Is Local Food More Environmentally Friendly? The GHG Emissions Impacts of Consuming Imported vs. Domestically Produced Food

Presented by Misak Avetisyan

Texas Tech University

Based on article by: Avetisyan, Hertel and Sampson published in *Environmental and Resource Economics*

What is the food miles debate?

- Agriculture and transportation sectors combined contribute more than one-third of global GHG emissions
- Critics question the wisdom of transporting food products vast distances instead of consuming locally produced food – the average US food product travels 5000 miles from farm to fork!
- Doesn’t this lead to a larger carbon footprint than if the food were sourced locally?
- It turns out that the answer to this question is not as obvious as would appear at first glance

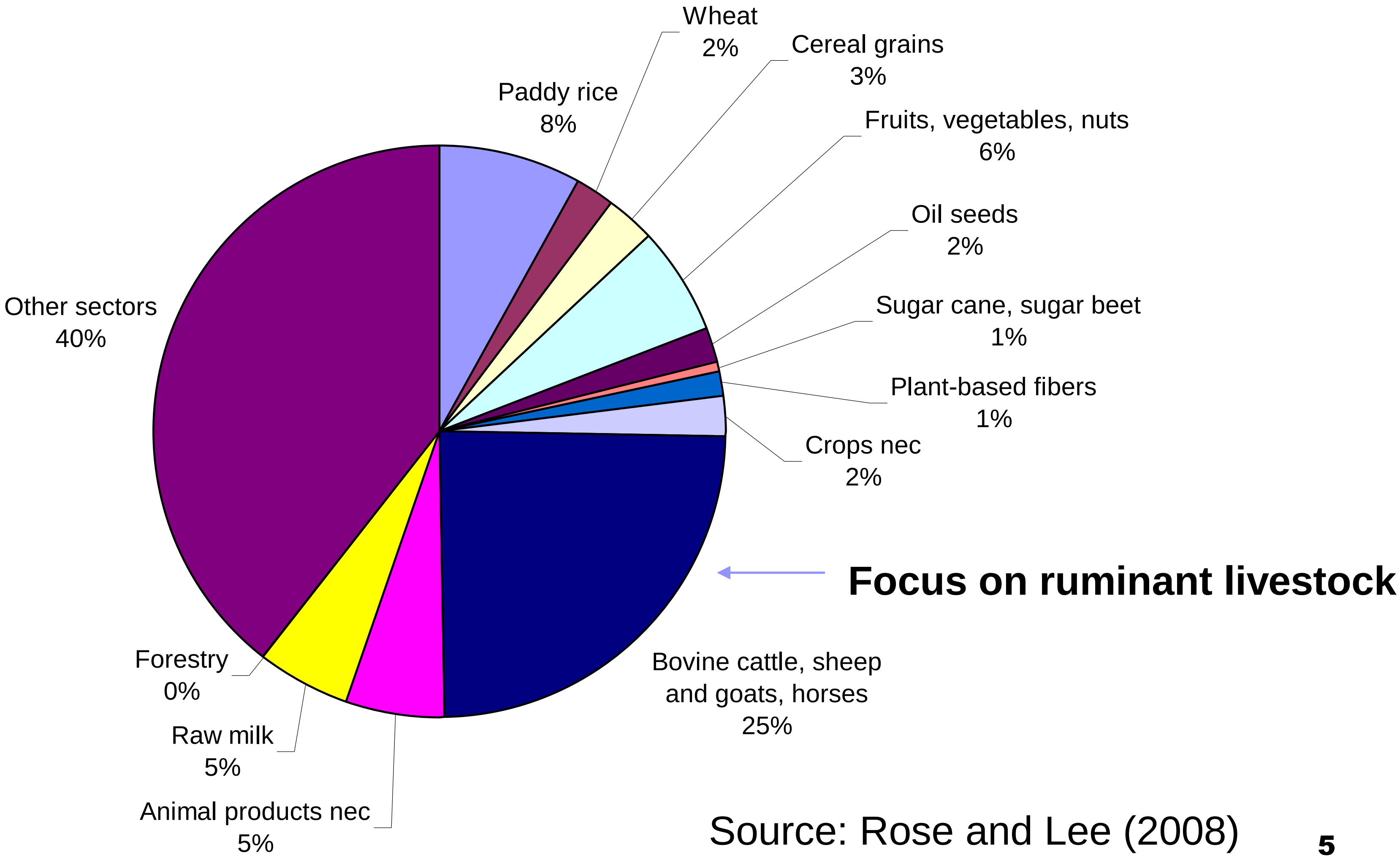
Literature review:
The case for local sourcing

