Stocks and Shocks: Assessing the Relative Roles of Public and Private Inventories in Buffering Rice Price Volatility in the Philippines

Bernhard Dalheimer[1] Kenneth Foster[1] Gerald Shively[1] Valerien O. Pede[2] Dela Dem Doe Fiankor[3] Jacob Ricker-Gilbert[1] Pratibha Bist[4]

[1]Department of Agricultural Economics, Purdue University
[2]Transformative Policies Unit, International Rice Research Institute
[3]Department of Agricultural Economics and Rural Development, University of Goettingen
[4]Department of Agriculture and Resource Economics, University of California at Davis

October 24, 2025
Dyson School of Applied Economics and Management
Cornell University

Motivation

- Food markets are volatile
- Governments implement trade polices, self-sufficiency policies, price bands and stocks to safeguard against price volatility and protect consumers against high prices
- Public food stock programs are
  - Often implemented
  - Politically contentious
  - Economically challenging
  - Hard to evaluate empirically because of poor data
- Most countries countries **have** ample stock(s) (programs)
- Yet, stock programs are very heterogeneous in terms of size and regulations

Food stocks post–war origins: From scarcity to stability (1940s–1960s)

- Governments were concerned with (wartime) famines, rebuilding food security.
- **Exporters (U.S., Canada, Australia):**
  - Intervention prices + public reserves for farm income and export reliability.
  - U.S. Commodity Credit Corporation (CCC) and PL–480 (Food for Peace) moved surpluses abroad.
- **Importers (Europe, Asia):**
  - Rebuilt via Marshall Plan grain flows.
  - Early stabilization schemes under colonial or state trading boards.
- International Wheat Agreement (1949) and FAO's early grain-balance monitoring sought price stability through coordination rather than large buffer stocks.

1970s: Price stabilization

- 1972–74 food crisis revealed problems of thin reserves
- Focus shifts from famine prevention to price stabilization.
- **Exporters:**
  - U.S. "Farmer-Owned Grain Reserve" (1977) incentivized private storage
  - Europe's CAP accumulated huge "butter mountains" and grain surpluses — stabilizing floors, but fiscally costly.
- **Importers:**
  - Many Asian economies (India, Korea, Japan, Philippines) created statutory public rice stocks.

1980s–1990s: Market liberalization and private stockholding

- **Exporters:**
  - U.S. phased out reserves (CCC surpluses sold off; Farmer-Owned Grain Reserve ended 1996).
  - EU reforms curbed intervention buying; CAP shifted toward direct payments.
- **Importers:**
  - Focused on trade liberalization + safety nets, relied increasingly on private traders.
  - Public stocks limited to food security reserves for emergencies.
- 1995 WTO Agreement on Agriculture limited trade-distorting public procurement and subsidized stockholding.

2000s–2010s: Hybrid storage and renewed security concerns

- **2007–08 and 2010–11 price crises** exposed fragility of low food stock regimes
- **Importers:**
  - Rebuilt public reserves (India's FCI, China's Sinograin, Indonesia's Bulog).
  - ASEAN +3 launched APTERR (2011): shared rice emergency reserve.
- **Exporters:**
  - U.S. replaced physical reserves with the Bill Emerson Humanitarian Trust (cash-based food aid fund).
- WTO "Peace Clause" (2013–): protects food-security stockholding while permanent rules are negotiated.
- Private storage for routine smoothing; modest public buffers for tail-risk events.

Global Food Stocks Today (2020s)

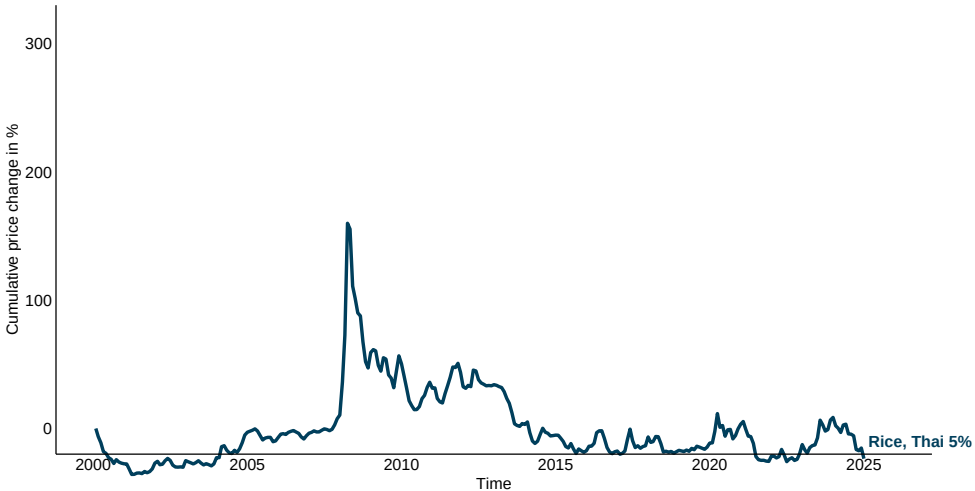
Still lots of heterogeneity:

- Size of public buffer (rice):
  - Korea mandates 62 days of national disappearance
  - India and Japan target 50 days of nat. disappearance
  - (In India puclic stocks often exceed 180)
  - Philippines mandate 15/30 days
  - Bangladesh has a minimum of 9 days
- Import buffers or not?
- Other price support policies or not?
- Commercial incentives?

