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Modeling and Forecasting Agricultural Commodity Support in the Developing Countries

Jing Zhao, J. Isaac Miller, Julian Binfield, and Wyatt Thompson

Selected presentation for the International Agricultural Trade Research Consortium's (IATRC's) 2022 Annual Meeting: Transforming Global Value Chains, December 11-13, 2022, Clearwater Beach, FL.

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IATRC COMMISSIONED PAPER

Modeling and Forecasting Agricultural Commodity Support in the Developing Countries

JING ZHAO, J. ISAAC MILLER, JULIAN BINFIELD, AND WYATT THOMPSON



The views expressed should not be taken to represent those of the institutions to which the authors are attached, nor to the IATRC and its funding agencies.

Context and goals

Recall: agricultural support varies among countries and over time

- Less developing countries tended to tax agriculture
(Krueger, Schiff, Valdés 1988, 1991)
- As income rise, more likely to subsidize agriculture & nature of support changes
(Anderson, Nelgen 2013, Anderson, Rausser, Swinnen 2013)

Our goal: estimate how agricultural support evolves and forecast

- Rising income → different level and nature of agricultural support in past – and future

Relevance?

- Future support relevant to future supply and demand conditions, future responses to policies
- Negotiations might target what policies will be, not what they were

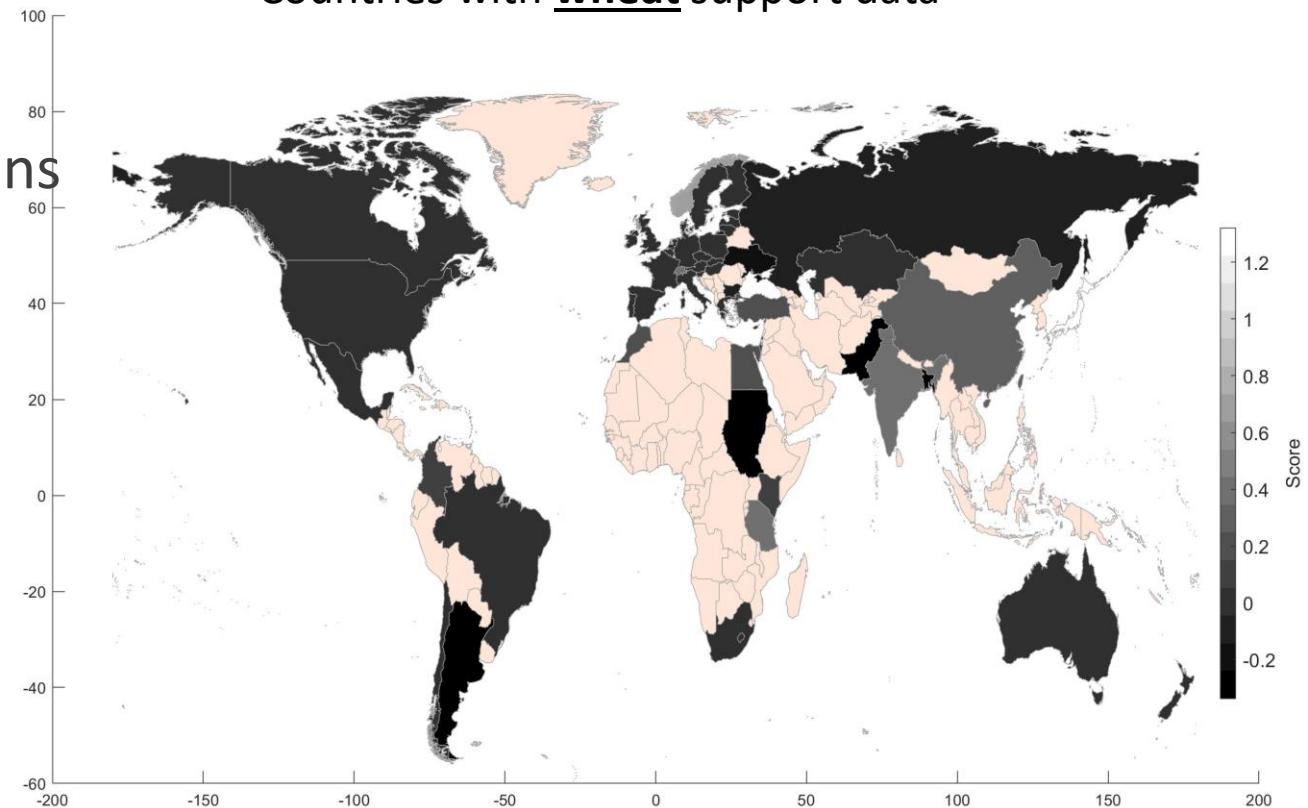
Data

DATA: SUPPORT AND EXPLANATORY
VARIABLES

➤ World Bank Agricultural Distortions
Database, 1961-2011

Anderson, Valenzuela 2008
www.worldbank.org/agdistortions

Countries with **wheat** support data



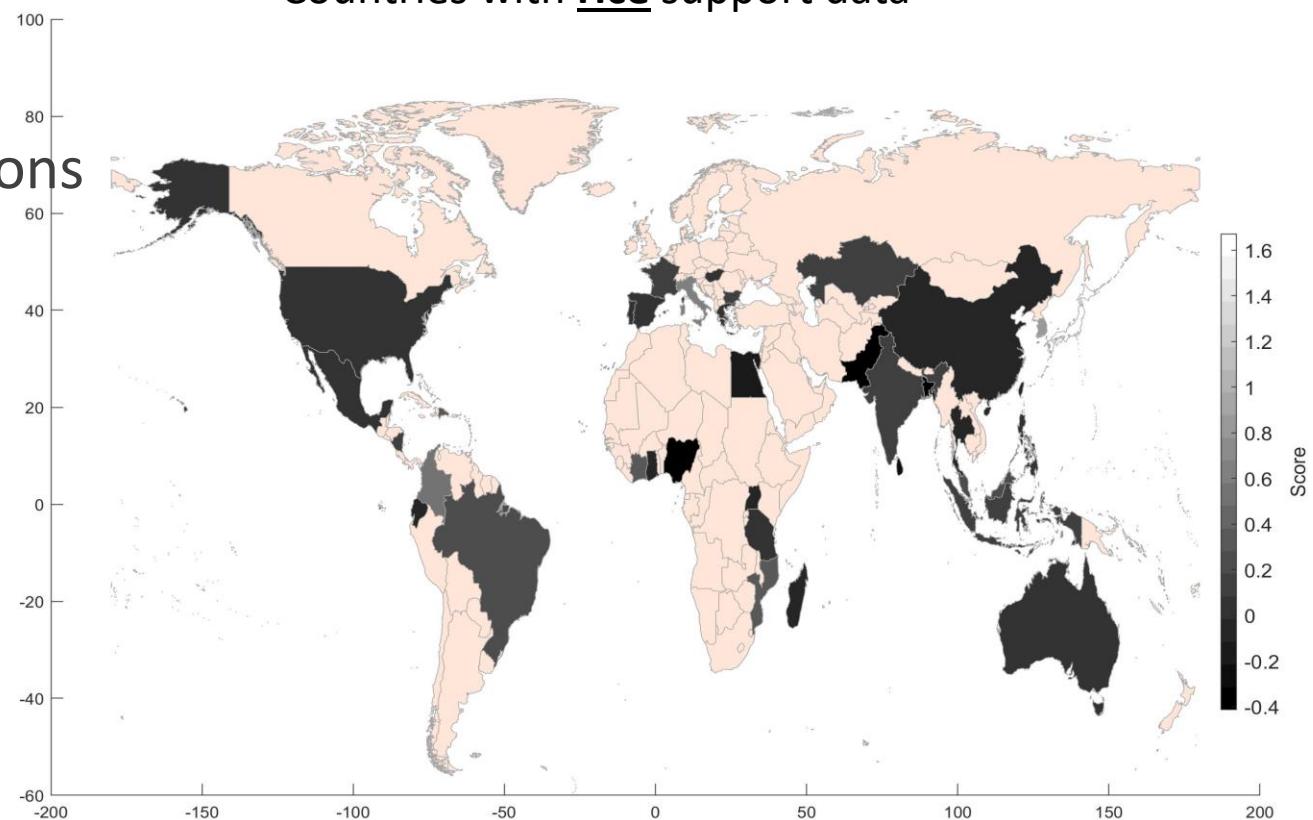
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Countries with **rice** support data



