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The Crucial Role of International Trade in Adaptation to Climate Change

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Selected Paper prepared for presentation at the International Agricultural Trade Research Consortium's (IATRC's) 2017 Annual Meeting: Globalization Adrift, December 3-5, 2017, Washington, DC.

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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 ➔ Multinominal 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

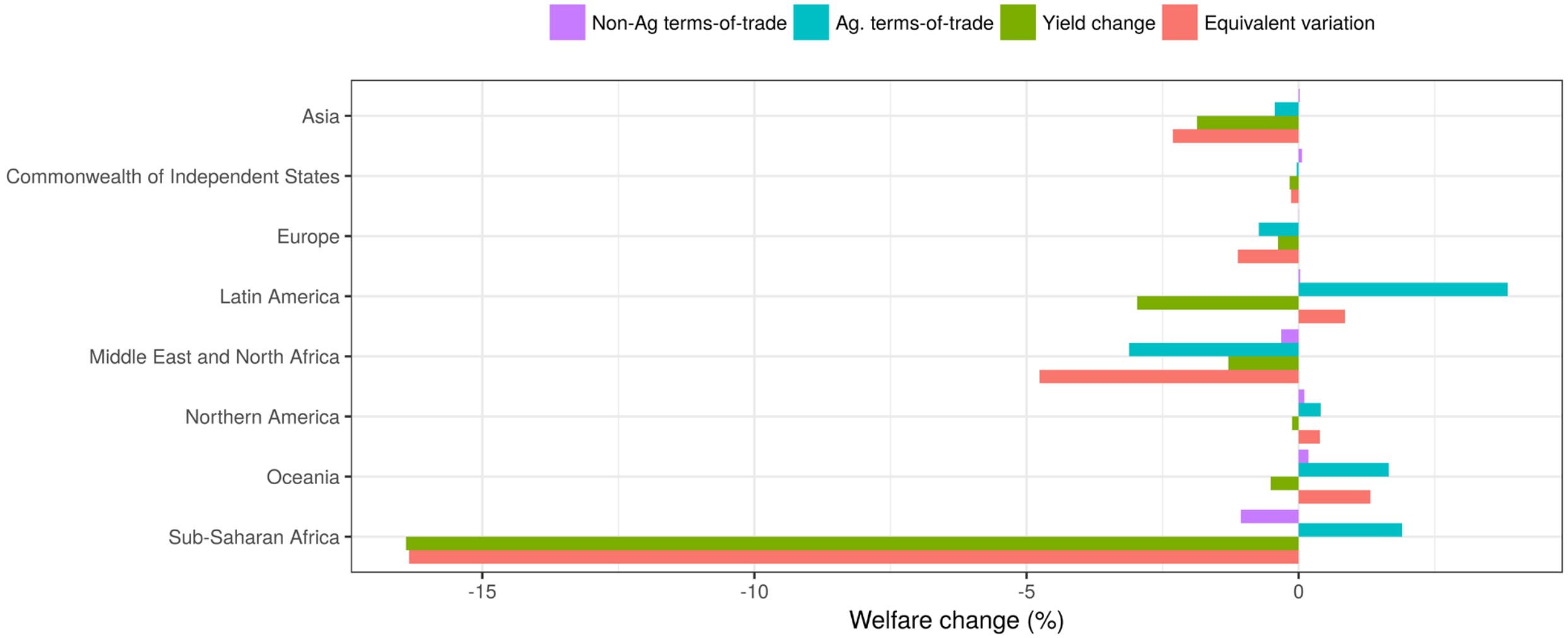
Behavioral parameters

- 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

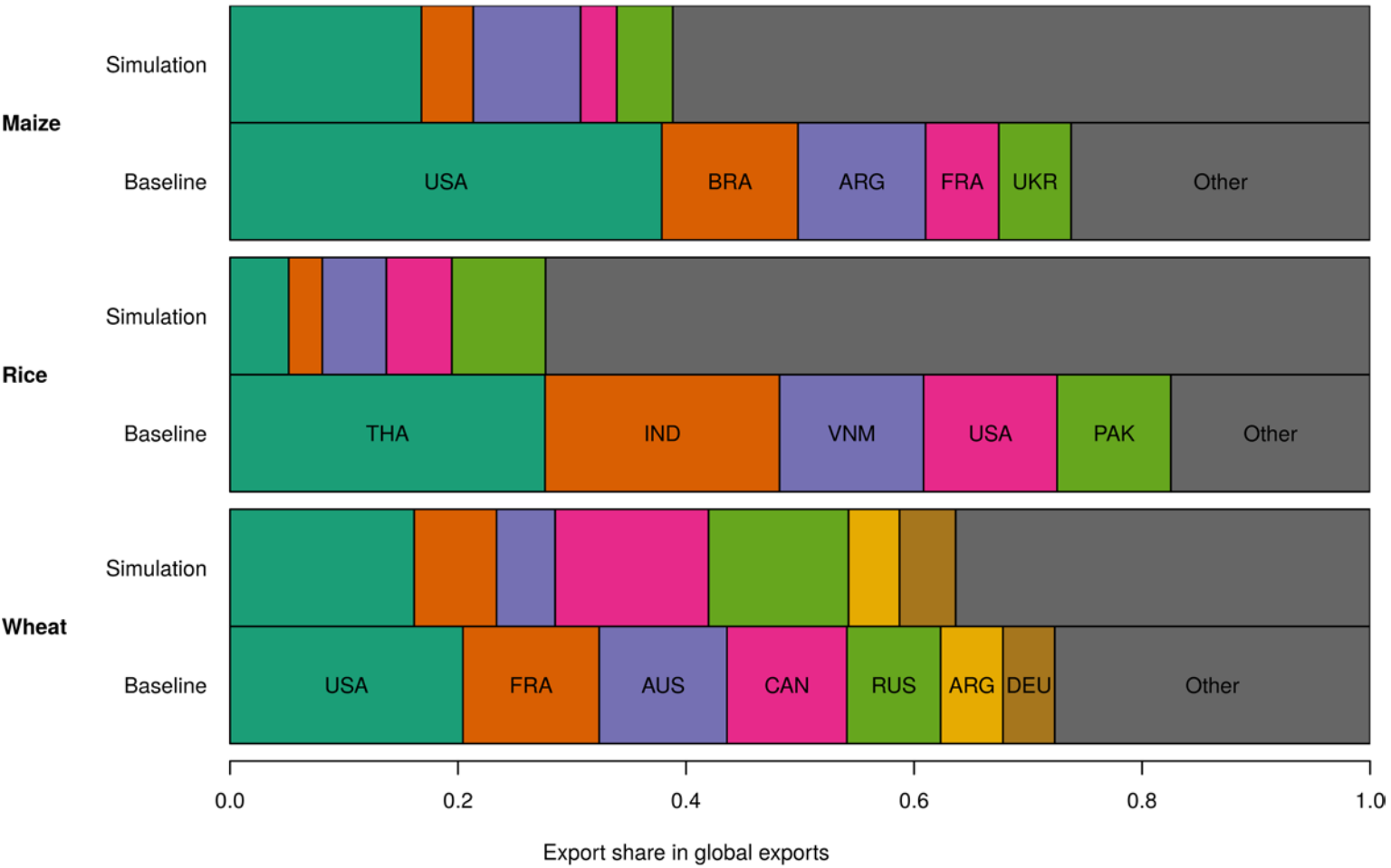
Initial and counterfactual equilibrium

- 2011 base year
- Potential yields from GAEZ
  - High inputs, rain fed scenario
  - CC shock: Scen. A1FI (close to RCP8.5) simulated with Hadley-CM3 GCM model for 2080s with CO2 fertilization
- Value of production, feed, and trade from FAOSTAT
- Extent of agricultural land from Ramankutty and Foley for 2007
  - No extension over other land uses
- Other data from GTAP 9.2

