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The Future of Agricultural Trade Policy Modeling: Insights from Meta-Analysis

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1. Background and motivation

"Abolishing all trade barriers could boost global income by $US2.8 trillion and lift 320 million people out of poverty by 2015."

M. Moore, Director-General, WTO 2002

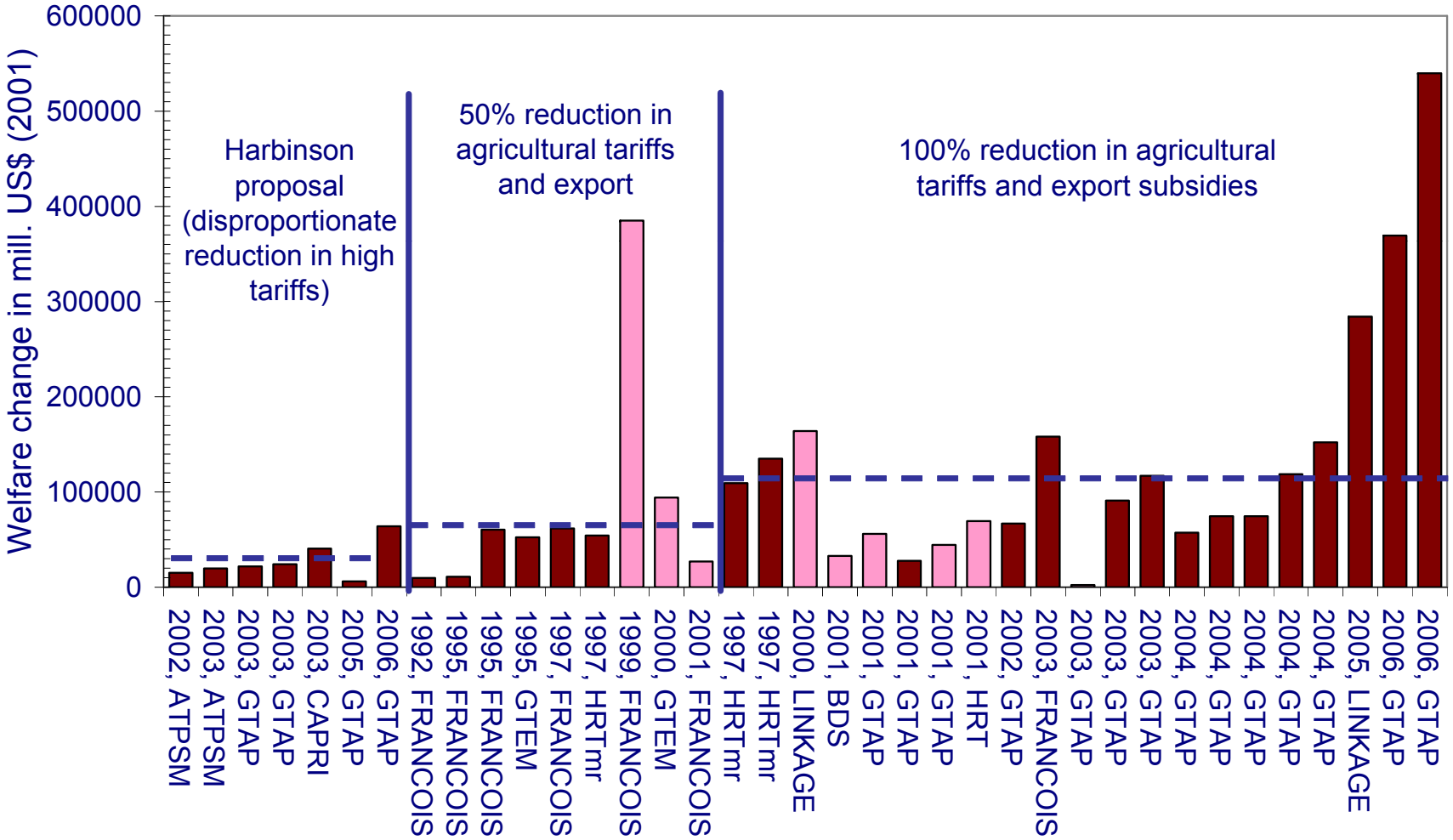
"I am confident that I can concoct a model to generate any result desired by a reader with a deep pocketbook."

