or non-tradable products is that excess production growth can lead to large reductions in producer prices, to the point where production is unprofitable. More cyclically, prices can fluctuate due to the uncoordinated supply responses of the many thousands of producers in any given country. If all producers respond to high prices, for example, this can lead to gluts (over-supply) in the market. The USA, for example, still suffers from “hog cycles” where pork prices fluctuate markedly. In the case of LMICs, a pertinent example is the boom and bust cycle that characterized the later stages of Andhra’s Pradesh’s rapid growth in aquaculture production (Belton et al. 2017).

There are several solutions to the challenges of managing price declines.

First, in LMICs where ASF productivity levels are extremely low, productivity-driven production growth still has scope to simultaneously sustain farm income growth even as real consumer prices decline. This is most obvious in the case of poultry, with its exceptionally steep economies of scale which hugely reduce unit production costs once intensive production systems are adopted. As we saw above, countries with more intensive poultry systems have much lower prices, and this is sustainable. Scale economies are not as steep in other ASF sectors, but productivity-driven growth is certainly possible. The modernization of dairy and aquaculture in many Asian countries are prime examples, though admittedly supported by rising demand for these products in rapidly growing economies such as China and Vietnam.

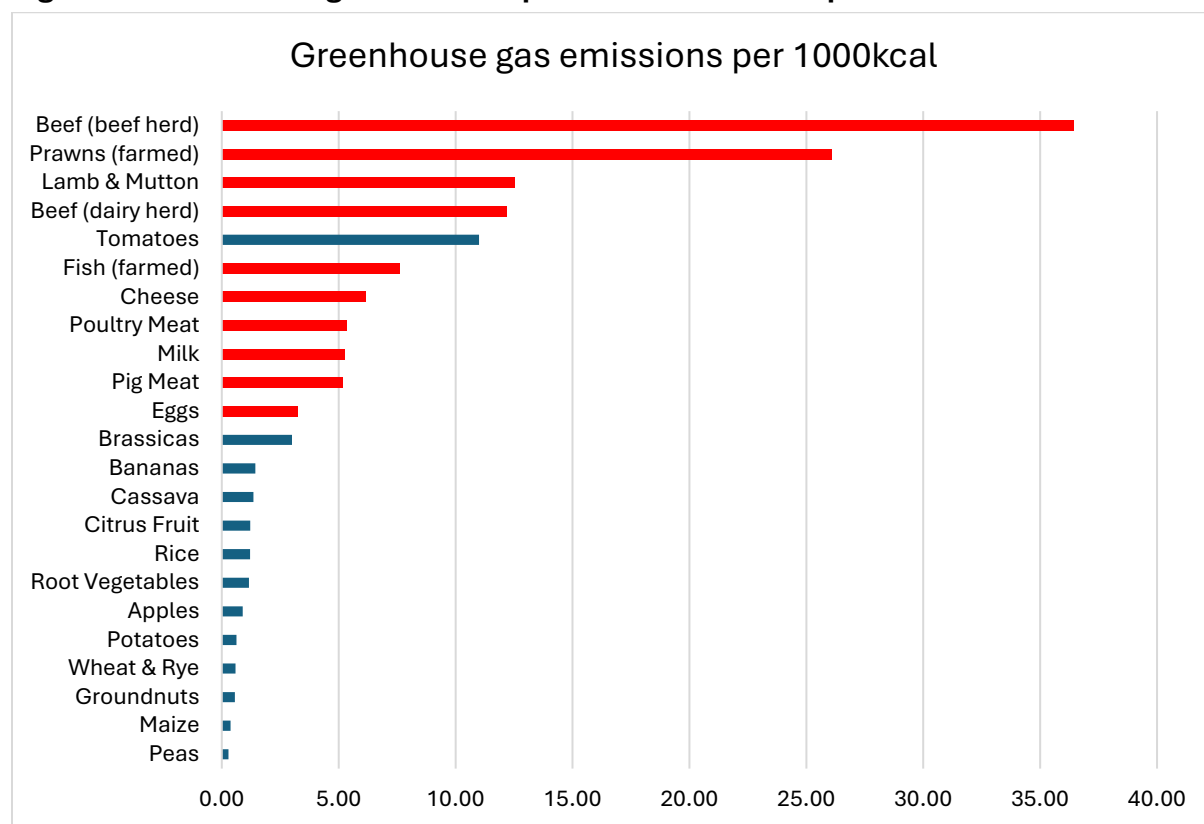
Another option for striking a balance between the welfare of consumers and ASF producers is to promote ASF exports to prevent price collapses. For example, the development of Uganda’s dairy sector has been substantially driven by dairy export development driven by collection centers that can improve “farmgate prices” and farmer incomes by offering increased sales volumes to farmers (Van Campenhout, Minten and Swinnen, 2021). Of course, the tradeoff here is that export growth can lead to more limited reductions in domestic prices.