- Jones (2006) compared green bean production of UK and Kenya:
  - Similar energy requirements for production systems.
  - Difference in the airfreight (energy footprint Kenyan beans was 12-13 times greater than that for UK).
- Sim et al. (2007) estimated a factor of 20-26 times the GWP for imported Kenyan and Guatemalan beans vs. locally grown in UK
- *Suggests a much smaller carbon footprint from locally produced food*

Literature review: Differences in technology matter

- However, *transport-related emissions may be offset by local climate/other favorable factors*
- Williams (2007) compares the supply of cut roses to the UK from Kenya vs. Netherlands:
  - Production of this good requires more energy
  - Even with the higher emissions from air transport, roses produced in Kenya generated lower emissions
- Hauwermeiren et al (2007)
  - Greenhouse tomatoes use 10-18 times more energy
  - Locally produced goods not always the least emitting
- Blanke & Burdick (2005): energy for apple storage equal to that used for transporting apples from overseas

And what about non-CO2 emissions? Global emissions across sectors



Source: Rose and Lee (2008)

Literature review: Inter-industry linkages are also important

- Hendrickson et al. (1998) extend LCA methodology to include national input-output analysis; both direct and indirect effects
- Tukker et al. (2006): production and transportation of food accounted for 31% of direct/indirect GWP in EU-25
- Peters (2011) has used global IO analysis to look at carbon footprint of various activities
- Does not factor in economic behavior
- Have not addressed the food miles debate

This study extends the literature on the food miles debate

- Most analyses of food miles:
  - product-specific – hard to generalize
  - use differing methodologies
  - focus on EU
  - struggle with carbon accounting in globalized world -- transit of goods through supply chain and countries prior to consumption
  - Have ignored non-CO_2 GHG emissions
- We examine range of products and countries using single methodology accounting for all GHGs globally

