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The Crucial Role of International Trade in Adaptation to Climate Change

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The Crucial Role of International Trade in Adaptation to Climate Change

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Motivation

Large yield changes from
Climate Change



Large changes in
comparative advantages



Large changes in
international trade

Large trade changes only if adjustments in domestic demand and supply not enough to reduce the imbalances.

Recent work by Costinot et al. (2016, JPE):

- Acreage changes will play a big role in adaptation
- Role of international trade minimal
 - Because large adaptation through demand and supply

Conclusion challenged here:

- Development of a new agricultural trade model with spatially-explicit land use
- Analyze the role of each adjustment margin

Related literature on trade and climate change

- Start in the early 1990s with PE (Reilly & Hohmann, 1993) and GE approaches (Randhir & Hertel, 2000; Rosenzweig & Parry, 1994; Tsigas et al., 1997)
 - Only Randhir & Hertel (2000) analyze the role of international trade
 - Assumption that **land is uniform within countries** → Impossible to account for within-country change in comparative advantages
- Recent work includes land heterogeneity (land classes or gridded information)
 - But land-use/acreage choice representation inconsistent with theoretical literature, except Costinot et al.
 - Models in the AgMip project point to large changes in trade patterns but without analyzing role of trade





Key elements of the modeling framework

Main elements

- Static general equilibrium Armington trade model
 - Ricardian approach with a focus on changes in sectoral productivities
- 50 countries
- 3 types of good
 - 35 crops
 - 1 livestock sector
 - 1 outside good
- 2 factors of production
 - Labor
 - Land
 - Collection of 11,801 fields (1 degree)
 - No possibility to expand over non-agricultural land use

Adjustment margins

- Demand side 
 - Demand for calories
 - Substitution between ag. products
- Supply side 
 - Acreage change
 - Yield response (in sensi. Analysis)
 - Substitution between crops for feed
- Trade

Land-use/ acreage choice modeling

Key question:

how to prevent full specialization in the crop with the highest land rents?

Land-use/ acreage choice modeling

Applied simulation models

- CGE models: land allocation through CET function
 - No representation of the physical constraint on land use
 - Production functions in which yields are only implicit
- Programming models
 - Ad hoc constraints to avoid full specialization and restrict land-use changes

Land-use/ acreage choice literature

- Dynamic: Crop rotations
- Stochastic: Risk diversification
- Static:
 - Convexity of production functions
 - Decreasing return to specialization
 - Heterogeneity of land
 - Yields follow a certain distribution
 - Extreme Value Distribution → Multinomial logit

No link between the two literatures!

Land-use/ acreage choice modeling

- Land-use choice representation inspired from Eaton-Kortum approach to modeling perfectly competitive trade.
 - Use previously by Costinot et al. (2016) and Sotelo (2015)
- Here:
 - Countries endow with several fields with between- and within-field yield heterogeneity.
 - Crop production = Leontief function of land and labor value-added
 - Yields ~ Extreme value distribution (Fréchet) → Acreage shares follow a logit form:

$$\pi_i^{fk} = \frac{(R_i^{fk})^\theta}{\sum_l (R_i^{fl})^\theta}$$

- Features:
 - Satisfy physical constraints
 - Make yields explicit and account for their spatial heterogeneity
 - Could make the connection between land-use literature / CGE models / programming models

Other aspects of the model setup

- Final demand:
 - Quasi-linear utility with respect to aggregate agricultural good consumption
 - CES function between agricultural products
- Supply
 - Livestock production
 - Leontief function of feed and labor
 - Feed = CES function of crops (including grass)
 - Outside good: produced using labor only
- Trade
 - Armington assumption for all products except grass that is non-tradable
 - Iceberg trade cost
 - No trade policy