J. Markusen

1. Background and motivation

- Quantitative models are arguably the single most visible input into trade policy debates that economists provide
- However, quantitative models are frequently criticised:
  - Weak empirical and theoretical foundations
  - Complexity, 'black-box' character
  - Results vary widely even across similar experiments

1. Background and motivation



1. Background and motivation

This:

→ is confusing for policy makers

→ is water on the mills of those who question liberalisation

→ reflects poorly on our credibility as a profession

Goal: To identify characteristics of simulations that systematically influence results, and to derive quantitative estimates of these influences

Outline

1. Background and motivation
2. What drives model simulation results?
3. Meta analysis
   - with a literature sample
   - with synthetic data
4. Conclusions

2. What drives simulation results?

I = f{ MC, LE, DB, RC }

where:

I = simulated impact of the liberalisation experiment

MC = a vector of model characteristics

LE = the nature of the liberalisation experiment

DB = the database employed

RC = the research context

2. What drives simulation results?

Modellers are, of course, aware of these issues:

1. Sensitivity analysis
   - Usually uni- or bi-variate
   - Propensity to document ‘robustness’

2. Qualitative review
   - Subjective selection of studies for analysis
   - Again, not multivariate

3. Meta analysis

- Main uses:
  - Combining evidence to obtain more precise estimates of an effect size (e.g. Medicine, but also economics)
  - Evaluating methods: quantifying the share of variance in a given set of estimates that is due to differences in methods, assumptions and other factors