Zoonotic diseases. Another risk associated with ASF expansion is zoonotic diseases. Avian influenza is particularly problematic with poultry. The rapid commercialization of poultry in Asia, for example, has dramatically amplified the risk and economic impact of Highly Pathogenic Avian Influenza (HPAI) outbreaks. Risks of outbreaks appear to be highest in countries undergoing a transition from small-scale production and trade to a mixed combination of intense production systems often clustered closely together, dense live bird markets, wild bird interfaces, mixed farming (particularly chickens and ducks) and varied biosecurity levels (Gupta et al., 2026; Islam et al., 2025). While larger commercial farms have the capacity for stricter biosecurity, commercialization processes have often resulted in dense clusters of farms and intense live poultry trade networks, which act as catalysts and conduits for the rapid spread of the virus.

Other research suggests that low-tech backyard livestock production—particularly poultry—can also have harmful impacts on a child’s gut and hence their broader nutrition, health and physical and cognitive development. Many households in LMICs live in overly close proximity to poultry and other livestock, with young children often exposed to fecal matter from livestock that are exceptionally high in bacteria and can be digested directly (through mouthing) or through contaminated food, water or hands (Headey and Hirvonen, 2016; Headey et al., 2017; Mbuya et al., 2015; Prendergast et al., 2014). Commercialization of ASF production may actually reduce these risks, however. Another option is to try to improve livestock-related WASH practices in LMICs (Gelli et al., 2023; Ngure et al., 2019).

Environmental externalities. ASF production systems have well known environmental externalities including high rates of water use, land conversion (e.g., deforestation) and greenhouse gas (GHG) emissions. Food production is estimated to account for over a quarter (26%) of global GHG emissions, half of the world’s habitable land, 70% of global freshwater withdrawals are used for agriculture, and 78% of global ocean and freshwater eutrophication. Moreover, 94% of non-human mammal biomass is livestock and 71% of bird biomass is poultry livestock. GHG emissions typically derive the most attention. Figure 5 reports data from Poore and Nemecek (2018) who estimate GHG emissions per 1000 kcal of food produced. Unsurprisingly, beef herds are the biggest GHG emitters in caloric terms, followed by prawns and lamb and mutton. However, the ASF sectors encompassed in this study—poultry, eggs, farmed fish and dairy—have significantly lower GHG emissions per 1000 kcal, because these are intensive and quite efficient production systems. Moreover, a key point here is that the more productive an ASF production system, the lower its GHG output per unit of food produced.

Figure 5. Greenhouse gas emission per 1000 kcal of food produced



Source: Poore and Nemecek (2018), processed by Our World in Data: <https://ourworldindata.org/grapher/ghg-kcal-poore>

5.3 Key areas for future research on ASFs, food affordability and nutrition

While the findings above are insightful, they only cover stylized relationships between production and prices, and further research is needed in several important areas. First, a key empirical challenge in identifying the impacts of production pathways on prices is to control for demand scenarios. Factoring in demand for ASFs is also important for assessing opportunities for profitable ASF investments. Countries with low incomes, low levels of urbanization and stagnating economies may struggle to generate opportunities for profitable public or private investments in ASFs.

Second, it is important to connect detailed empirical work on ASF revolutions with economic modelling of future scenarios, particularly to drill down into specific interventions or intervention packages that can be expected to increase production and reduce real consumer prices under realistic assumptions. For these questions, simulation models are best equipped to capture the many structural relationships between interventions and economic outcomes. One such example is the Rural Investment and Policy Analysis Model (RIAPA) developed by IFPRI.

6. Conclusions

Animal sourced foods are critical for human nutrition, especially for young children, delivering both high-quality protein and a wide array of highly bioavailable nutrients. They are also an important source of income generation in LMICs, with considerable potential for greater contributions to income growth because productivity gaps are often immense in LMICs (Herrero et al., 2016).

In this study we primarily focused on the complex relationships between production or productivity in ASF production and real or relative ASF prices. While there are caveats to the evidence presented, the body of evidence suggests that countries with greater production and productivity have lower relative ASF prices, and that ASF production growth can lead to lower real consumer prices for ASF products over time. Real ASF price reductions are not always guaranteed—it depends on tradability of the ASF and trade policies—and there are potentially caveats around how feasible it is to achieve rapid productivity growth in ASFs in the absence of strong demand due to robust economic growth and urbanization. But the evidence is indicative of the potential of ASF investments and policies to improve nutrition through real price changes, in addition to other pathways such as income generation of ASF suppliers.

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