Data

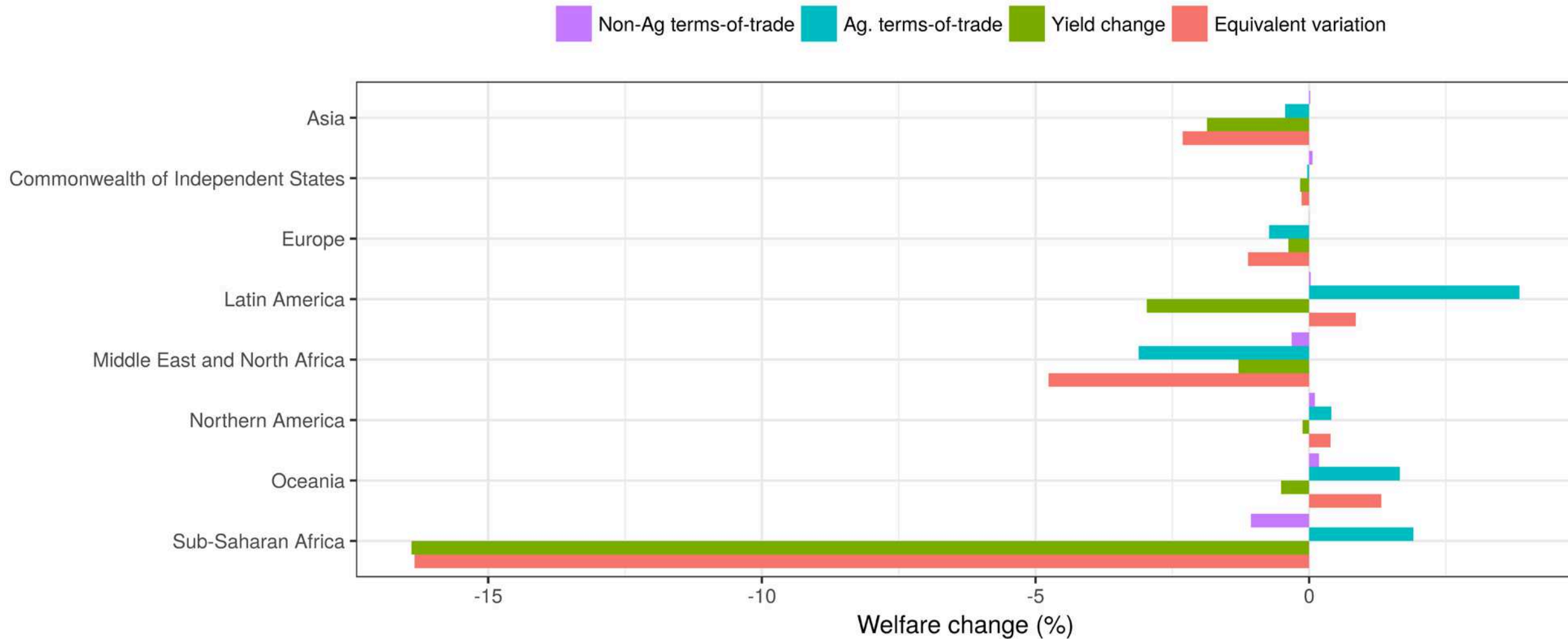
Behavioral parameters

- Caloric elasticity: -0.2
- Elast. of subst. betw. food: 0.6
- Elast. of subst. betw. feed: 0.9
- Crop-level acreage elasticity, $\theta = 1.1$
 - US maize: 0.33, soybean: 0.38
- Trade elasticity: -5 for outside good & -9 for agricultural goods