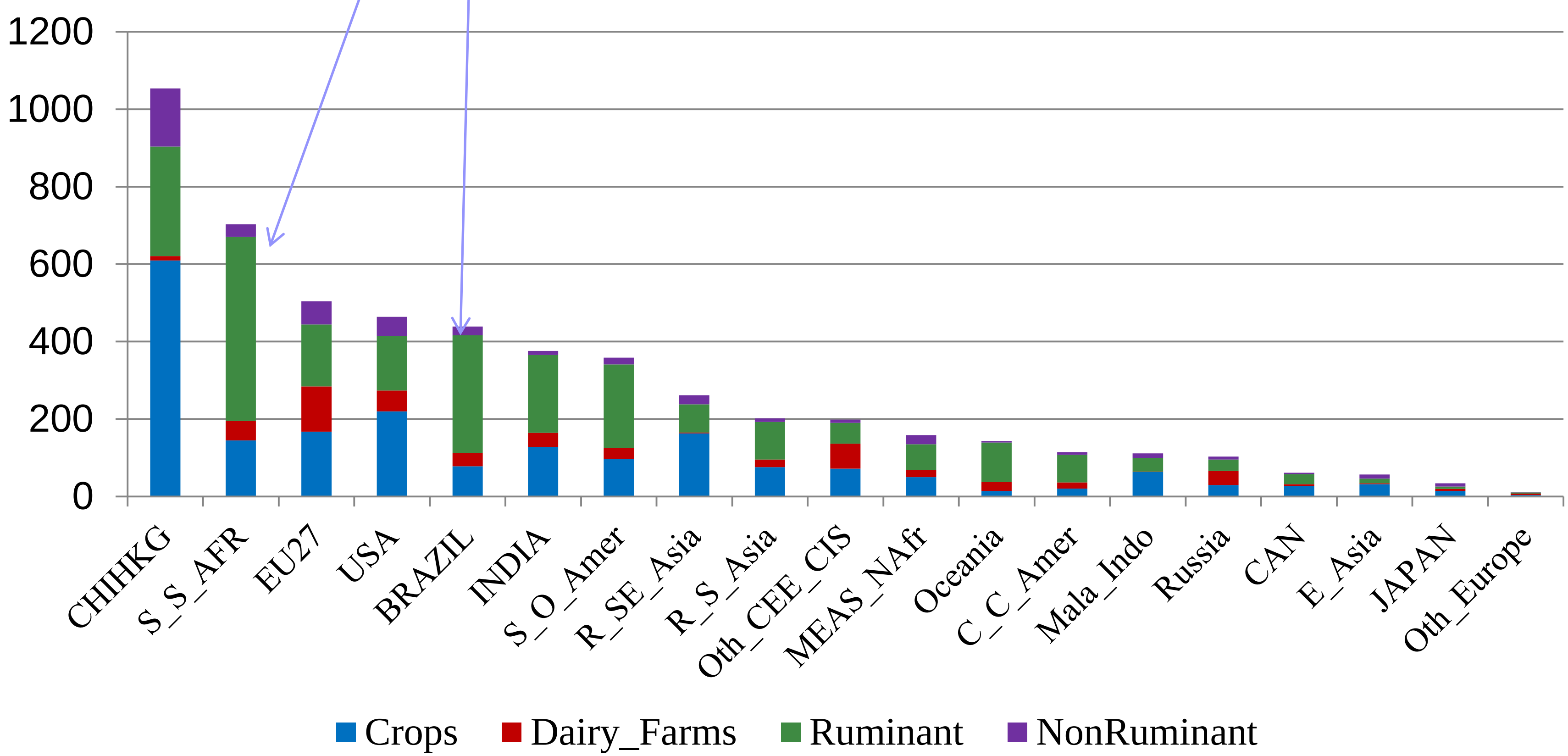
Methodology

- We use the GTAP-AEZ-GHG model
  - GTAP= Global Trade Analysis Project
  - AEZ = Agro-ecological zones
  - GHG = Greenhouse gas emissions
- CO_2 emissions linked to fossil fuel combustion
- Non-CO_2 emissions are linked to specific drivers in the model (e.g. fertilizer, animals)
- For each food category in each region, we impose a tax on imports for consumption
- Explore the impact on global GHG emissions of local sourcing of each product in each region