- *I = f{MC, LE, DB, ~~RC~~, u}*

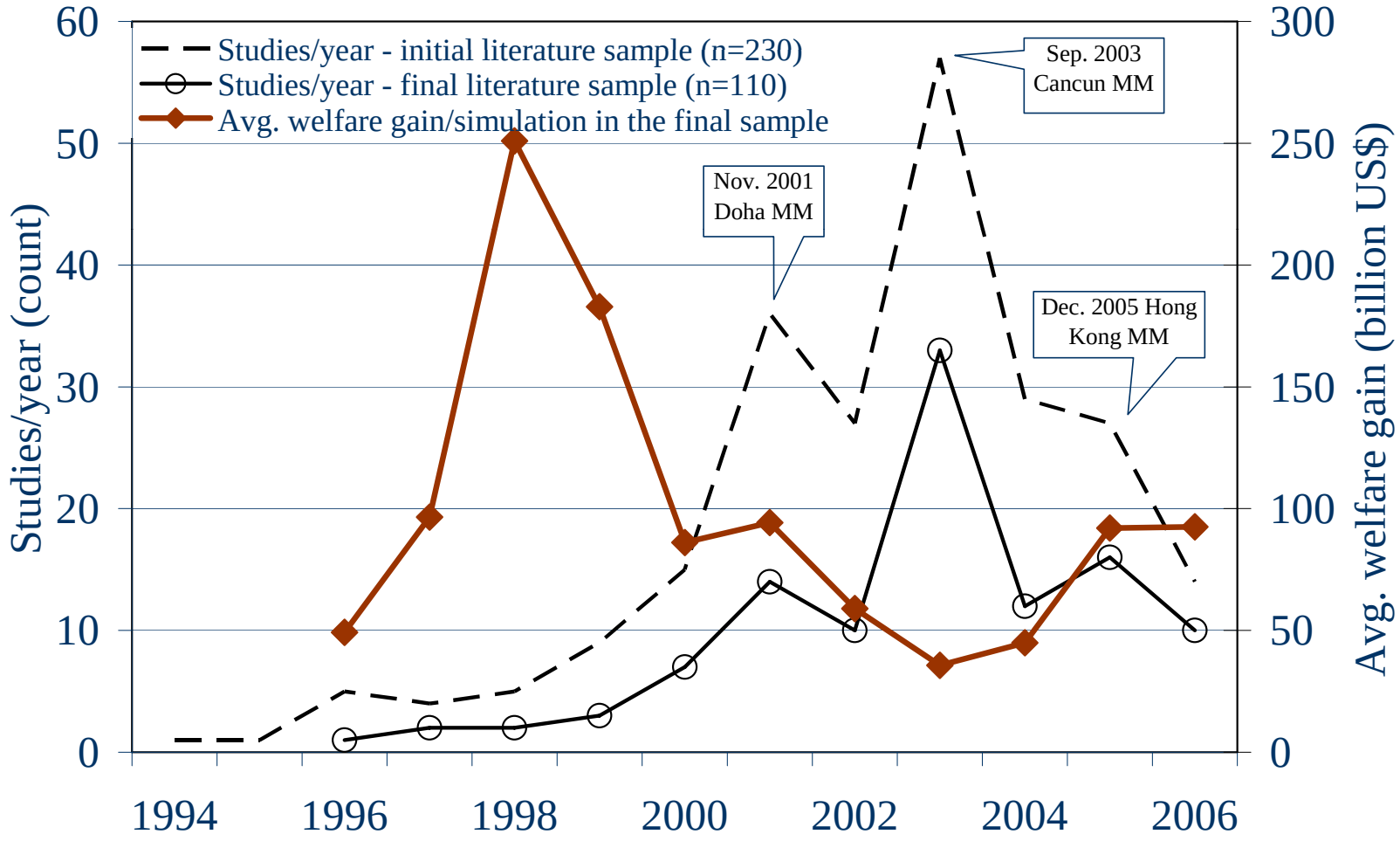
3. Meta-analysis: Literature sample

- Exhaustive literature search: 160 combinations of 10 'Doha' and 16 'modelling' keywords, 18 databases
- Result → 1200 studies
- Eliminating:
  - repetition and redundancies
  - studies that do not report welfare changes
  - studies that provide no information on the model used

  → 230 studies
- Eliminating:
  - studies that do not focus on Doha Round liberalisation
  - studies that do not document key model characteristics

  → 110 studies

3. Meta-analysis: Literature sample



3. Meta-analysis: Literature sample

- Each of the 110 studies produces an average of 53 individual observations → n = 5835
- *I* = simulated Δwelfare in million US$ (dummies account for different measures)
- *MC* = a vector of 23 model characteristics (e.g. CRTS vs. IRTS, size of Armingtons, etc.)
- *LE* = a vector of 5 measures of the size of the simulated liberalisation (e.g. tariff reduction, reduction in NTBs, shift to blue box spending)
- *DB* = a vector of 4 dummies (GTAP-4, GTAP-5, etc.)

3. Meta-analysis: Literature sample

- This set of explanatory variables is the result of a specification search using:
  - stepwise regression
  - regression trees
  - an earlier sample of 53 studies
  - roughly 150 potential explanatory variables

- Unweighted and weighted OLS used to account for different number of observations per study

3. Meta-analysis: Literature sample

Results (1)

- Standards of documentation and transparency in the modelling literature are low
- Not seldom that the authors of a simulation are unable, a few years later, to reconstruct exactly how it was produced
- Modelling community small:
  - 288 authors contribute to the 230 studies
  - 25 most frequent authors involved in 176 (76%) of these studies

3. Meta-analysis: Literature sample

Results (2)

- R^2 in unweighted regression 24%, in weighted 46%
- Signs and significance of coefficients robust
- Most coefficients have expected signs and plausible magnitudes, e.g.:
  - Larger liberalisation steps → larger welfare gains
  - Higher Armington elasticities → larger welfare gains
  - Shocks to technical change → larger welfare gains

3. Meta-analysis: Literature sample

Dummies for model interactions				Coeff.	Std.err.	Signif.
Dynamic	CRTS/ perfect comp.	Cap. fixed	Arm's high	12342	939	***
		Cap. accum.	Arm's low	2106	723	***
			Arm's high	12290	707	***
	IRTS/ imperfect comp.	Cap. accum.	Arm's low	451	1102	
			Arm's high	14483	1863	***
Comparative static	CRTS/ perfect comp.	Cap. accum.	Arm's low	4518	278	***
			Arm's high	4708	830	***
	IRTS/ imperfect comp.	Cap. fixed	Arm's high	20746	4766	***
		Cap. accum.	Arm's low	5717	555	***
			Arm's high	6090	2586	**

3. Meta-analysis: Literature sample

Problems

- Many important variables can only be captured as dummies
- Functional form, interaction terms
- Many studies cannot be included due to incomplete documentation
- DDA studies focus on a limited sub-set of the relevant variable space (e.g. mostly tariff reductions)

Therefore: Synthetic data

3. Meta-analysis: Synthetic data

PE Model "GSIM"

(Francois&Hall 2003)