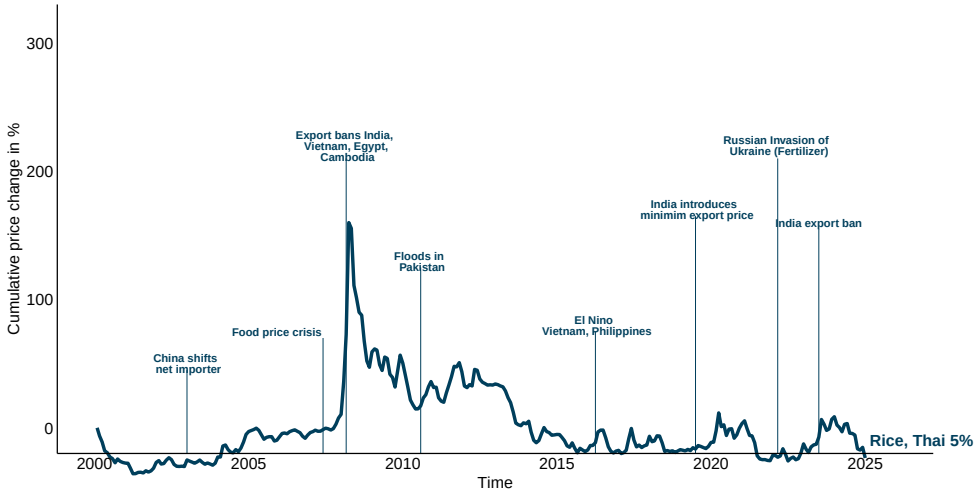
Policy Context: Why It Matters

- Philippines: world's largest net importer of rice.
- 2019 Rice Tariffication Law (RTL) replaced import monopoly with tariffs.
- The RTL provides a natural experiment on public stock policy.
- Broader implications for price stabilization in import-dependent economies.

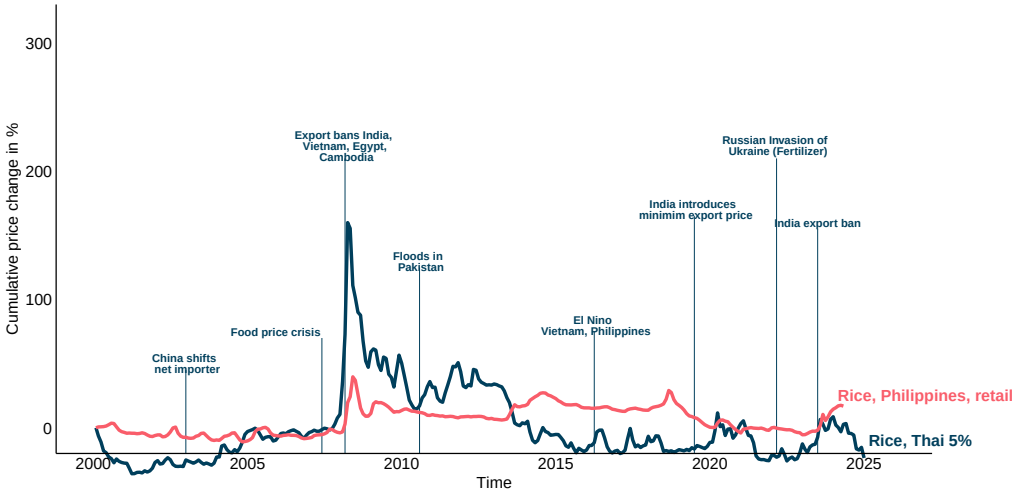
Motivation: Real Rice Prices in Global and Philippine Markets