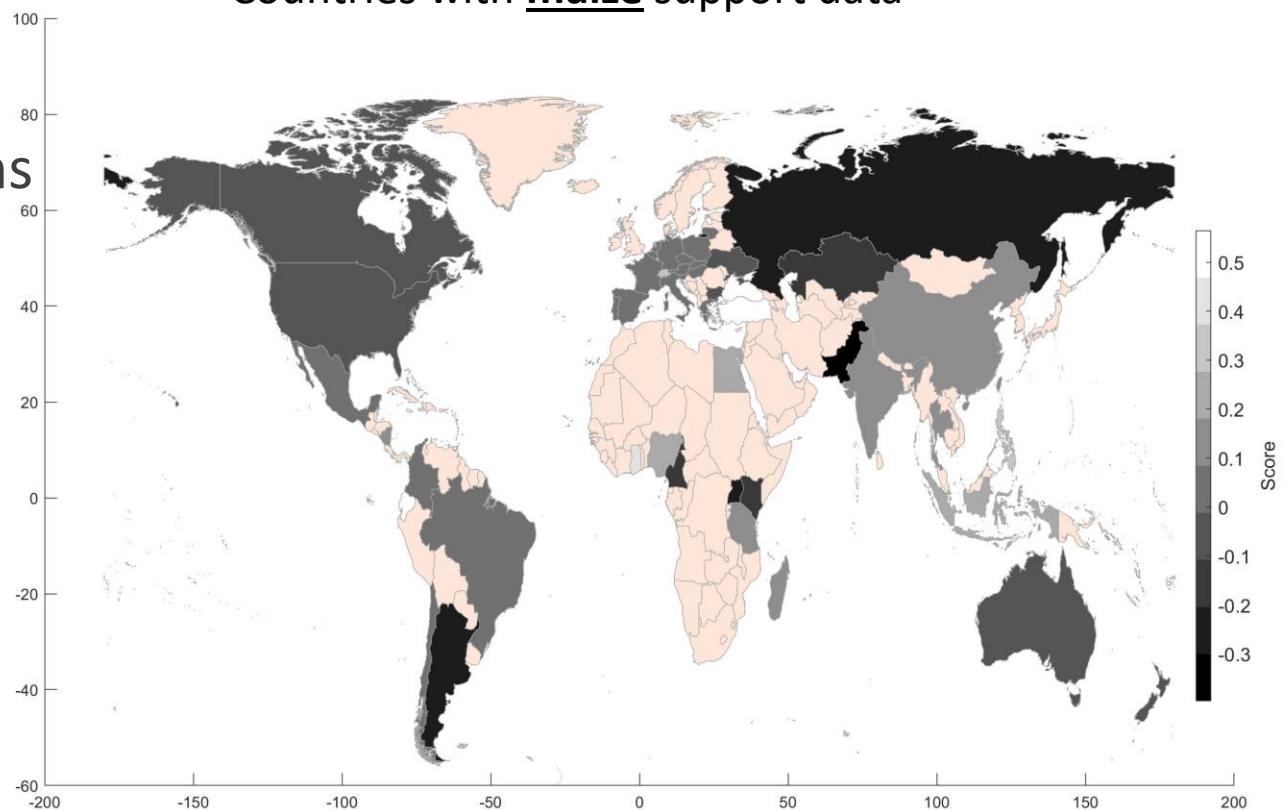
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➤ World Bank Agricultural Distortions
Database, 1961-2011

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Countries with **maize** support data