GTAP-AEZ-GHG

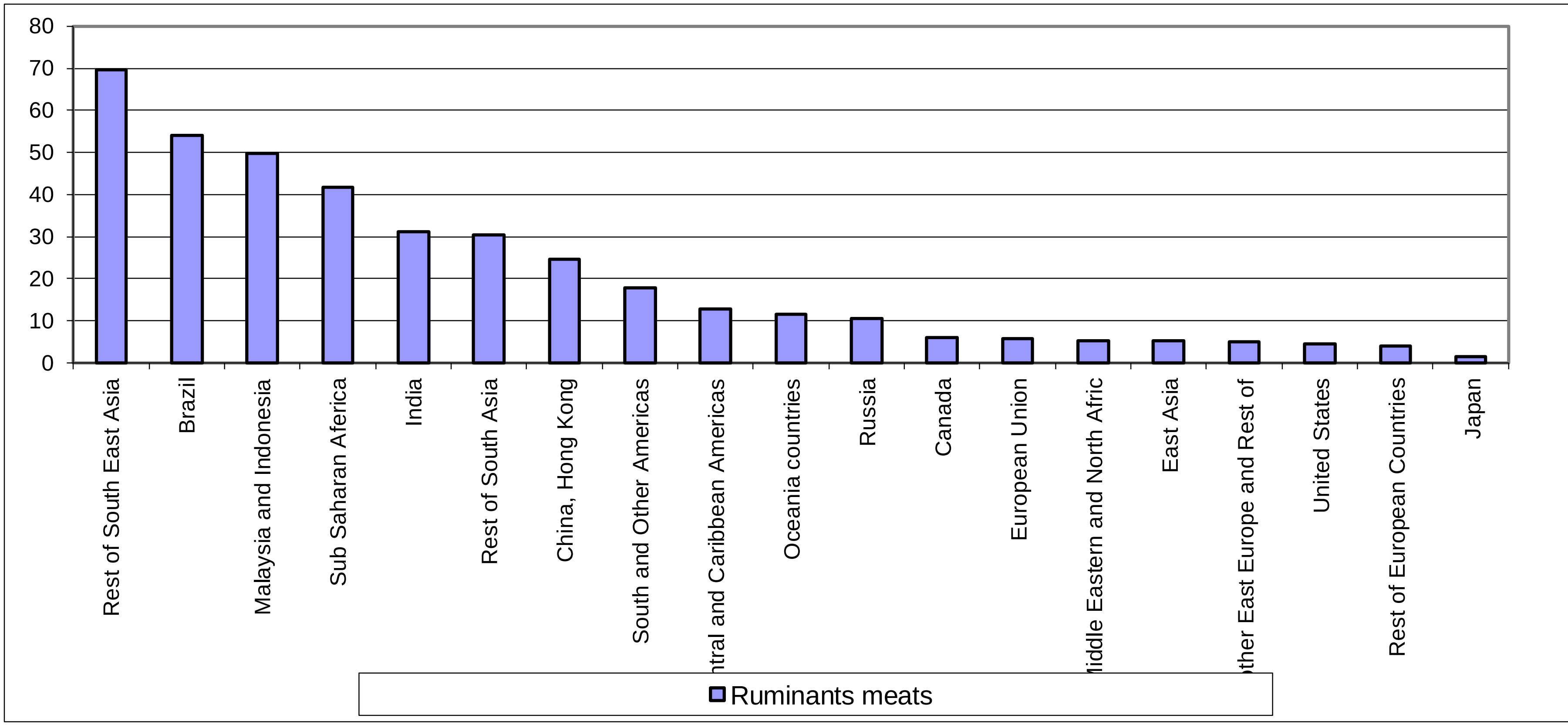
- Global computable general equilibrium model
- At full disaggregation:
  - 57 sectors cover all economic activity in a region
  - 139 regions cover global economy
  - Here, we use an aggregation focused on food miles
- Key assumptions:
  - Producers minimize costs
  - Entry and exit of firms dissipates profits
  - Consumer behavior is price and income responsive
  - Product differentiation by region allows for tracking of bilateral trade -- from where do you source your food?
  - Three modes of international transport: air, sea, land

Ruminant meats sector emits large share of agricultural non-CO_2 GHG emissions (mill tCO_2eq)



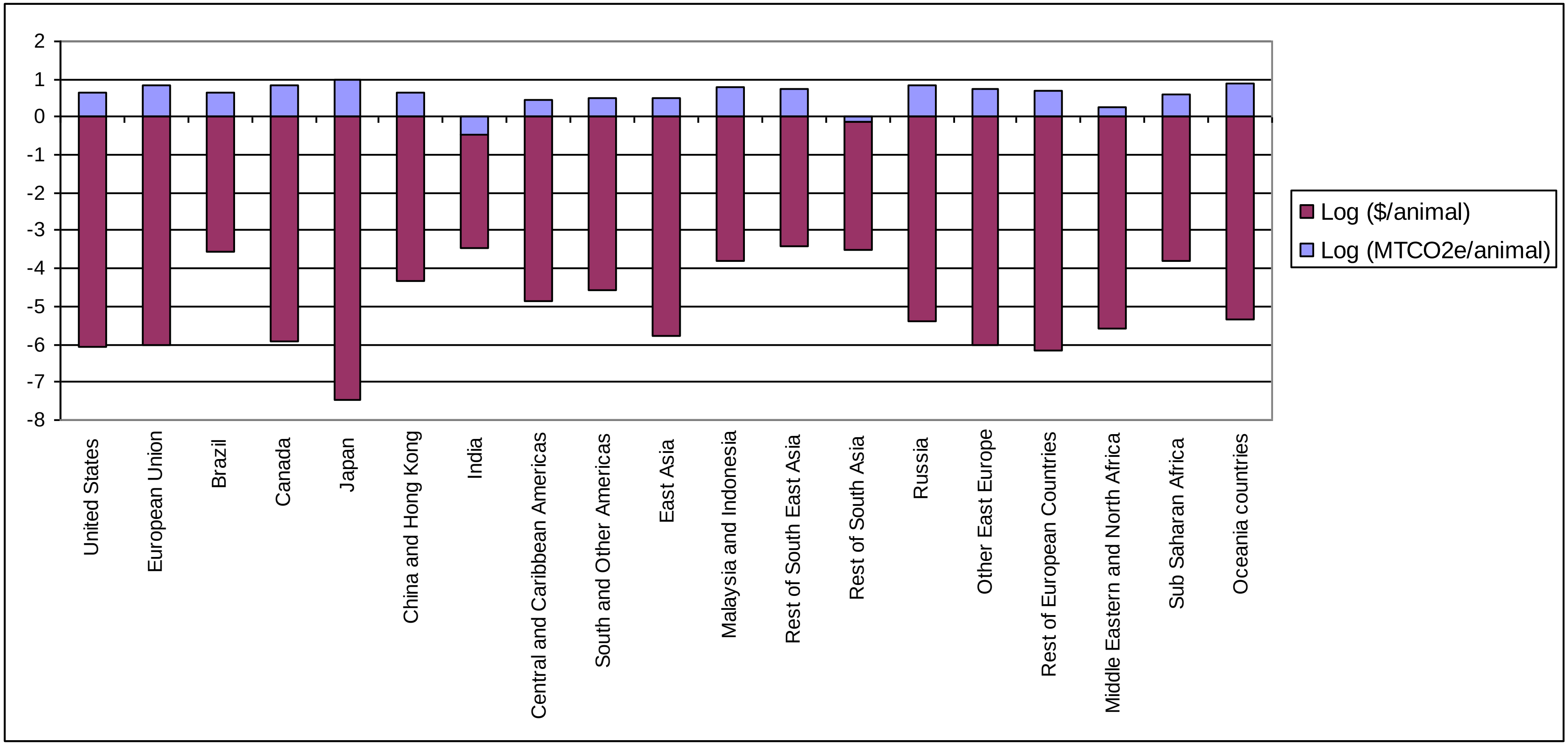
The emissions intensity of output varies greatly across countries (kgCO_2eq/$ of output)