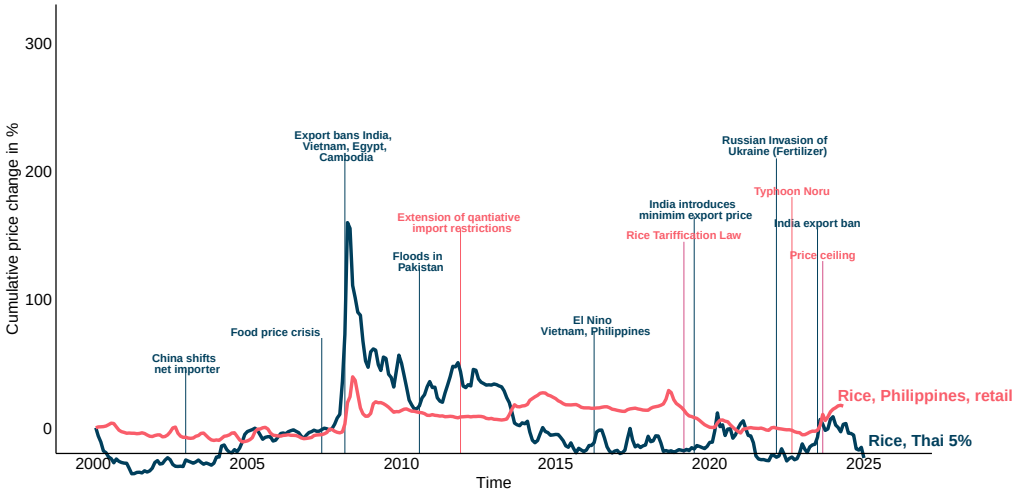
Motivation: Real Rice Prices in Global and Philippine Markets



Motivation: Real Rice Prices in Global and Philippine Markets



Motivation: Real Rice Prices in Global and Philippine Markets



Preview of findings

- Small, rules-based, yet flexible stock program helped contain extend of local and global shocks
- The stock program had little effect after RTL changes, markets were more exposed
- The program was also cheap compared with consumer losses of price spikes
- Commercial stocks work to contain routine volatility push prices upwards during local supply shocks
- Commercial and public stocks are no substitutes
- Public stocks need to counteract commercial storage behavior, i.e. buy when prices are high and be the buyer of last resort
- No crowding out

Contributions to the Literature

Rational-expectations competitive storage:

- Theory of competitive storage. (Wright and Williams, 1982; Gouel, 2013, 2014)
- Macro-level food stocks (e.g., Cafiero et al., 2011; Bobenrieth et al., 2013, 2021)
- Public vs. private stock holding:
  - Crowding out (Gouel, 2014)
  - Rules-based, hybrid systems (Gouel, 2013)
- Cost of public stock programs (Tripathi and Mishra, 2024; Gouel et al., 2016; Larson et al., 2014; Dorosh, 2008)
- Literature largely based on simulations, aggregate stocks few distinguish between public and private, contradicting results of benefits of public stock programs some have made arguments for hybrid systems but no empirical evidence
- We distinguish between private and public stocks and exploit a policy shift, causal long-term empirical evidence

Other related literature

1. **Food market shocks and price volatility policy** (e.g. Berger et al., 2021; Pieters and Swinnen, 2016; Gouel, 2016; Rude and An, 2015; Anderson and Rubin, 1949; Jayne et al., 2006; Valera et al., 2022; Ubilava et al., 2022; Larch et al., 2024)
2. **Rice markets and policy in the Philippines** (Yao et al., 2005; Balié and Valera, 2020; Valera et al., 2021; Briones, 2018)
3. **Data-driven identification in agricultural commodity & food markets analysis**. (Baumeister and Kilian, 2014; Dalheimer et al., 2021; Dong et al., 2025)

Theoretical framework: Competitive Storage

Storage Arbitrage Condition

$$P_t = \max\{P_t^s,\ \beta E_t[P_{t+1}] - c\}$$

- Agents store if expected future price (minus cost) exceeds current spot price.
- Under open trade, opportunity cost linked to world price P_t^W.

Interaction between shocks and stocks

- Large open economy
- Domestic production shocks vs. global price shocks.
- Public vs. private stockholder responses differ.

Table: Stylized outcomes of global and domestic shocks.

$\Delta P^W \downarrow$ / $\Delta Q^D \rightarrow$	**Low domestic production**	**High domestic production**
$\Delta P^W < 0$ ($P^W \downarrow$)		
$\Delta P^W > 0$ ($P^W \uparrow$)		

Interaction between shocks and stocks

- Large open economy
- Domestic production shocks vs. global price shocks.
- Public vs. private stockholder responses differ.

Table: Stylized outcomes of global and domestic shocks.

$\Delta P^W \downarrow$ / $\Delta Q^D \rightarrow$	**Low domestic production**	**High domestic production**
$\Delta P^W < 0$ ($P^W \downarrow$)	Imports + possible stock release Domestic ΔP: moderated Private $\downarrow$ / Gov. neutral	
$\Delta P^W > 0$ ($P^W \uparrow$)		

Interaction between shocks and stocks

- Large open economy
- Domestic production shocks vs. global price shocks.
- Public vs. private stockholder responses differ.

Table: Stylized outcomes of global and domestic shocks.

$\Delta P^W \downarrow$ / $\Delta Q^D \rightarrow$	**Low domestic production**	**High domestic production**
$\Delta P^W < 0$ ($P^W \downarrow$)	Imports + possible stock release Domestic ΔP: moderated Private $\downarrow$ / Gov. neutral	Private storage $\uparrow$ (carry) Domestic ΔP: smaller $\downarrow$ Private $\uparrow$ / Gov. neutral
$\Delta P^W > 0$ ($P^W \uparrow$)		

Interaction between shocks and stocks

- Large open economy
- Domestic production shocks vs. global price shocks.
- Public vs. private stockholder responses differ.