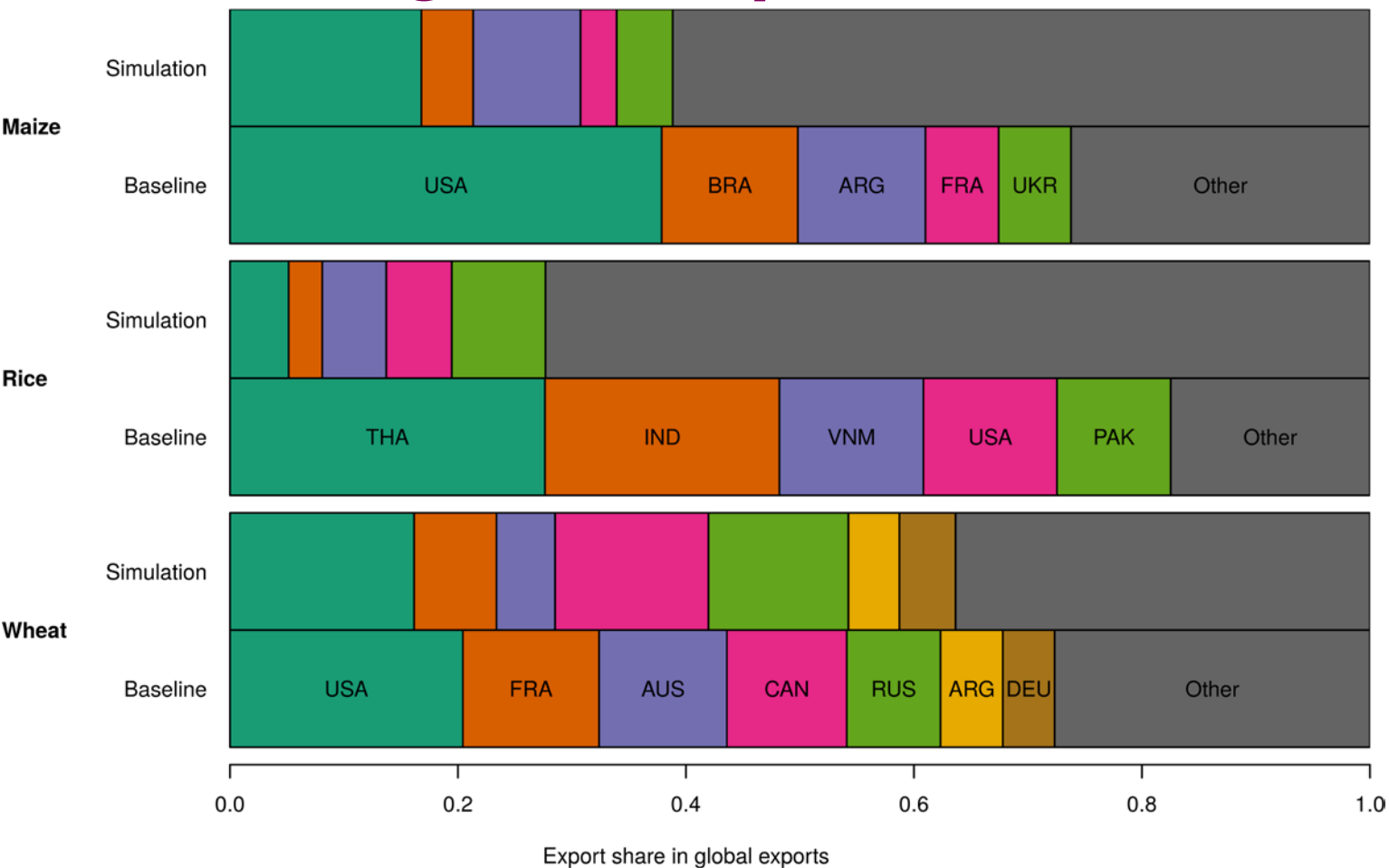
Initial and counterfactual equilibrium

- 2011 base year
- Potential yields from GAEZ
 - High inputs, rain fed scenario
 - CC shock: Scen. A1 FI (close to RCP8.5) simulated with Hadley-CM3 GCM model for 2080s with CO₂ fertilization
- Value of production, feed, and trade from FAO STAT
- Extent of agricultural land from Ramankutty and Foley for 2007
 - No extension over other land uses
- Other data from GTAP 9.2