- Livestock sector non-CO_2 emissions divided by value of sector output



Differences in emissions intensity are driven by differences in $ output/animal

$$Log[\text{Em. intens.}(\text{MTCO2e}/\$)] = Log[\text{Em.intens}(\text{MTCO2e/animal})] - Log[\text{Value of output per animal}(\$/\text{animal})]$$



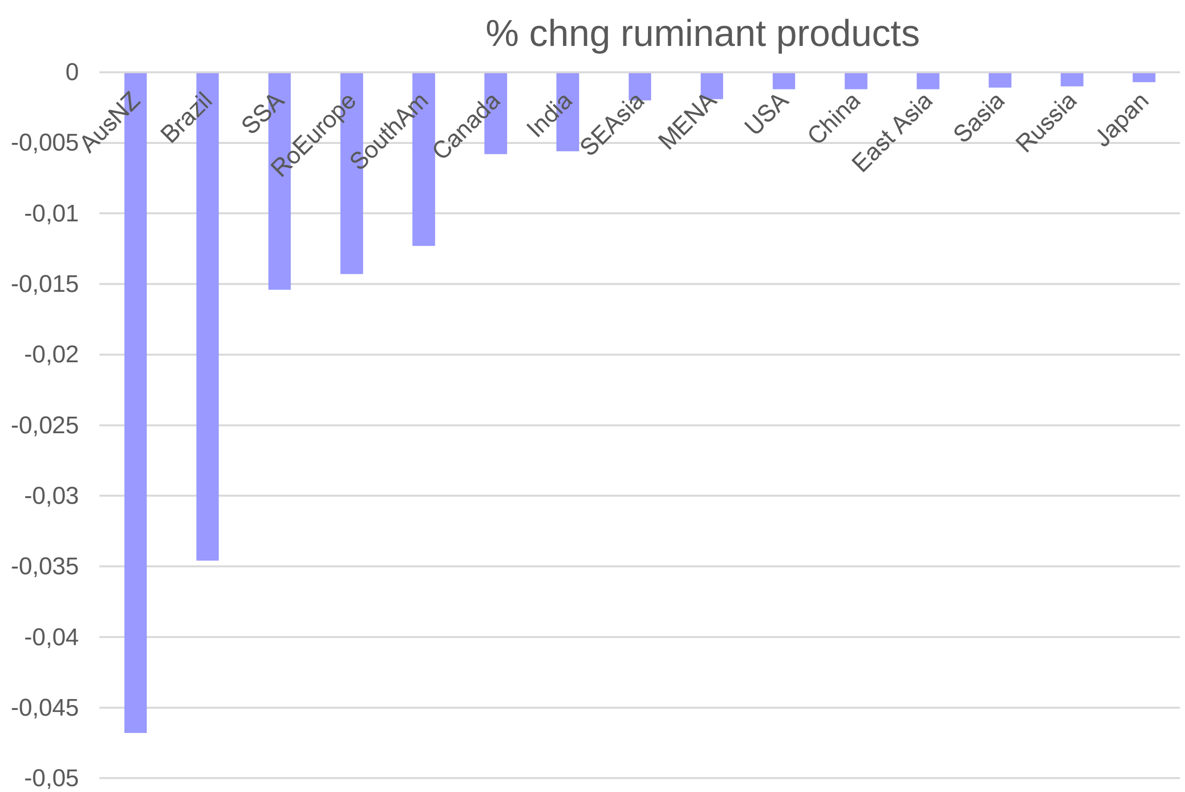
Source: Avetisyan et al. (2010)