Table: Stylized outcomes of global and domestic shocks.

$\Delta P^W \downarrow$ / $\Delta Q^D \rightarrow$	**Low domestic production**	**High domestic production**
$\Delta P^W < 0$ ($P^W \downarrow$)	Imports + possible stock release Domestic ΔP: moderated Private $\downarrow$ / Gov. neutral	Private storage $\uparrow$ (carry) Domestic ΔP: smaller $\downarrow$ Private $\uparrow$ / Gov. neutral
$\Delta P^W > 0$ ($P^W \uparrow$)	Stocks drawn down, imports costly Domestic ΔP: may exceed global **Gov. buys stocks**	

Interaction between shocks and stocks

- Large open economy
- Domestic production shocks vs. global price shocks.
- Public vs. private stockholder responses differ.

Table: Stylized outcomes of global and domestic shocks.

$\Delta P^W \downarrow$ / $\Delta Q^D \rightarrow$	**Low domestic production**	**High domestic production**
$\Delta P^W < 0$ ($P^W \downarrow$)	Imports + possible stock release Domestic ΔP: moderated Private $\downarrow$ / Gov. neutral	Private storage $\uparrow$ (carry) Domestic ΔP: smaller $\downarrow$ Private $\uparrow$ / Gov. neutral
$\Delta P^W > 0$ ($P^W \uparrow$)	Stocks drawn down, imports costly Domestic ΔP: may exceed global **Gov. buys stocks**	Private storage weak Domestic ΔP: moderated **Gov. purchases surplus**

Philippine Rice Market: Institutional Context

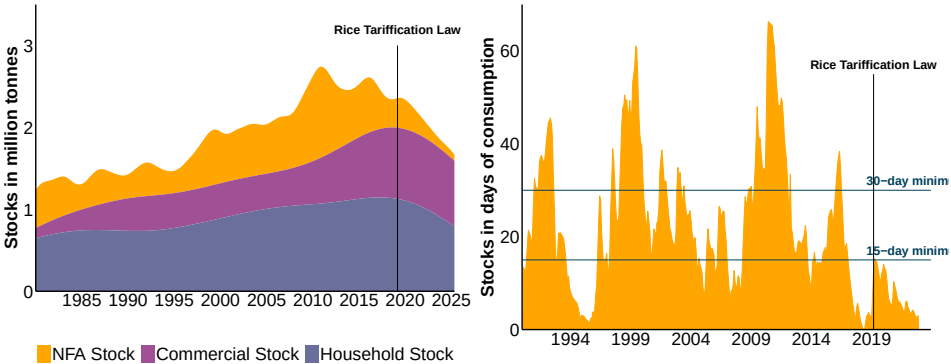
- National Food Authority (NFA) mandate: maintain 15 days of national consumption, 30 at lean season.
- Dual storage system: NFA vs. commercial/household agents.
- Under President Duterte, the 2019 Rice Tariffication Law (RTL) aimed at
  - (i) lowering prices for consumers (increasing supply through trade liberalization and imports),
  - (ii) supporting domestic producers (mainly through input support and credits **and removing of import mandate of NFA**
  - (iii) cut NFA financing and regulative authority (cut government spending).
- With regards to public rice stocks, this regulation
  - removed import mandate of NFA
  - restricted procurement to domestic grain.
  - cut budget and ended borrowing rights.

Data Overview

- Monthly data (2000–2024).
- Sources:
  - Philippine Statistics Authority collects data on
    - Public stock holdings (from NFA)
    - Commercial stock holding (through monthly surveys)
    - Household stock holdings (through monthly surveys)
  - FAO: National average retail price
  - World Bank: Thai 5% broken rice price
  - COMTRADE: Trade volumes

Stockholding facility near Quezon City, Source: DA Philippines

Stocks by Holder, 2000–2024



NFA, commercial, and household stocks; note post-2019 decline in NFA reserves.

Empirical Model: SVAR with ICA Identification

- Structural VAR with monthly data:

$$y_t = \nu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \mathbf{B}\varepsilon_t$$

- Variables:
  - Global exports (ΔX_t), global price (p_t),
  - Domestic stocks (Δs_t), production (Δq_t),
  - Philippine retail price (p_t^{PHP}).
- Identification problem:

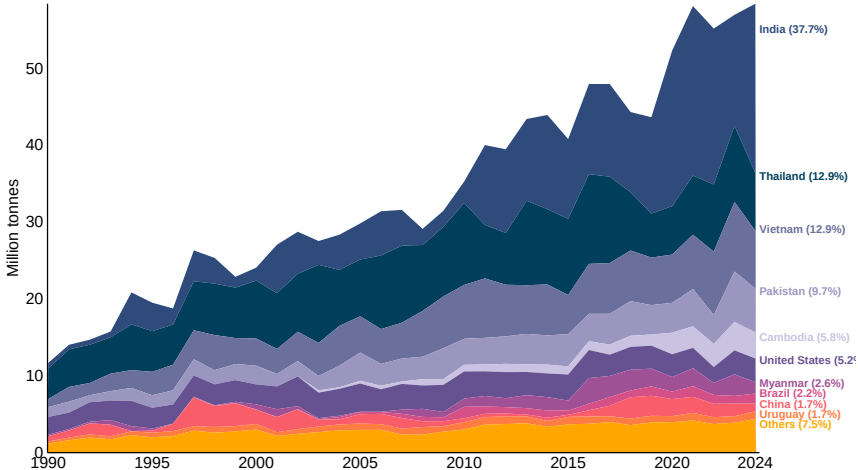
$$\varepsilon_t = \mathbf{B}^{-1} u_t$$

- To estimate Global demand, Global supply (trade), domestic demand, domestic supply, and domestic stock shocks

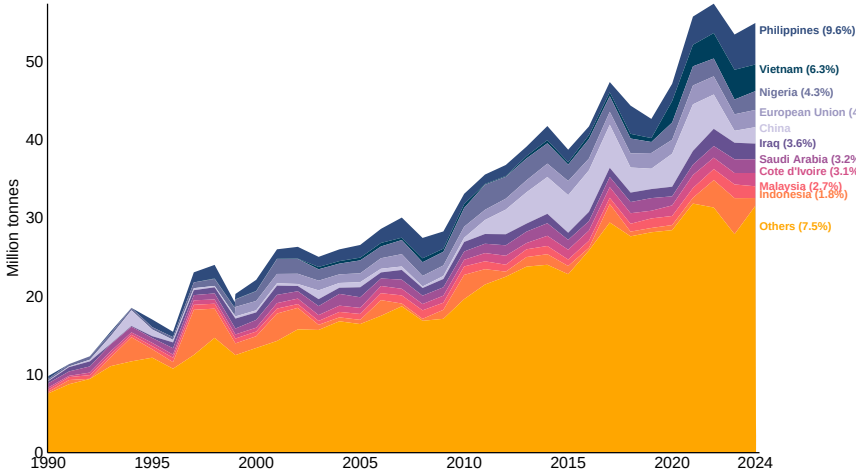
Data driven identification of time series models

- Economic assumptions: Choleski decomposition, short-run and long-run restrictions
- Statistical assumptions
  - Heteroskedasticity
  - Independence based (non-Gaussanity)

World rice exports



World rice imports



Independent component analysis (Distance Covariance)

- Find $\mathbf{B}$ such that

$$\varepsilon_t(\mathbf{B}) = \mathbf{B}^{-1}\hat{u}_t$$

- ICA (distance-covariance) searches for a rotation such that the transformed components are as independent as possible, i.e. minimize pairwise distance covariances:

$$\mathcal{U}_T\big(\varepsilon_t(\mathbf{B})\big) \;=\; T\sum_{k=1}^{K-1}\mathcal{V}^2\big(\varepsilon_{t,k},\varepsilon_{t,k^+}\big)$$

$$\widehat{\mathbf{B}} \;=\; \arg\min_{\mathbf{B}\in\mathcal{O}(K)}\mathcal{U}_T\big(\varepsilon_t(\mathbf{B})\big),$$

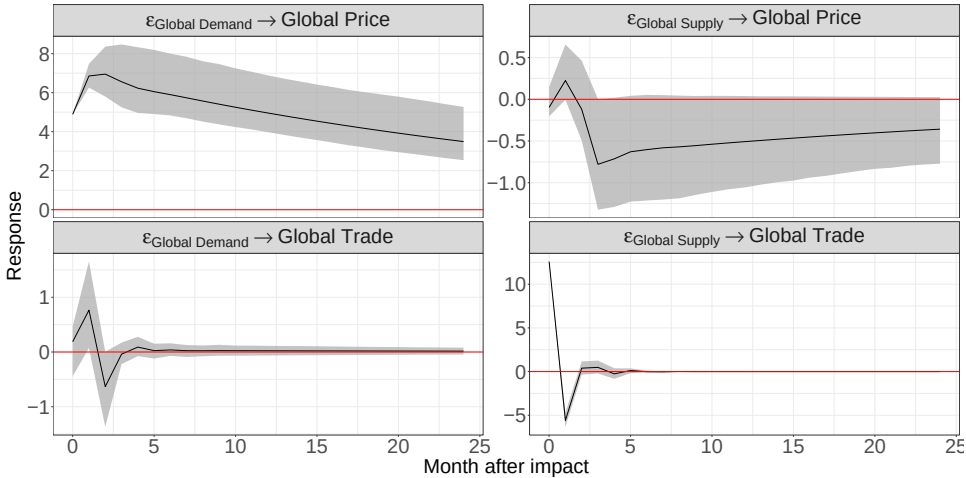
- Statistical assumptions:
  - If at most one component is Gaussian, $\mathbf{B}$ is unique
  - The sample must be large enough for higher-order moments to be estimated reliably