Welfare decomposition

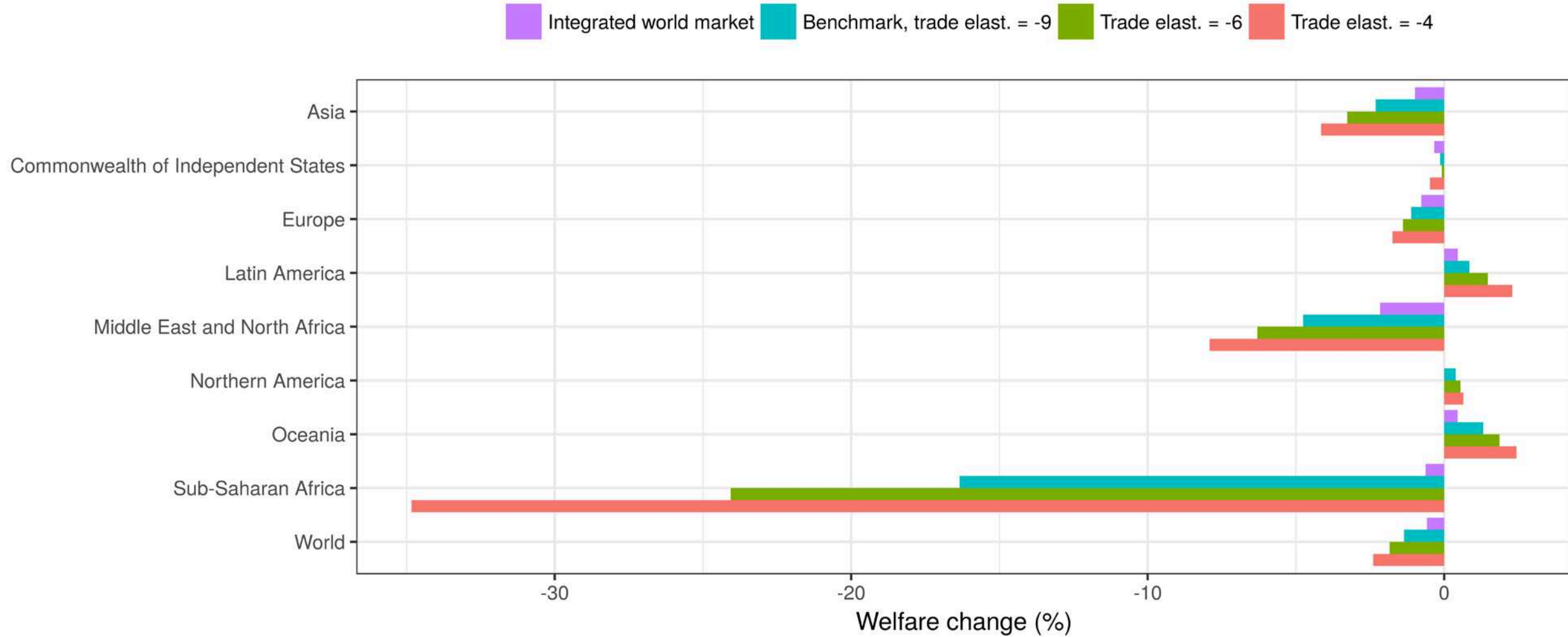


Changes in export shares

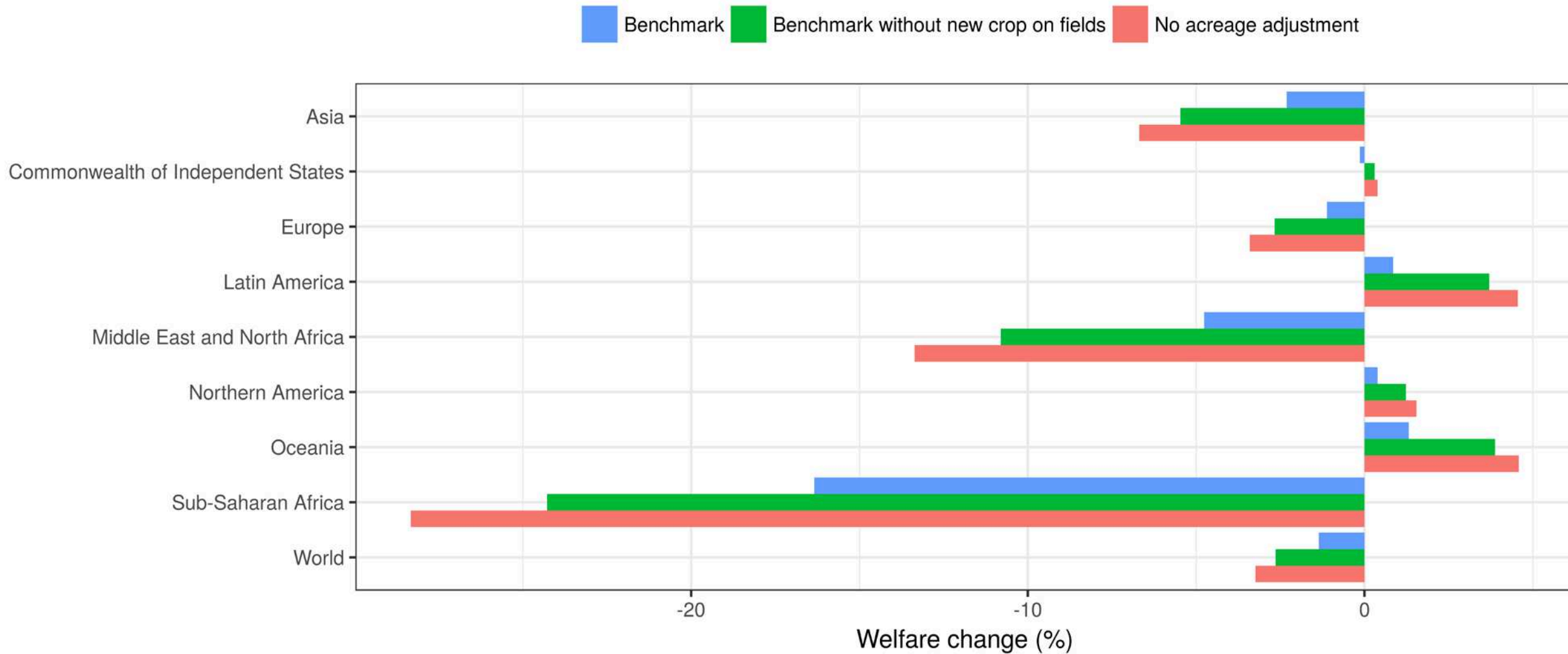


Global trade change	Global production change
+44%	+18%
+444%	+34%
+17%	-24%

Role of trade assumption



Role of land-use assumption



Other sensitivity checks

- Having elastic yields or different values for substitution between feed do not affect the amount of changes in trade volumes
- Doubling the acreage elasticity has little effect on trade
 - Key difference with Costinot et al.: not possible to extend over other land uses
- Important effect of the demand elasticity
 - More flexible demand → Less trade changes
 - But inelasticity of food demand (in primary products) is a well recognized feature of agricultural markets

Take-home messages

- Role of international trade in adaption to climate change
 - Very high
 - Similar to acreage changes
 - Because demand-side adjustments are limited
- Role of international trade is a function of its flexibility
 - Prevalence of public policies that may impede these adjustments
 - Or even lead to maladaptative adjustments
 - For the new trade patterns to emerge, need of investments in new transport infrastructures that will have to be planned in advance.
- New approach to land-use modeling consistent with land-use literature
 - After a few developments should be able to account for many important real-world features
 - Non-constant yield elasticity
 - Extension over non-agricultural land uses.

THANK YOU

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