Start with illustrative experiments

- **EURUMINANTS =** Tax on cons. of ruminant meat imports in EU, which replaces imports by domestic purchases of $50 million
- **CHNRUMINANTS =** Tax on cons. of ruminant meat imports in China, which replaces imports by domestic purchases of $50 million
- Follow these with other food products/regions
- Explore implications for:
  - Global pattern of production
  - Global GHG emissions:
    - Associated with transport services: domestic and international
    - Associated with production

Change in RoW output when shift to domestic ruminant prdts in EU

- Differential impacts reflect geography of trade
- Strongest import ties to ANZ and Brazil
- Some impact felt in all regions



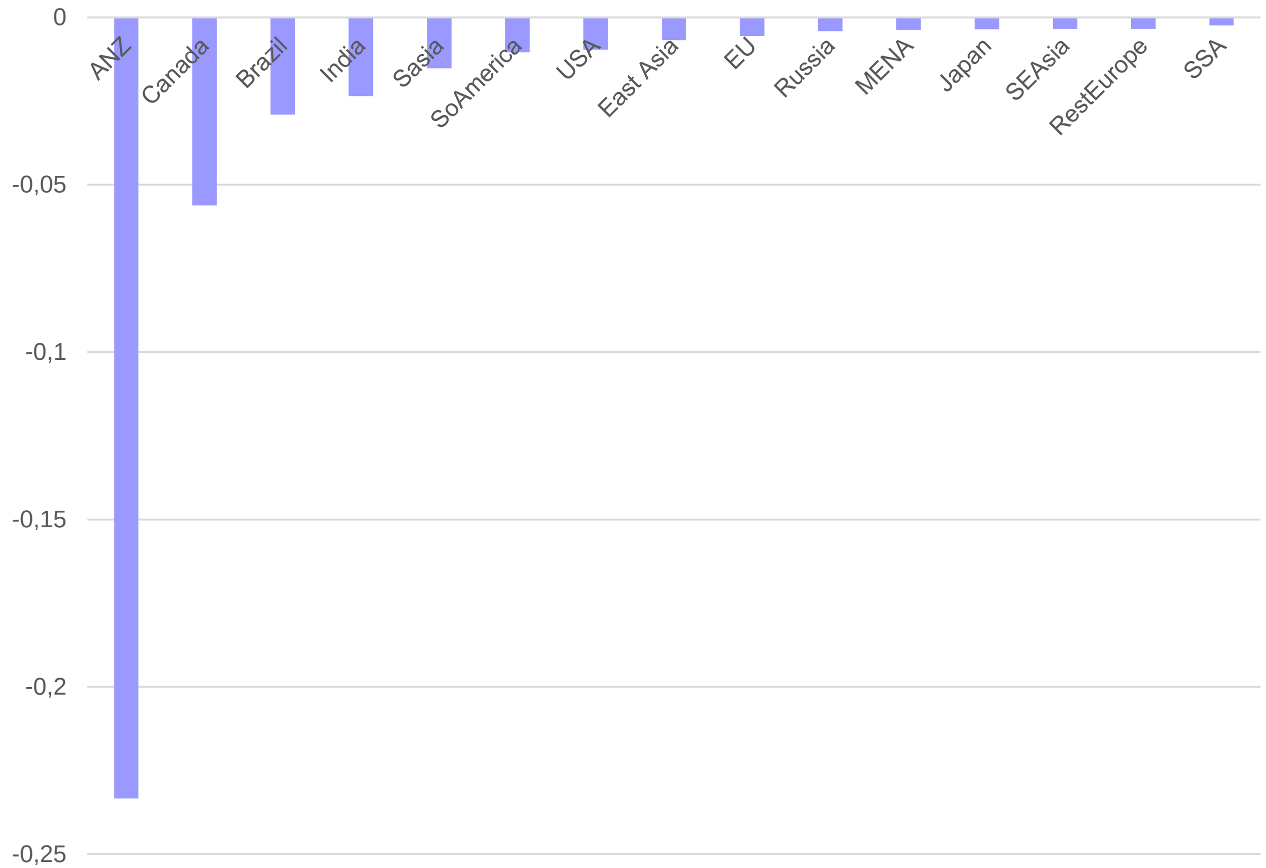
Change in emissions by GHG under EU-Ruminants ($MTCO_2e$)