Robustness

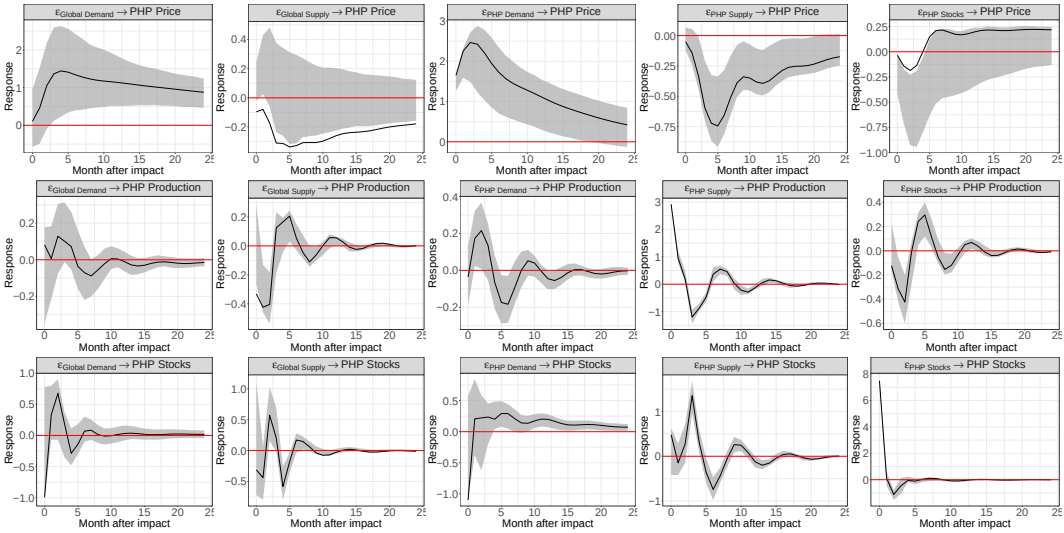
Identifying assumption: non-Gaussian, independent shocks. To validate this, we show

1. Independence diagnostics (Normality tests)
2. Meaningful IRFs
3. Stability under alternative samples and lag lengths,
4. Consistent IRFs under alternative identification schemes
5. Case studies

Meaningful IRFs?



Impulse Response Functions Philippines

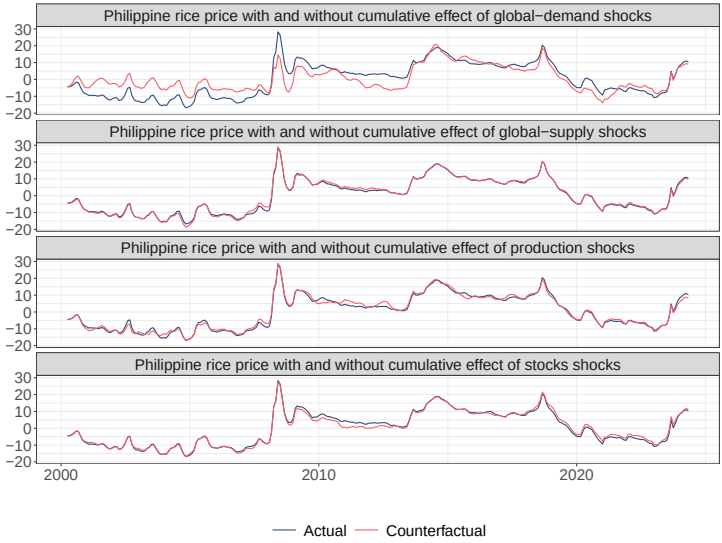


Responses of Philippine rice prices, production, and stocks to structural shocks.

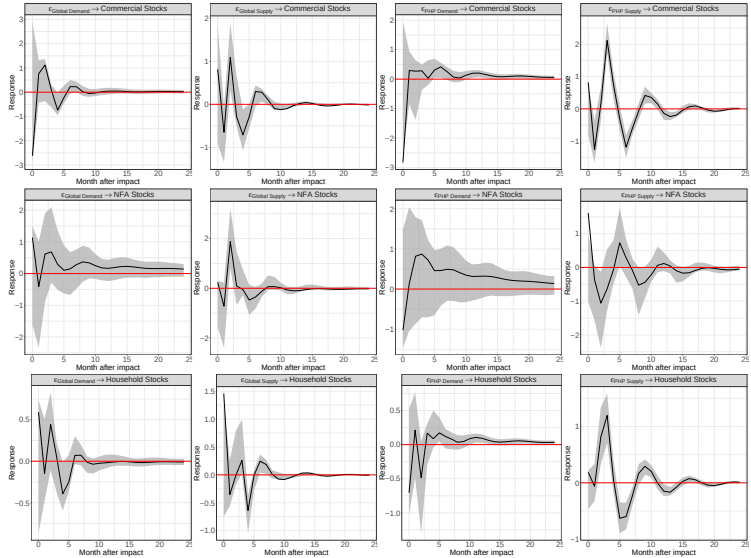
Findings

- Global-demand shocks transmit quickly and strongly.
- Domestic production shocks modest and short-lived.
- Responses and effects from stocks
- Overall: external forces dominate, inventories moderate.