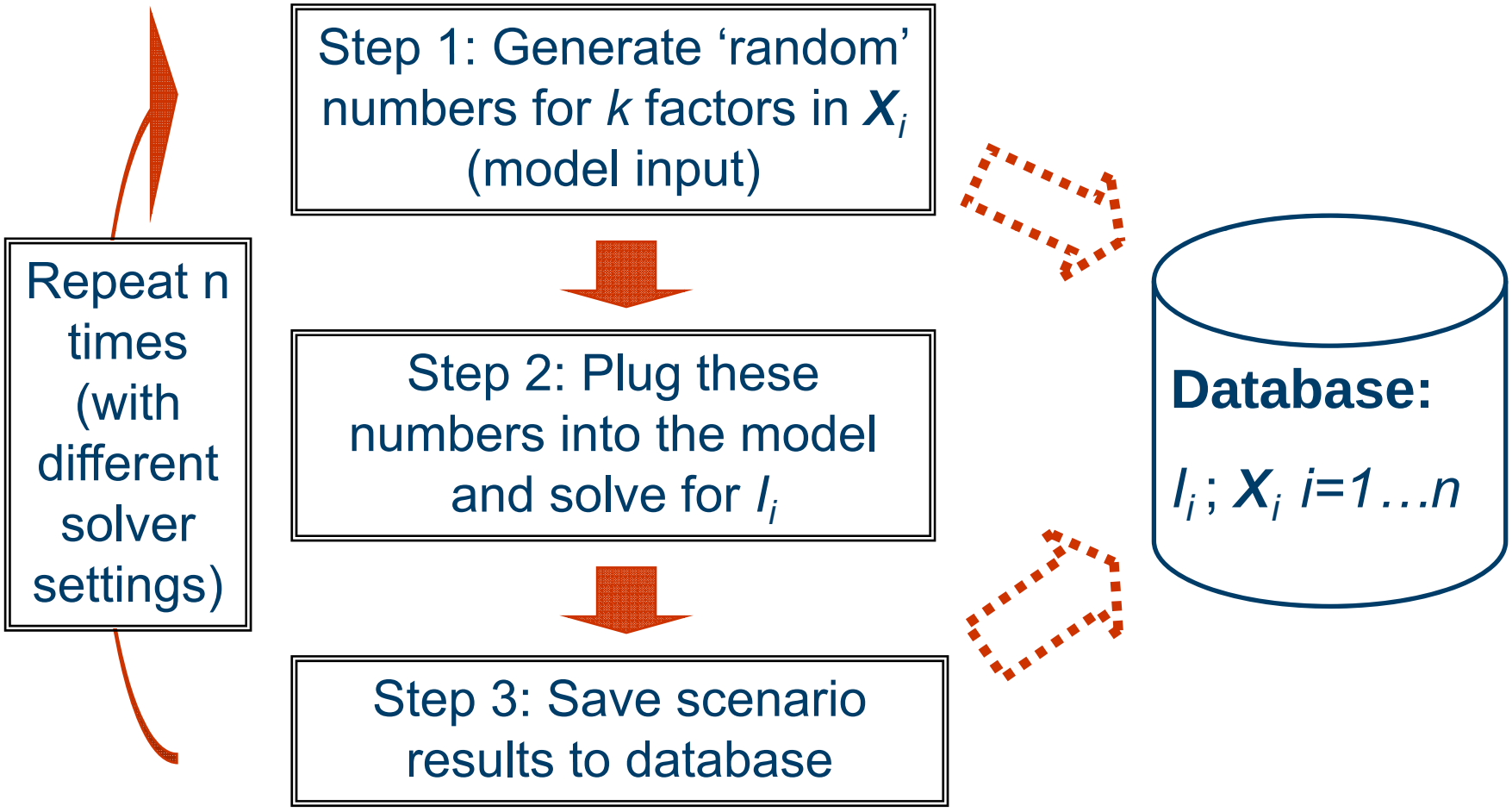
- Wheat
- Canada, US, EU, ROW
- Data = GTAP-5
- Armington-style import differentiation
- Bilateral trade flows and tariffs
- Elasticities: demand, supply, import substitution

Single Country CGE

(van der Mensbrugghe, 2000)

- Agriculture & All other
- CAN & ROW
- SAM=GTAP-5
- Armington import substitution
- Import tariffs, export subsidies, MFN
- CES production, CET exp./dom., ELES

3. Meta-analysis: Synthetic data



3. Meta-analysis: Synthetic data

- Generalized Additive Model (GAM)

- $g(m) = \underbrace{\beta \boldsymbol{X}_{ji}}_{\text{parametric}} + \underbrace{f_1(\boldsymbol{X}_{mi}) + f_2(\boldsymbol{X}_{li}, \boldsymbol{X}_{li})}_{\text{smooth functions, non parametric}} + \varepsilon$