- EU and global CO_2 emissions fall due to decreased transport emissions
- EU N_2O emissions rise as fertilize pastures and grains for feed; but globally N_2O emissions fall
- EU CH_4 emissions rise as ruminant production rises, but falls elsewhere and globally
- F-gases are driven by non-agricultural activity which falls in EU and rises in RoW

Regions	EURUMINANTS				
	CO_2	N_2O	CH_4	FGAS	Total
USA	319	-1,194	-1,042	0	-1,917
EU	-184	10,206	21,615	-76	31,561
Brazil	-582	-18,407	-51,160	61	-70,088
Canada	-21	-447	-846	9	-1,304
Japan	-78	-94	-33	0	-204
China	-380	-587	-1,140	4	-2,103
India	68	-25	-231	0	-188
CentAmer	37	-141	-561	1	-663
SouthAmer	448	-3,765	-7,559	15	-10,862
East Asia	-238	-73	-87	8	-390
SouthAsia	-31	-220	-516	2	-766
SEAsia	-14	-35	-72	0	-121
Russia	-18	-44	-60	3	-119
RestEurope	-11	-100	-304	6	-409
MENA	73	-198	-198	4	-319
SSA	105	-4,840	-8,328	23	-13,040
ANZ	-35	-2,237	-11,221	87	-13,406
Total	-244	-22,334	-62,078	153	-84,503

Change in output when shift to domestic ruminant prdts in China

- Differential impacts reflect geography of trade
- Strongest import ties to ANZ, CN and Brazil
- Some impact felt in all regions



Change in ruminant meat, transport and total emissions ($MTCO_2e$)

Regions	EURUMINANTS emissions			CHNRUMINANTS emissions		
	Ruminant meat	Transport	Total	Ruminant meat	Transport	Total
USA	-1,548	348	-1,917	-13,623	-156	-17,918
EU	30,581	-816	**31,561**	-7,889	-666	-10,153
Brazil	-68,777	-337	-70,088	-58,108	-244	-59,495
Canada	-1,142	-66	-1,304	-11,073	61	-11,342
Japan	-42	-9	-204	-156	101	-26
China	-1,423	-93	-2,103	507,541	-2,222	**478,274**
India	-258	-17	-188	2,880	14	3,359
CentAmer	-637	26	-663	-2,141	-27	-2,277
SouthAmer	-10,639	8	-10,862	-8,818	-13	-9,400
East Asia	-94	-173	-390	-330	-193	-684
SouthAsia	-776	-66	-766	-1,403	-133	-1,438
SEAsia	-77	-8	-121	0	4	-128
Russia	-65	-100	-119	-302	-62	-335
RestEurope	-379	-23	-409	-98	-37	-188
MENA	-250	-95	-319	-1,137	-154	-1,536
SSA	-13,048	-88	-13,040	-2,670	-33	-2,903
ANZ	-13,713	-298	-13,406	-60,840	-1,405	-60,099
Total	-82,642	-2,070	**-84,503**	341,032	-5,451	**302,773**

Why does the "food miles" approach to reducing emissions fail?