Counterfactual Analysis

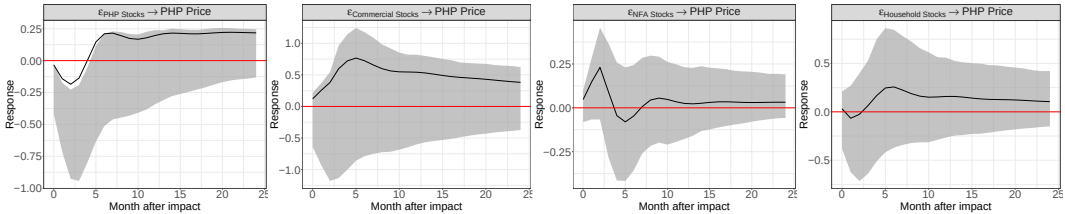


Holder-Specific IRFs



Responses of commercial, NFA, and household stocks to global/domestic shocks.

Stock Shocks and Domestic Prices



Commercial $>$ Household $>$ NFA in short-run price impact; complementary roles.

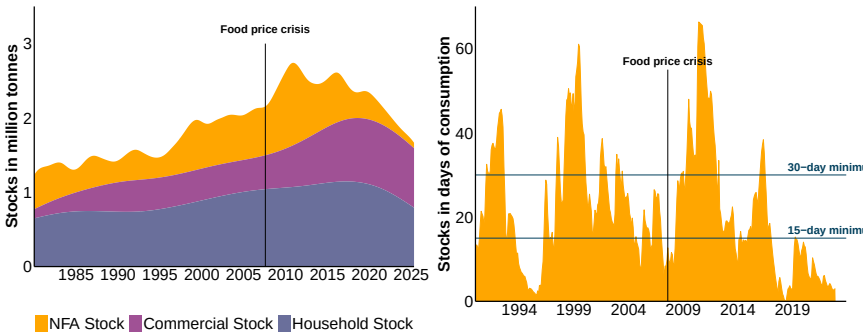
Case studies

We use historical decompositions to analyze

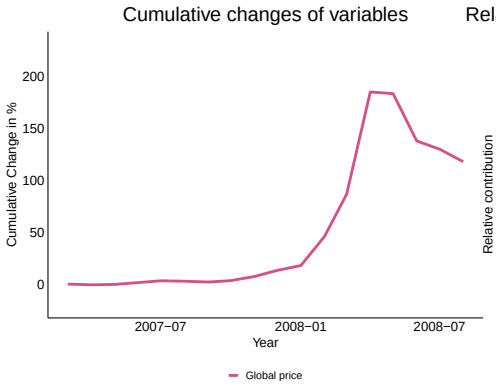
1. Global demand shock: Food price crisis of 2007-08
2. Domestic production shock: Hurricanes Ketsana and Parma of 2009
3. Global supply (trade) shock: India's rice export ban of 2023

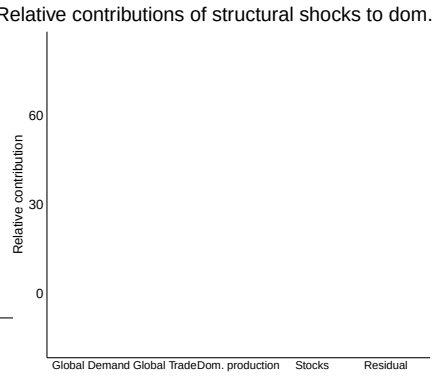
Historical decomposition I: 2007–08 Global Demand Shock

- Rapid income growth across Asia, biofuel expansion, and export bans in India, Vietnam, Egypt, and Cambodia triggered a sharp surge in world food prices, including rice prices.
- NFA held reserves above the 15-day statutory minimum.
- Mandate allowed imports and budget flexibility.



