Long-run Projections of Animal Agriculture: A Macroeconomic Approach

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What is the Trajectory of Animal Agriculture to 2050?

- Animal agriculture has large externalities (Funke et al., 2020)
  - Environmental stressors (both local and global)
  - Antimicrobial resistance
  - Human health effects
  - Animal welfare (e.g., Kuruc and McFadden, 2022, forthcoming)
- Thus knowing this sector's trajectory under a business-as-usual (BAU) scenario can help us prioritize policy goals and inform policy discussions.
- However, few medium-run forecasts have been developed (e.g., FAO, Komarek et al., 2021)
  - Use micro-focused simulations and aggregate up.
- We complement these with a parsimonious yet rigorous macroeconomic forecasting approach.

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A Simple Projection Approach

We use three components to project growth in animal-based foods:

1. Population forecasts
   - Take these from the United Nations (UN)
2. Elasticity between animal consumption growth with respect to national income growth
   - Provides novel estimates from a cross-country analysis of long-differences
3. Income growth
   - Calibrate a model of catch-up growth to match Yale Growth Survey estimates

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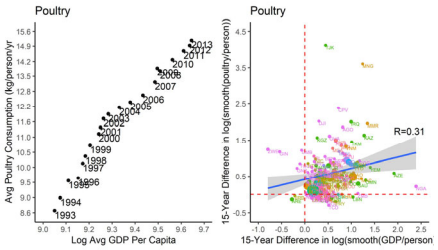
Motivating Trends and Elasticities: Poultry and Income



Source: Authors' estimates.

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Methodology Overview

1. Estimate elasticities using cross-country data
2. Feed in income per capita growth
   - When combined with macro elasticities, this gives us per capita consumption (to couple with population estimates)
   - Fix maximum possible consumption at current maximum-observed levels for each product
     - In other words, our results are not driven by, say, Americans eating 10 chickens per day.

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Some Simple Long-Difference Regressions

- To control for country-specific effects, we estimate the elasticities using a 15-year long difference.
- We use smoothed endpoints to remove noise in the food data and get at a cleaner measure of per-capita GDP growth.
- Specifically, for each variable, V_t, we difference (smoothed) 1997 values from smoothed 2011 values:

$$\frac{1}{5}\sum_{t=2009}^{2013} V_t - \frac{1}{5}\sum_{1995}^{1999} V_t$$

- For each animal-based product, there are five regressions:
  1. Log per-capita food on log per-capita income
  2. Specification 1 with interaction: log per-capita income x per-capita income
  3. Specification 2 with global region fixed effects (FE)
  4. Specification 2 using aggregate GDP weights
  5. Specification 2 with aggregate GDP weights and global region FE

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Regression Results

		Specification				
Product	Regressor	(1)	(2)	(3)	(4)	(5)
Bovine	Income	0.037	0.051	0.058	0.187	0.413**
	Interaction		-1.1×10^{-7}	-6.1×10^{-8}	-6.9×10^{-7}	-4.9×10^{-7}
Pork	Income	0.304***	0.328***	0.151	0.208	0.166*
	Interaction		-2.0×10^{-7}	-1.9×10^{-7}	-2.8×10^{-7}	-5.4×10^{-7}
Poultry	Income	0.804***	0.863***	0.402***	0.740***	0.348***
	Interaction		-4.6×10^{-7}	-2.8×10^{-7}	-1.4×10^{-7}	-1.4×10^{-7}
Mutton-Goat	Income	0.103***	0.153*	0.218***	0.381***	0.923***
	Interaction		-4.0×10^{-7}	-5.1×10^{-7}	-2.5×10^{-7}	-2.7×10^{-6}
Milk	Income	0.216***	0.259***	0.200***	0.906***	1.267***
	Interaction		-3.4×10^{-7}	-2.7×10^{-7}	-2.0×10^{-6}	-2.5×10^{-6}
Eggs	Income	0.362***	0.424***	0.249***	0.452***	0.381***
	Interaction		-4.9×10^{-7}	-6.3×10^{-7}	-7.2×10^{-7}	-7.7×10^{-7}
Interaction		N	Y	Y	Y	Y
GDP Weights		N	N	N	Y	Y
Region FE		N	N	Y	N	Y

Source: Authors' estimates.