- Although the substitution of domestic for imported ruminant products reduces GHG emissions from international trade and transport, these emissions reductions are dominated by changes in global output emissions due to variations in GHG emissions intensities (per dollar of output) of ruminant meat production
- *Redirecting consumption to local food only reduces global GHG emissions when implemented in regions with relatively low economic emissions intensities*.
- Key questions:
  - Can we predict these outcomes without the model?
  - How pervasive is the case wherein reducing food miles fails to reduce global emissions?

Economic geography of food miles

- Arrange regions in ascending order of ruminant meat emissions intensity from Japan to Brazil

Region with "food miles" experiment	Ruminant meat emissions intensity, MkgCO2e/$
Japan	1.47
Rest of Europe	3.91
USA	4.45
MENoAfr	5.28
EU	5.74
Canada	6.06
Russia	10.44
ANZ	11.42
CentAmer	12.75
SouthAmer	17.91
China	24.63
SSA	41.82
Brazil	54.05

Economic geography of food miles

- Compare prod inten to the import-weighted avg emissions intensity
- CN has low prod intensity but imports from USA – even lower one
- South Amer is opposite since imports from Brazil

Region with "food miles" experiment	Ruminant meat emissions production intensity, MkgCO2e/$	Ruminant meat import-weighted emissions intensity, MkgCO2e /$
Japan	1.5	12.7
Rest of Europe	3.9	10.1
USA	4.5	8.1
MENoAfr	5.3	8.8
EU	5.7	8.1
Canada	6.1	5.1
Russia	10.4	7.6
ANZ	11.4	10.6
CentAmer	12.8	7.6
SouthAmer	17.9	19.4
China	24.6	11.8
SSA	41.8	37.0
Brazil	54.1	15.3

- Compare prod-intensity to the import-weighted average emissions intensity
- With exception of Central America, this accurately predicts change in global prod emissions
- If domestic intensity exceeds import intensity, ruminant emissions rise

Region with "food miles" experiment	World emissions chng: Ruminant meat	Ruminant meat emissions intensity	Ruminant meat import-weighted emissions intensity
Japan	-78,029	1.47	12.69
Rest of Europe	-40,171	3.91	10.12
USA	-130,113	4.45	8.07
MENoAfr	-273,353	5.28	8.77
EU	-82,642	5.74	8.11
Canada	20,089	6.06	5.05
Russia	110,143	10.44	7.58
ANZ	20,935	11.42	10.62
CentAmer	-5,696	12.75	7.63
SouthAmer	-151,646	17.91	19.37
China	341,032	24.63	11.84
SSA	610,098	41.82	37
Brazil	813,044	54.05	15.31

- But must factor in the reduction in global emissions related to transportation
- This is dwarfed by ruminant production emissions
- Global emissions still follow emissions associated with production

Region with "food miles" experiment	Change in world emissions, MTCO2e		
	Ruminant meat	Transport	Total
Japan	-78,029	-1,730	-37,746
Rest of Europe	-40,171	-1,835	-37,661
USA	-130,113	-713	-114,601
MENoAfr	-273,353	-14,264	-305,239
EU	-82,642	-2,070	-84,503
Canada	20,089	-6,326	16,603
Russia	110,143	-9,818	103,699
ANZ	20,935	-2,657	10,771
CentAmer	-5,696	-2,928	-19,231
SouthAmer	-151,646	-6,230	-159,103
China	341,032	-5,451	302,773
SSA	610,098	-4,838	599,864
Brazil	813,044	-447	821,779

How robust are these findings?

- Same experiment for other food products: non-ruminant meats, dairy products, rice and vegetable oils:
  - Emissions intensities smaller for these prods (with exception of rice which is also high)
  - Change in transport emissions dominates food miles story in 20% of cases (esp. dairy in the EU, non-ruminants in Canada)
- Sensitivity to economic parameters:
  - Sample from distribution of trade elasticities to establish 95% confidence intervals
  - Vast majority of results are robust

Conclusions

- Agriculture is dominant source of non-CO_2 emissions globally
- When evaluating food miles impacts on global GHGs, N_2O and CH_4 emissions are critical -- it is misleading to focus solely on energy use
- In most cases global emissions changes under a “food miles” scenario are dominated by production emissions intensities – outcome depends on geography of international trade
- These differences will also play a key role when assessing the impacts of a global GHG policy

Thank you!