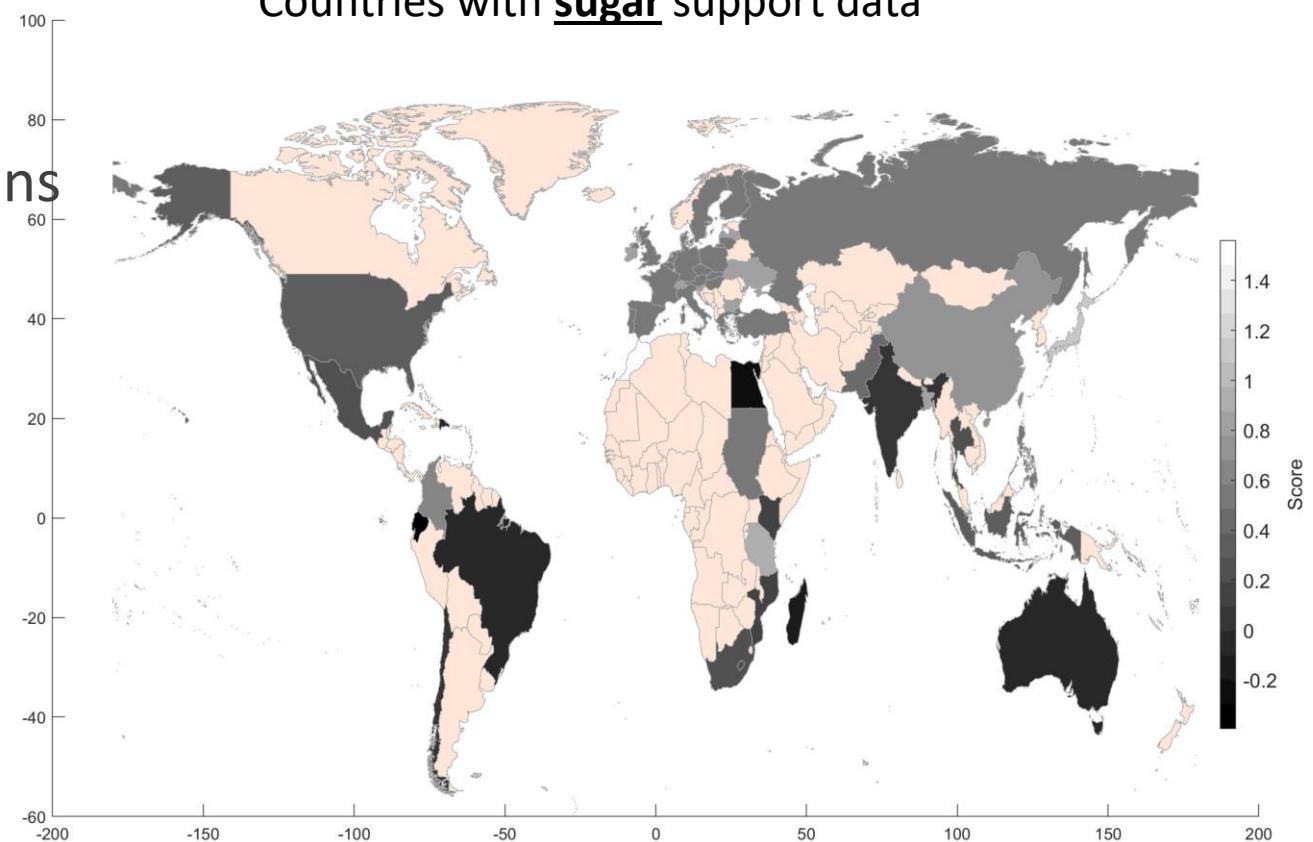
Data

DATA: SUPPORT AND EXPLANATORY
VARIABLES

➤ World Bank Agricultural Distortions
Database, 1961-2011

Anderson, Valenzuela 2008
www.worldbank.org/agdistortions

Countries with **sugar** support data



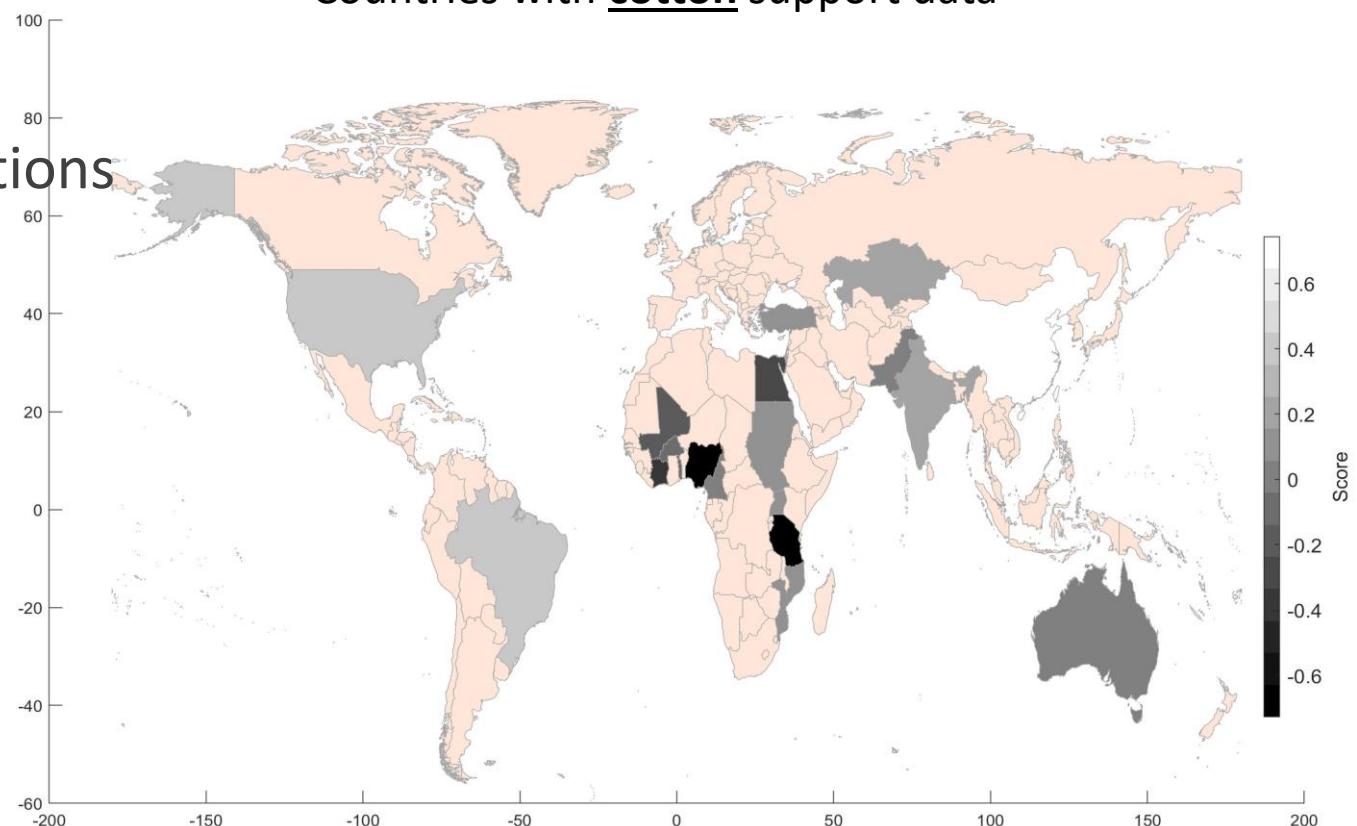
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DATA: SUPPORT AND EXPLANATORY
VARIABLES