Welfare decomposition

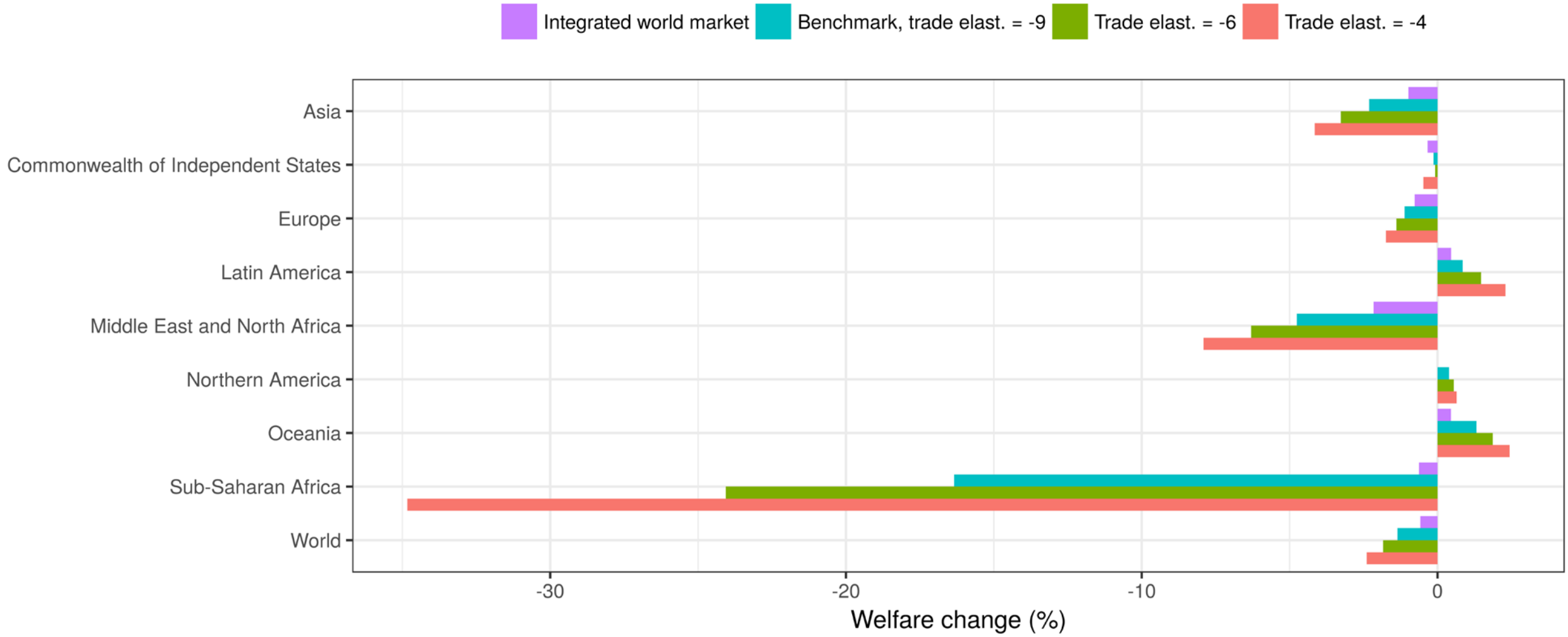


Changes in export shares

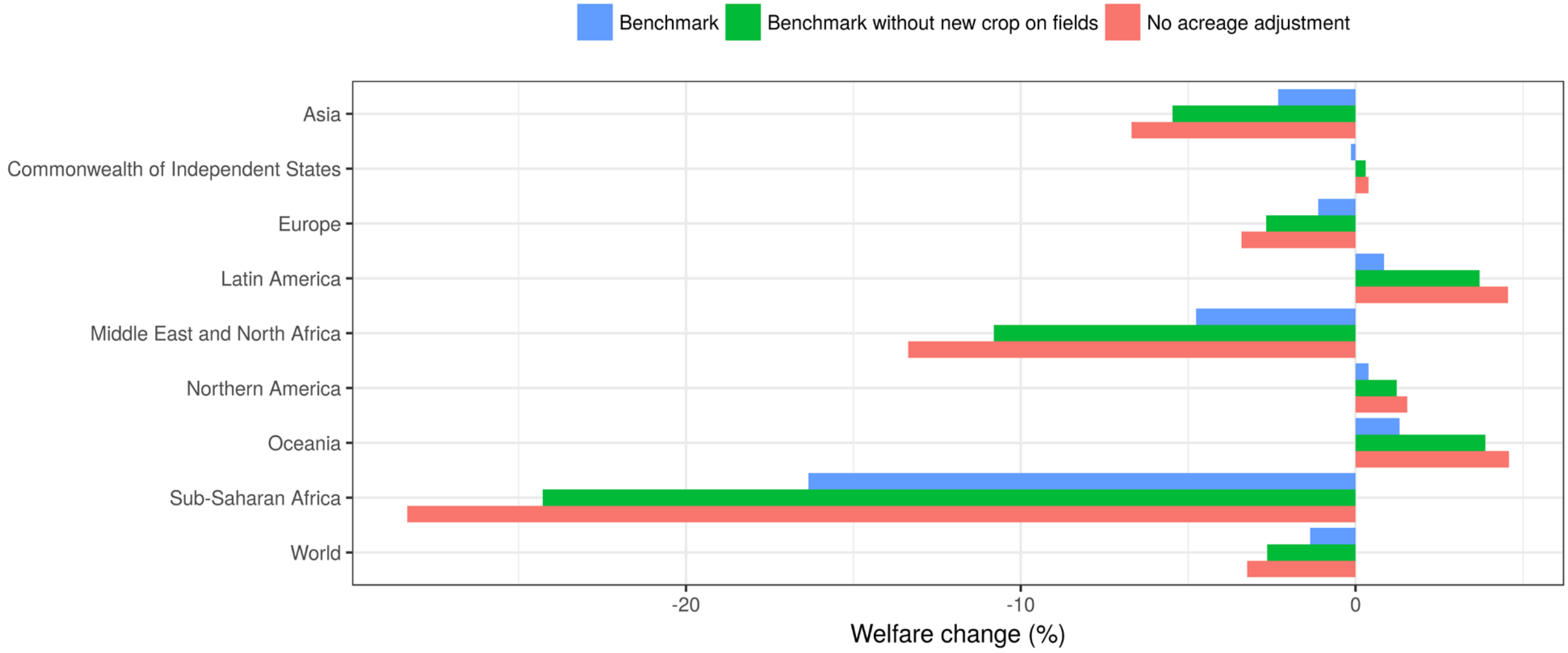


Global trade change	Global production change
+44%	+18%
+444%	+34%
+17%	-24%

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 been 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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