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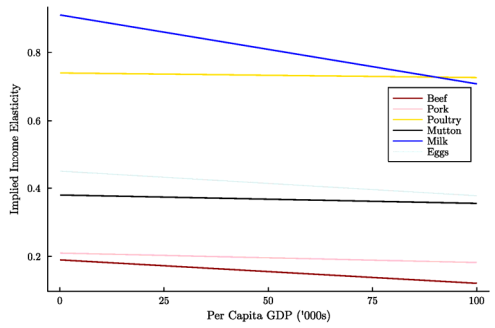
Main Elasticities Used



Source: Authors' estimates.

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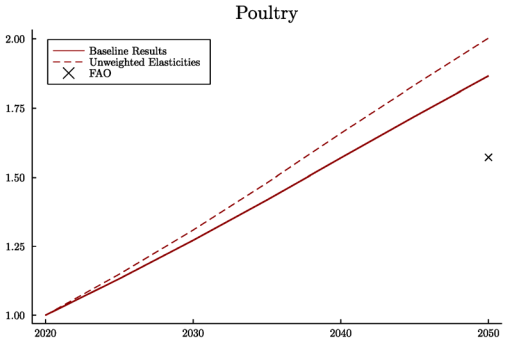

Source: Authors' estimates.

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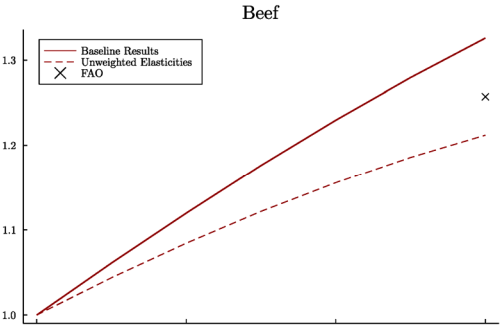

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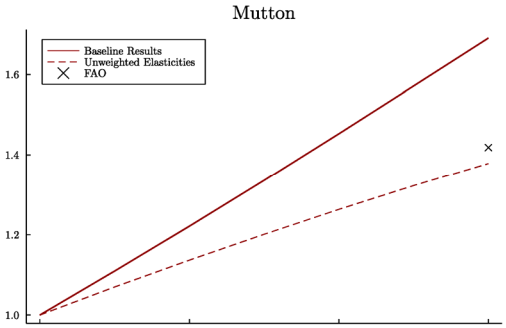

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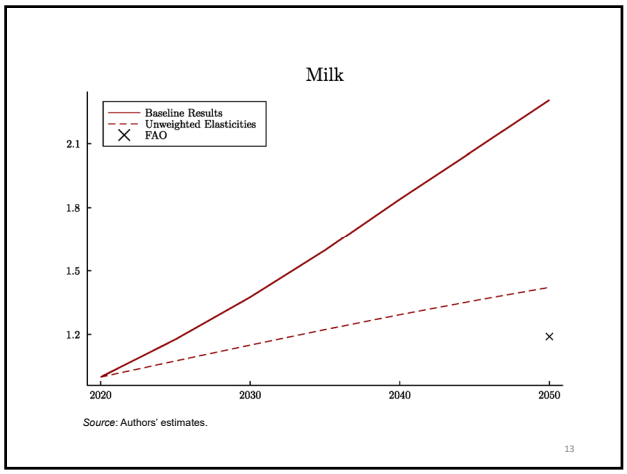

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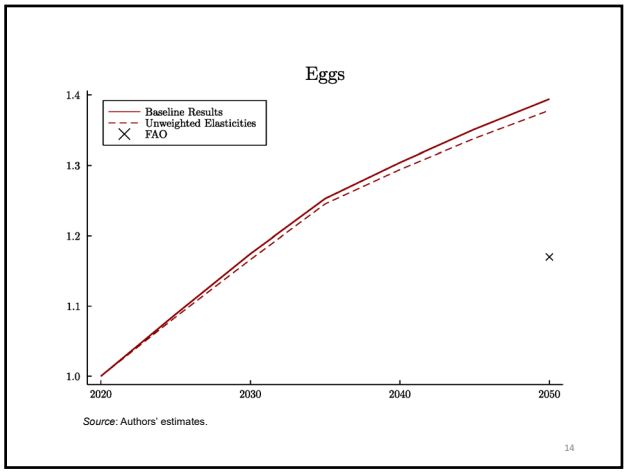

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Discussion and Next Steps

- Our results remain preliminary. We intend to:
  1. Compare with Komarek et al. (2021)
  2. Feed in commonly used GDP projections to decompose the differences between our results and those of others. This should determine how much of the differences are due to macro elasticity discrepancies vs. GDP projection discrepancies.
  3. Put a cap on total calories from animals (rather than animal-based food)
  4. Increase robustness of elasticities and then simulate over range of elasticities to generate uncertainty bands

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