➤ World Bank Agricultural Distortions
Database, 1961-2011

Anderson, Valenzuela 2008
www.worldbank.org/agdistortions

Countries with **cotton** support data



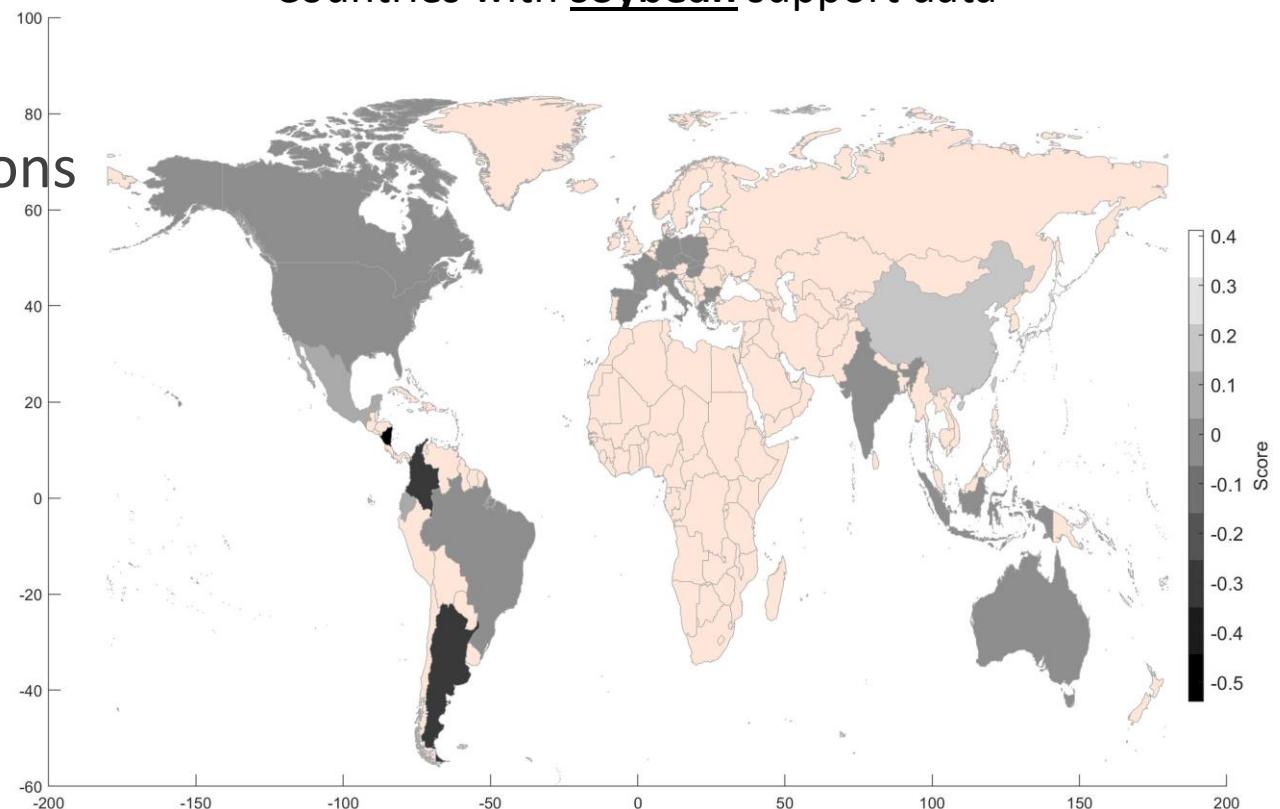
Data

DATA: SUPPORT AND EXPLANATORY
VARIABLES

➤ World Bank Agricultural Distortions
Database, 1961-2011

Anderson, Valenzuela 2008
www.worldbank.org/agdistortions

Countries with **soybean** support data



Data

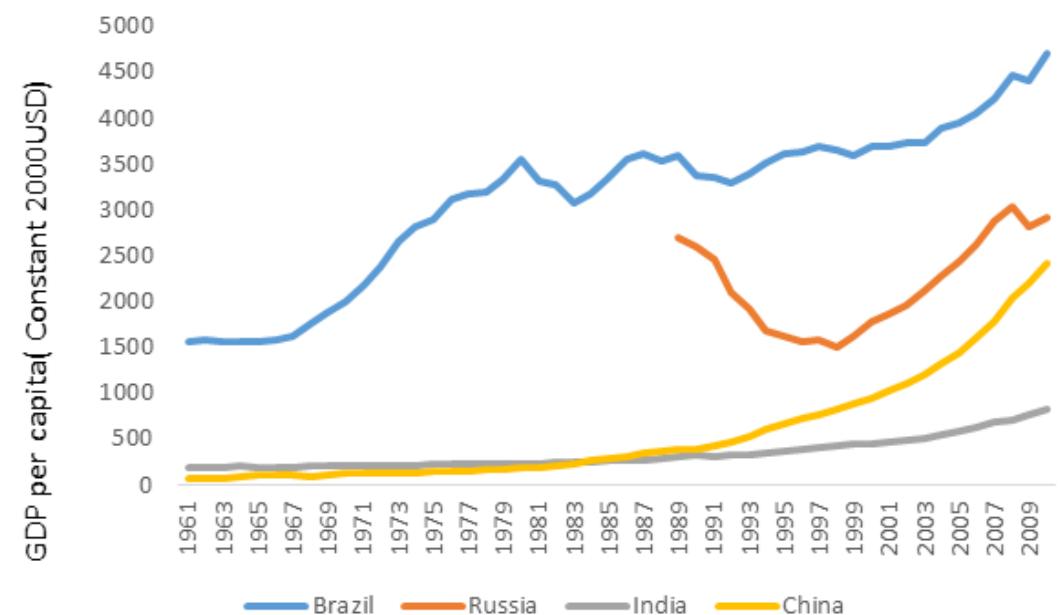
DATA: SUPPORT AND EXPLANATORY
VARIABLES

➤ World Bank Agricultural Distortions
Database, 1961-2011

Anderson, Valenzuela 2008
www.worldbank.org/agdistortions

➤ Economic indicators, past and
projected (World Bank)

HISTORIC GDP PER CAPITA IN BRIC
COUNTRIES, WORLD BANK



Data

DATA: SUPPORT AND EXPLANATORY
VARIABLES

- World Bank Agricultural Distortions Database, 1961-2011

Anderson, Valenzuela 2008
www.worldbank.org/agdistortions

- Economic indicators, past and projected (World Bank)

- Other
 - Market prices (USDA)
 - Trade data (FAO)

Data and methods

DATA: SUPPORT AND EXPLANATORY VARIABLES

- World Bank Agricultural Distortions Database, 1961-2011

Anderson, Valenzuela 2008
www.worldbank.org/agdistortions

- Economic indicators, past and projected (World Bank)

- Other
 - Market prices (USDA)
 - Trade data (FAO)

METHOD: REGRESS SUPPORT ON EXPLANATORY VARIABLES

- By commodity: wheat, corn, soybeans, rice, sugar, cotton
- By form: nominal rate of assistance of border measures (NRA_B), domestic support (NRA_D), and input support (NRA_I)
- Use all available data, but projections for Brazil, Russia, India, China

Why BRIC? large populations, high crop output, and cover a range of settings

	GDP per capita (constant 2000 USD)	Agriculture population (Million)	Population (Million)	Agricultural land (Ha per capita)
Brazil	4699	21	195	1.40
China	2423	834	1372	0.37
India	830	592	1225	0.15
Russia	2923	12	143	1.50

Source: World Bank, 2010

Why BRIC?

Crop production (million tons)

	Wheat	Rice	Maize	Soybeans	Sugar	Cotton
Brazil	6	11	55	69	717	1
China	115	197	178	15	121	6
India	81	144	22	13	292	6
Russia	42	1	3	1	22	n.a.

Sources: FAO, 2010

Why BRIC? Trade status as exporter (X), importer (M) or none (H)

	Wheat	Rice	Maize	Soybean	Sugar	Cotton
Brazil	M	M	X	X	X	X
China	X	X	X	M	M	M
India	H	X	H	X	M	H
Russia	X	n.a.	X	n.a.	M	n.a.

Notes: based on 2010 trade data

World Bank Agricultural Distortions database → our dependent variables (NRA_B, NRA_D, NRA_I)

Time period: 1955-2011

Scope: 75 countries and most of the major commodities

Major indicators: Many indicators, including Nominal Rate of Assistance (NRA)

Meaning of NRA: farmers gross returns caused by policy over farmer gross returns without policy

- E.g. $\text{NRA} > 0 \rightarrow$ policy increases farmer gross returns relative to what they get in the market

NRA components:

$$\text{NRA} = \text{NRA}_O(\text{output}) + \text{NRA}_I(\text{input}), \text{NRA}_O = \text{NRA}_B(\text{border}) + \text{NRA}_D(\text{domestic})$$

NPS is non-product specific support

Variables factors

Variable Name	Definition
NRA (NRA_B, NRA_D, NRA_I)	Indicators of aggregate market distortion
INC	Real GDP per capita
APR	Agricultural population rate
PAL	Per capita agricultural land
D ₁ , D ₂ , D ₃	Dummy for unusual crop price conditions (73-74, 86-88, 06-08)
DUMMY (TM,TH)	Dummy for trade status (import, no trade)
S	Shift variable to approximate WTO membership

Econometric model

$$y_{it} = \alpha + \rho y_{i,t-1} + x_{it}'\beta + d_i'\delta + \varepsilon_{it}$$

y_{it} stands for NRA components,

$x_{it} = (Inc_{i,t-1}, Inc_{i,t-1}^2, Inc_{i,t-1}^3, APR_{it}, PAL_{it}, D_{1it}, D_{2it}, D_{3it}, TM_{it}, TH_{it}, S_{it})'$,

d_i represent a vector of $N-1$ binary country indicators,

ε_{it} is an idiosyncratic error term.

Estimation method: OLS fixed effect model---best linear predictors

Results

Estimation results for different commodities

Forecast support levels in different countries

Example of regression results

	Wheat			Rice		
	NRA_B	NRA_D	NRA_I	NRA_B	NRA_D	NRA_I
NRA_lag	0.594***	0.662***	0.736***	0.798***	0.738***	0.270
INC_lag	-1.669**	-0.252	0.167*	1.306	0.018	0.206***
INC_lag^2	0.243**	0.033	-0.022*	-0.176	-0.001	-0.026***
INC_lag^3	-0.011**	-0.001	0.001**	0.008	0.000	0.001***
APR	0.175	-0.055	-0.029**	-0.257*	-0.013	-0.020**
PAL	0.000	0.002	0.000	0.004	0.000	0.000
S	-0.037*	-0.025***	-0.008**	-0.092***	-0.008	-0.003*
73-74	-0.281***	-0.028**	0.005	-0.311***	-0.025**	0.002
86-88	0.257***	-0.014	0.004	0.027	0.009	0.004
06-08	-0.089***	0.011	-0.001	-0.127***	-0.007	-0.003
TM	0.070***	0.019	-0.001	-0.043	0.010**	0.007**
TH	0.114**	-0.039	0.023	-0.126**	0.053**	0.028*
Obs	2609			2071		

Estimated impact of \$1 real income on support

At low income, +\$1

→ more border support for all crops but SB
 → more domestic and input support sometimes

At high income, +\$1

→ less border support for all but rice
 → increasing rate of growth in WT, CT domestic support
 → rising input support for all but rice - & rising rate

	Wheat			Rice			Maize		
	Border	Domestic	Input	Border	Domestic	Input	Border	Domestic	Input
Per person income									
250	0.01	0.02	0.02	0.09	0.02	0.01	0.03	-0.04	0.03
500	0.08	0.04	0.01	0.05	0.02	0.00	0.15	-0.02	0.03
1,000	0.11	0.06	0.01	0.02	0.02	-0.01	0.21	-0.01	0.04
10,000	0.01	0.10	0.02	0.10	0.03	-0.02	0.04	-0.05	0.06
20,000	-0.09	0.11	0.03	0.17	0.03	-0.01	-0.13	-0.07	0.08
Cotton			Sugar			Soybean			
Per person income									
250	0.16	0.01	0.04	-0.06	-0.07	0.05	-0.04	-0.46	0.04
500	0.15	0.02	0.03	0.06	-0.05	0.05	-0.03	0.05	0.06
1,000	0.13	0.04	0.02	0.12	-0.04	0.06	-0.03	0.40	0.07
10,000	-0.01	0.19	0.04	-0.08	-0.12	0.11	-0.12	0.41	0.12
20,000	-0.08	0.27	0.06	-0.27	-0.17	0.13	-0.18	0.07	0.13