- $g(m) = \mathrm{E}\{I_i\}$, $\varepsilon \sim \mathrm{N}(0,\sigma^2)$, model selection according to R^2

$\Rightarrow$ Detect functional forms, interactions of $\boldsymbol{X}$

$\Rightarrow$ Interpretation: Linear framework

3. Meta-analysis: Synthetic data

Results (1)

GAM order / Model	Linear (X+X)	GAM smooth	Linear Interaction (X*X)	Linear (X+X), (X*X), (X^2)
PE GSIM *Δ(CS+PS)*	0.77	0.78	0.87	0.87
CGE *Δreal GDP*	0.49	0.55	0.80	0.70

(Recall: R^2 unweighted literature sample ≈ 24%)

3. Meta-analysis: Synthetic data

Results (2): SAM

	Agriculture	Others	…
Agriculture	7924 (-0.031)	23188 (0.015)	…
Others	18736 (-0.007)	464809 (0.001)	…
Labour	8424 (-0.024)	312781 (0.004)	…
Capital	6977 (-0.038)	213616 (0.003)	…
Income Tax	-2105 (0.101)	12695 (-0.000)	…
…	…	…	…

3. Meta-analysis: Synthetic data

Comparing PE and GE models

1. Separate equations:

$$I_i^{GE} = \beta^{GE} X_i + \phi Z_i + u_i$$

$$I_i^{PE} = \beta^{PE} X_i + \gamma W_i + v_i$$

2. Single equation, fixed effects:

$$I_i = \beta X_i + \alpha \begin{pmatrix} D=0, GE \\ D=1, PE \end{pmatrix} + u_i$$

3. Single equation, imputed missing values, fixed effects:

$$I_i = \beta X_i + \phi \begin{pmatrix} Z_i, GE \\ \overline{Z}_i, PE \end{pmatrix} + \gamma \begin{pmatrix} \overline{W}_i, GE \\ W_i, PE \end{pmatrix} + \alpha \begin{pmatrix} D=0, GE \\ D=1, PE \end{pmatrix} + u_i$$

3. Meta-analysis: Synthetic data

$$I_i = \beta X_i + \phi \begin{pmatrix} Z_i, GE \\ \overline{Z}_i, PE \end{pmatrix} + \gamma \begin{pmatrix} \overline{W}_i, GE \\ W_i, PE \end{pmatrix} + \alpha \begin{pmatrix} D = 0, GE \\ D = 1, PE \end{pmatrix} + u_i$$

- I_i = ΔCS for PE model; = ΔUtility for GE model
- $R^2 = 0.77$
- Estimate of α = 4.76 bill. US$ (Prob >|t| = 0.000)

4. Conclusions

- Meta-analysis provides important insights beyond conventional sensitivity analysis and qualitative comparisons of model results
- Results with synthetic data confirm basic insights of literature data, but R^2 much higher
- Importance of interations between model characteristics and liberalisation experiments revealed by synthetic data
- Armington elasticities – weak empirical and theoretical basis, powerful impact on results

4. Conclusions

- First stab at assessing the impact of variations in base data (SAM)
- Indications that solvers can add considerable variability to simulation results
- Important: Our results do not point to the 'true' model
- Simulation results must be interpreted with great caution
- Document, document, document!

Thank you!

The Economist

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Literature search

- Exhaustive literature search: 160 combinations of 10 ‘Doha’ and 16 ‘modelling’ keywords, 18 on-line databases

Databases employed in the literature search

AgEconSearch	COPAC	Econis
EconLit	Google/ Google Scholar	IBZ
JADE	JSTOR	KVK
OCLC Journal Articles ECO	OCLC Papers	OCLC Proceedings
OCLC World Cat	OLC	RePec Articles
RePec Working Papers	SSCI	WTO House Library

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Literature search

Modelling keywords

applied model	CGE	comput*	dynamic
economy wide	equilibrium	forward* model	general model
global model	international model	mathemat*	multi commodity
multi region*	multi sector*	partial model	static

Doha keywords

doha agric* market*	doha develop*
doha domestic support	export subsid*
doha fair trad*	doha food security
doha market access	doha market* trad*
doha non trade	doha trade distort*

Fixed effects (bill. US$)

Country/region	Fixed effect (std. error)
ACP (intercept)	-11.6 (1.5)
Australia	5.0 (1.2)
Canada	7.3 (0.9)
India	8.3 (0.8)
EU-25	14.9 (2.5)
USA	16.9 (2.2)