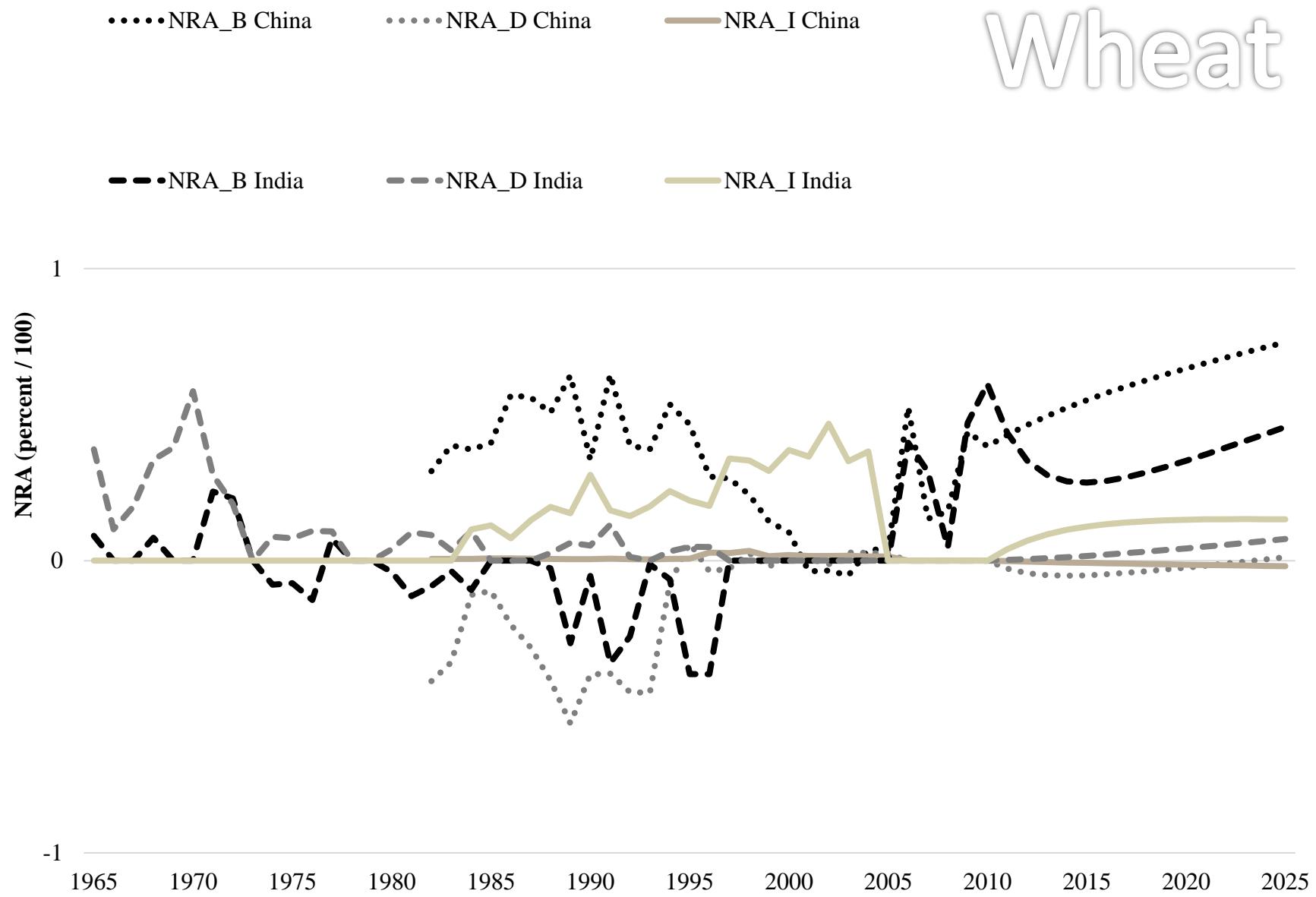
Forecasting the evolution of support in Brazil, Russia, India, and China

From end of World Bank dataset, project using IMF GDP per capita forecasts

Combine with regression parameters

Here: some results from the paper...

Wheat



2

NRA_B Brazil

NRA_D Brazil

NRA_I Brazil

Wheat

NRA_B Russia

NRA_D Russia

NRA_I Russia

NRA (percent / 100)

1

0

-1

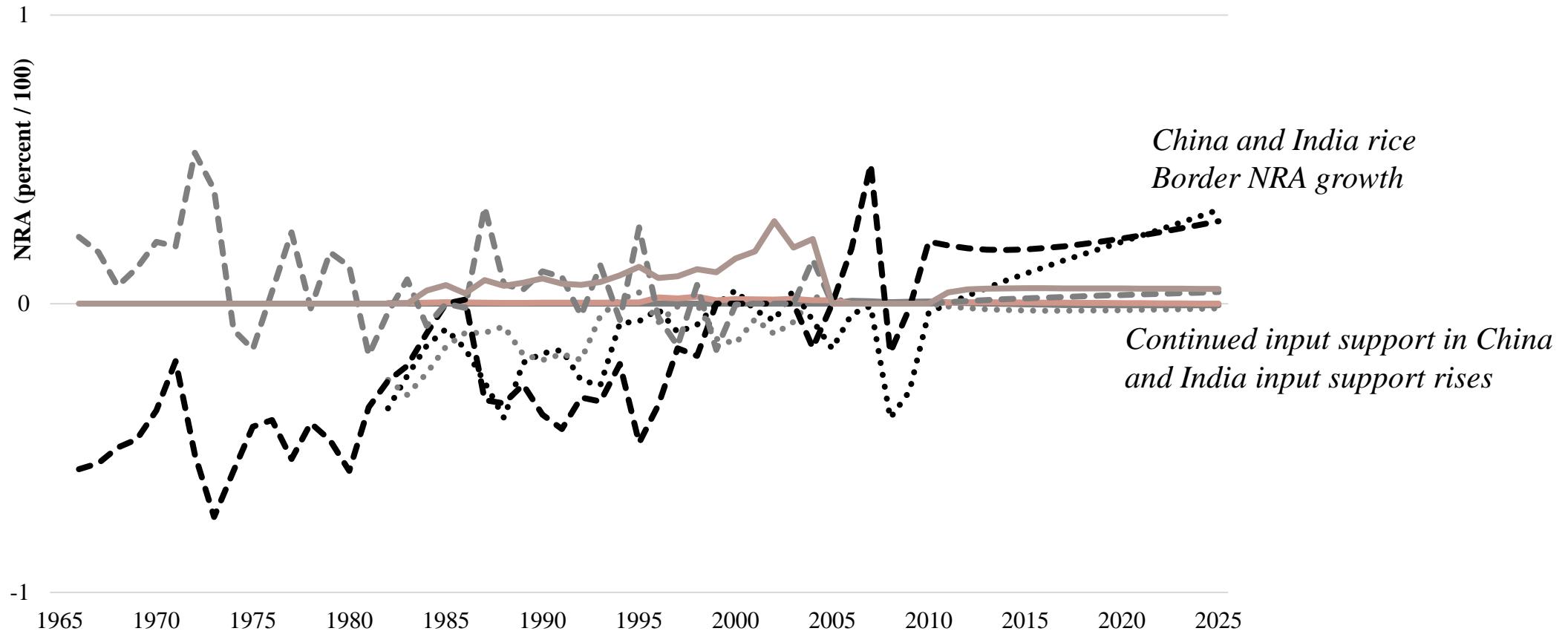
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025

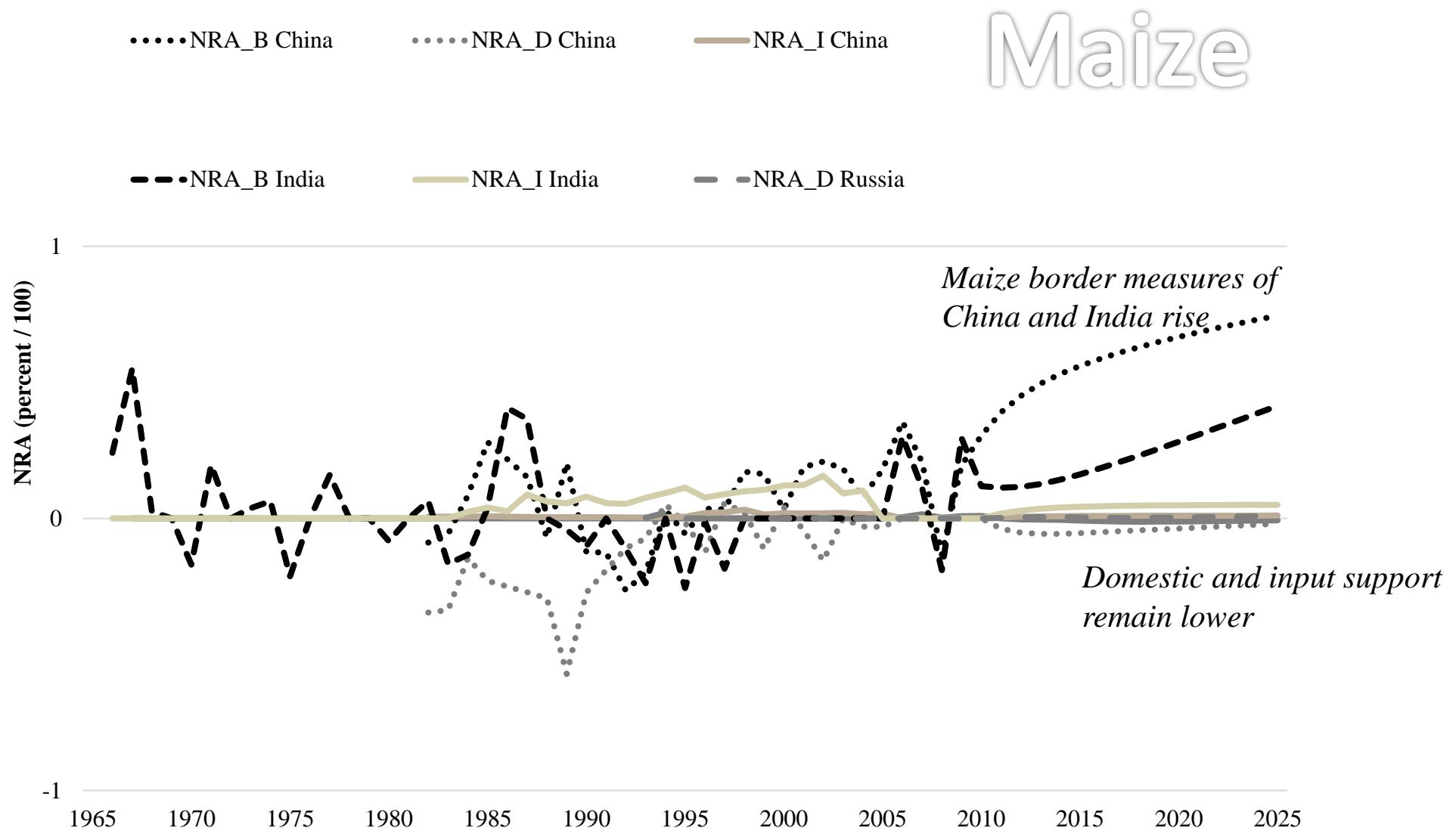
*Brazil border support
rises a bit*

*Brazil and Russia
negative domestic
support abates*

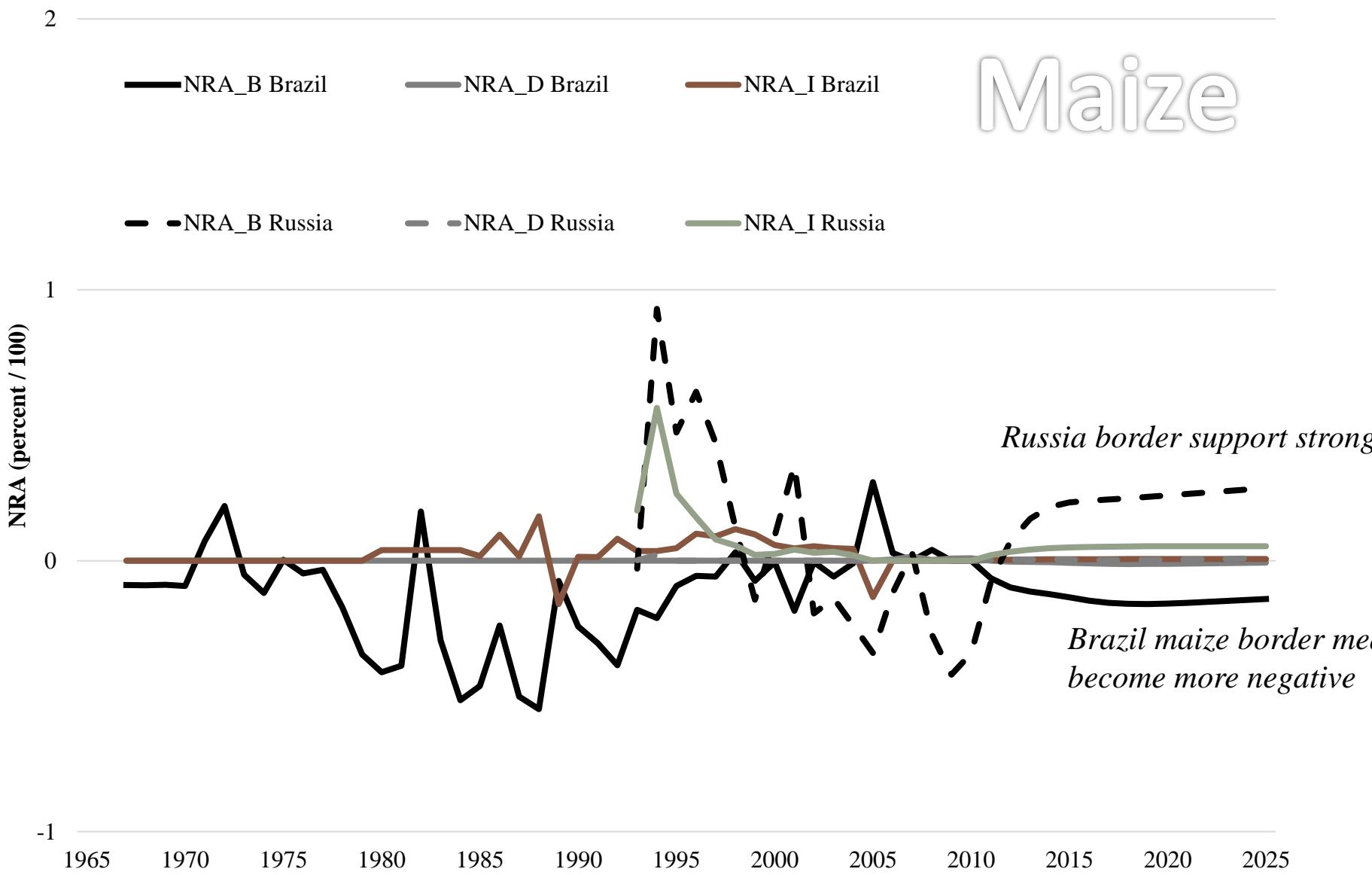
Rice

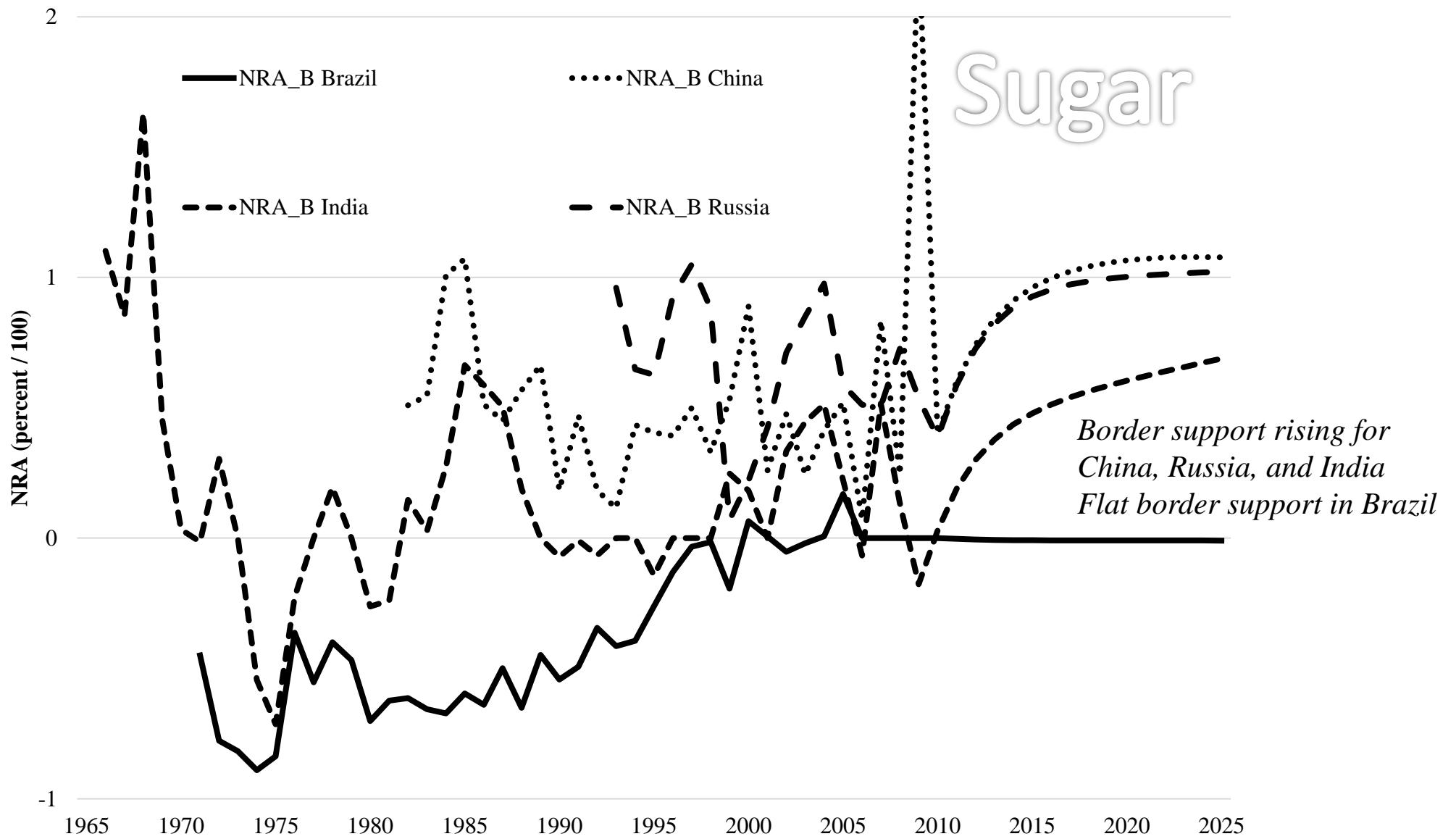
..... NRA_B China NRA_D China — NRA_I China
- - - NRA_B India - - - NRA_D India — NRA_I India



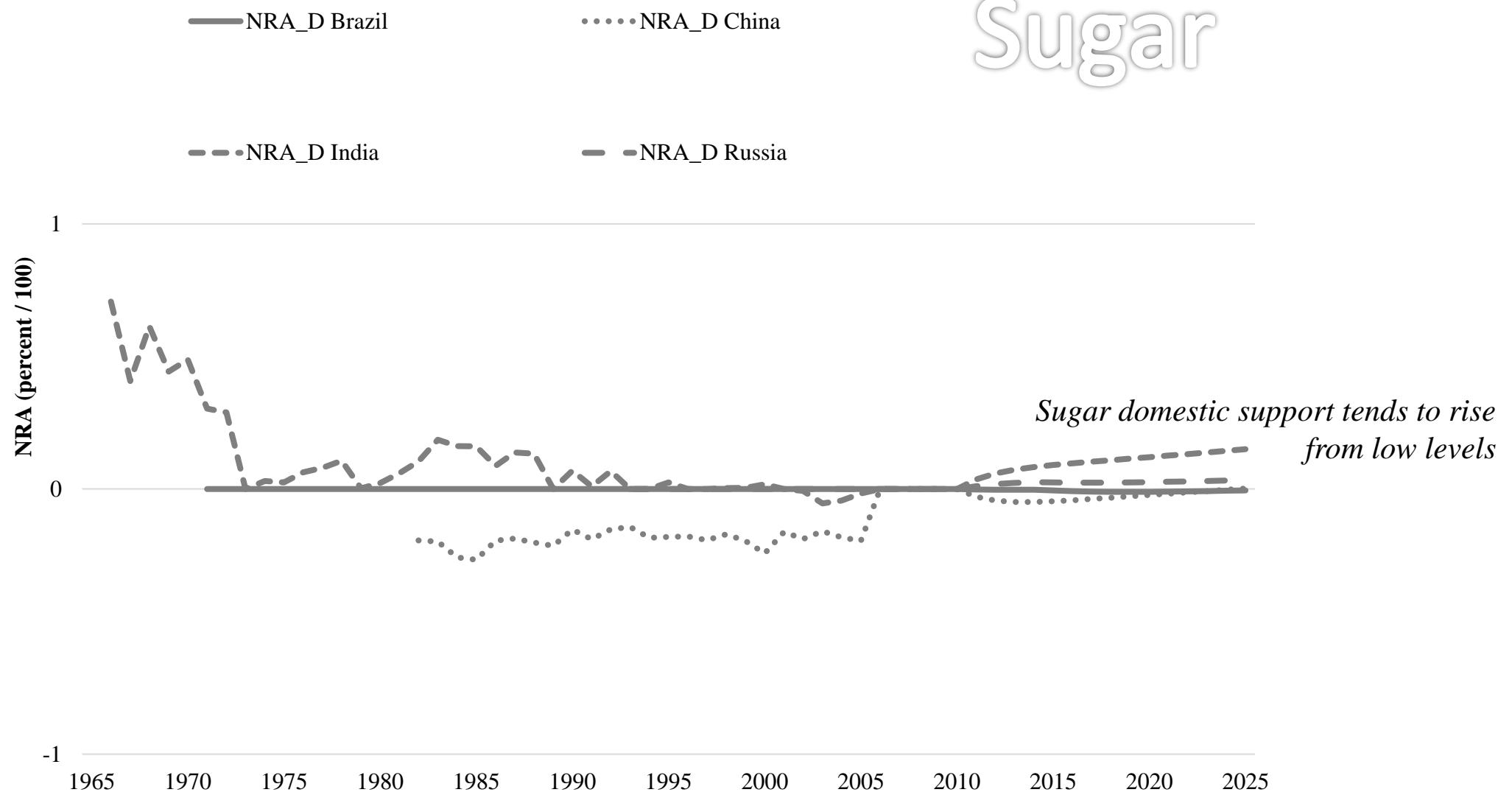


Maize



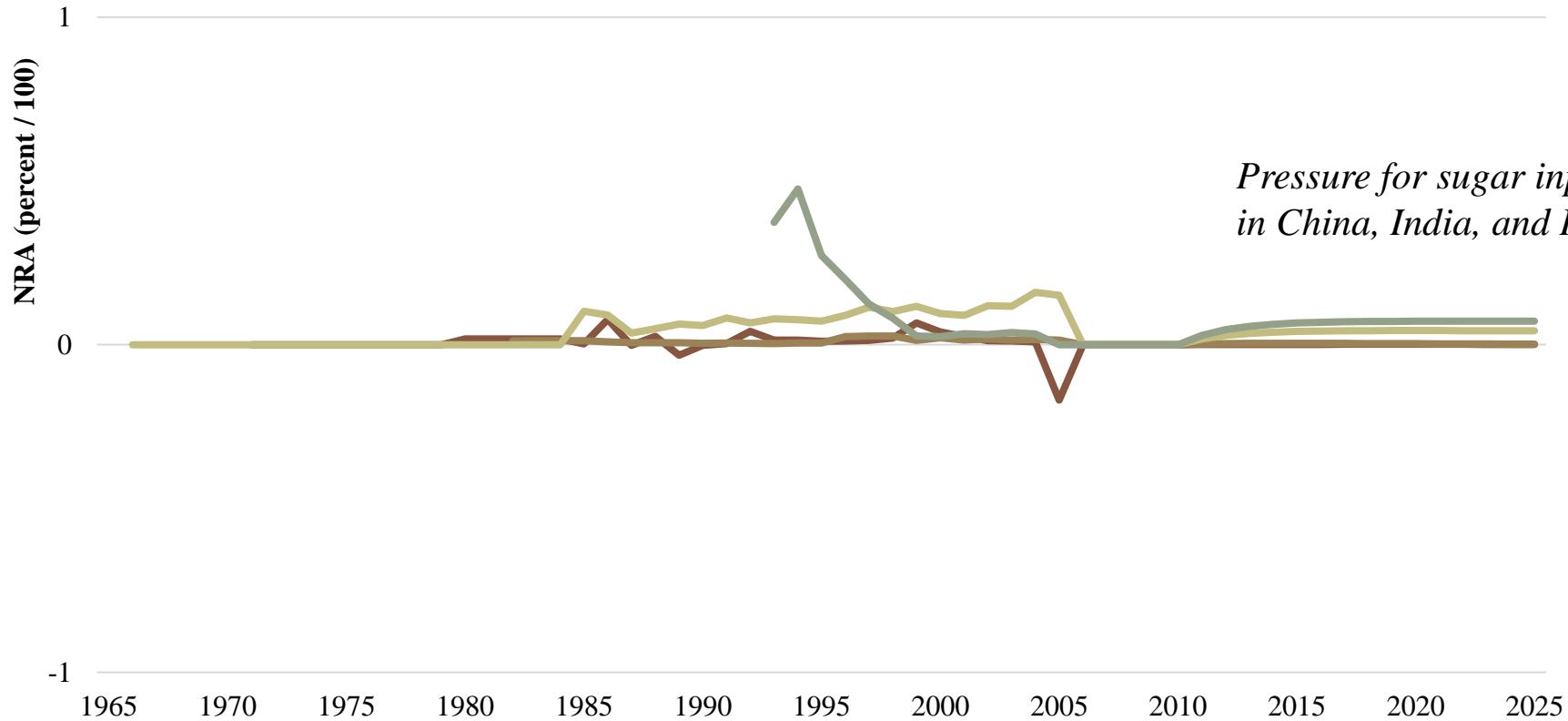


Sugar



Sugar

NRA_I Brazil NRA_I China NRA_I India NRA_I Russia



*Pressure for sugar input support to rise
in China, India, and Russia*

We relate our results to WTO – but only in a general way

Estimation has its limits

- Regression approximates relationships between economic development and support
- Historical support dataset end in 2012

NRA ≠ WTO notification data or commitments

Information can be useful

- What are the pressures that drive support?
- What forms (tariff, direct payment) do these pressures tend to take?

Conclusions

Regressions confirm link between some support to per capita incomes and other factors

- Especially border policies
- More complex relationships with income than previously explored

Projections suggest future trade disagreements

- Tendencies of BRIC or other countries to raise border supports, shift to domestic support, or adjust input supports in the future
- Forecast support levels consistent with long-run analysis
- Research question: if predicted support has not materialized, then difference might be caused by commitments of bilateral or multilateral agreements

Thanks!

Appreciation to the IATRC for commissioning this research
-- and for commissioning separately an update to the World Bank data!

Comments and questions?



Estimation Results(1)

	Wheat			Rice		
	NRA_B	NRA_D	NRA_I	NRA_B	NRA_D	NRA_I
NRA_lag	0.594***	0.662***	0.736***	0.798***	0.738***	0.270
INC_lag	-1.669**	-0.252	0.167*	1.306	0.018	0.206***
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INC_lag^3	-0.011**	-0.001	0.001**	0.008	0.000	0.001***
APR	0.175	-0.055	-0.029**	-0.257*	-0.013	-0.020**
PAL	0.000	0.002	0.000	0.004	0.000	0.000
S	-0.037*	-0.025***	-0.008**	-0.092***	-0.008	-0.003*
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TH	0.114**	-0.039	0.023	-0.126**	0.053**	0.028*
Obs	2609			2071		

Estimation Results(2)

	Maize			Soybean		
	NRA_B	NRA_D	NRA_I	NRA_B	NRA_D	NRA_I
NRA_lag	0.544***	0.455***	0.614***	0.588***	0.765***	0.392**
INC_lag	-2.714***	-0.479*	0.142**	-0.525	-10.314***	-0.070
INC_lag^2	0.398***	0.065*	-0.018**	0.077	1.356***	0.010
INC_lag^3	-0.018***	-0.003*	0.001**	-0.004	-0.056***	0.000
APR	0.430**	0.049**	-0.001	0.145	0.321	0.036
PAL	-0.006***	0.001	0.000	-0.002	0.009	0.000
S	-0.008	-0.005	-0.006**	-0.021	-0.040	-0.002
73-74	-0.230***	-0.005	0.005	-0.078	-0.004	-0.001
86-88	0.195***	0.008	0.003	-0.080**	0.089	0.010
06-08	-0.076***	0.000	-0.001	-0.026	-0.089*	-0.002
TM	-0.023	0.010	0.005**	0.009	-0.018	0.004**
TH	-0.045	-0.046	0.002	0.023	-0.048	0.014*
Obs	2320			1216		

Estimation Results(3)

	Sugar			Cotton		
	NRA_B	NRA_D	NRA_I	NRA_B	NRA_D	NRA_I
NRA_lag	0.678***	0.577***	0.604***	0.508***	0.467***	0.277
INC_lag	-3.080*	-0.759*	0.110	-0.206	0.337	0.346***
INC_lag^2	0.439**	0.104*	-0.014	0.066	-0.063	-0.044***
INC_lag^3	-0.020**	-0.005*	0.001	-0.004	0.004	0.002***
APR	0.127	0.071*	-0.014	0.058	0.055*	-0.035***
PAL	-0.005	-0.001**	0.000	0.012*	0.005**	0.000
S	0.096***	-0.009	-0.005	0.076***	0.010	-0.008***
73-74	-0.571***	-0.012**	0.004*	-0.042	-0.001	0.002
86-88	0.043	-0.025	0.001	-0.019	0.010	0.006
06-08	-0.255***	-0.002	-0.002	0.006	0.025	-0.006**
TM	0.063	0.006	0.007*	0.011	0.077***	0.013
TH	0.006	-0.043**	0.016**	-0.077	-0.043	0.013
Obs	2579			1365		