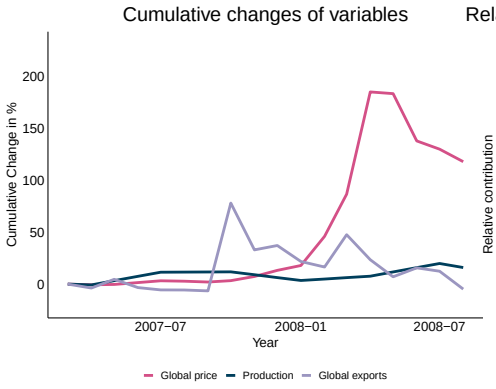
Historical decomposition I 1: 2007–08 Global Demand Shock

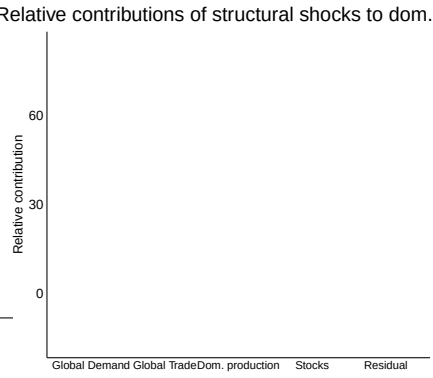




- World prices +185%
-
-

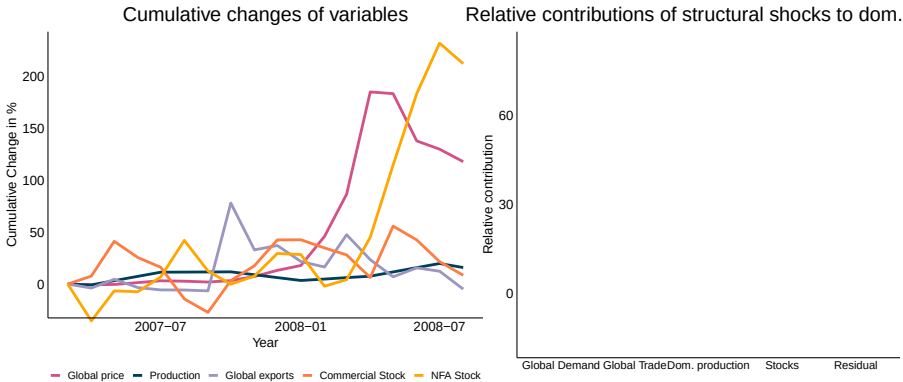
Historical decomposition I 1: 2007–08 Global Demand Shock





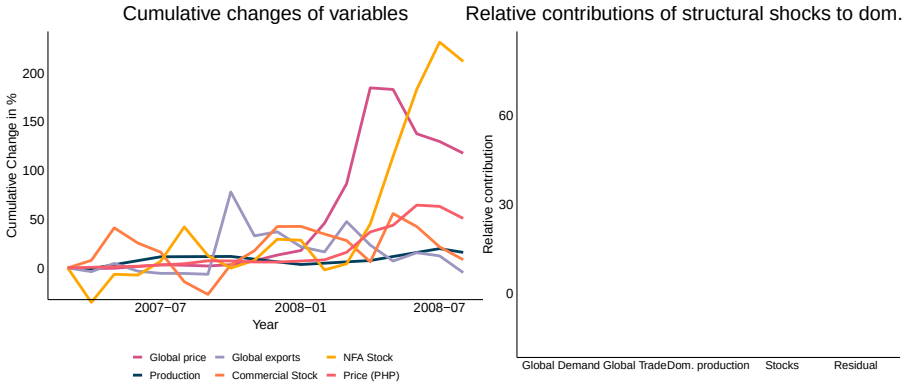
- World prices +185%
-
-

Historical decomposition I 1: 2007–08 Global Demand Shock



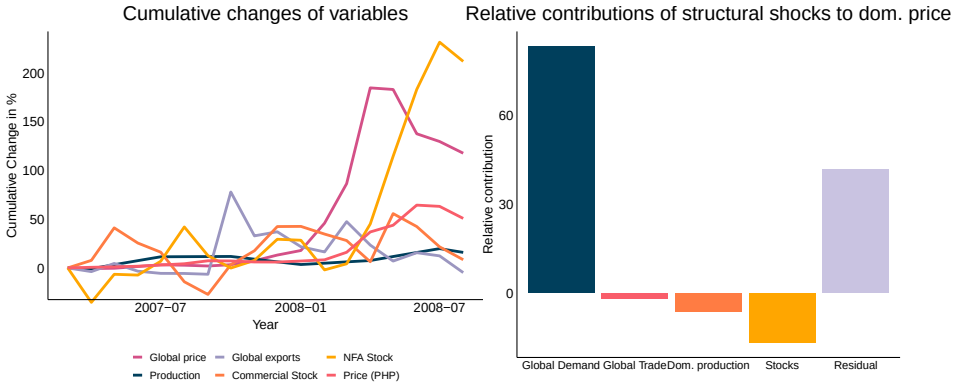
- World prices $+185\%$
- Commercials by and sell, NFA doubled reserves twice starting in spring of 2008
-

Historical decomposition I 1: 2007–08 Global Demand Shock



- World prices $+185\%$
- Commercials buy and sell, NFA doubled reserves twice starting in spring of 2008
- Philippine retail **only +64%**

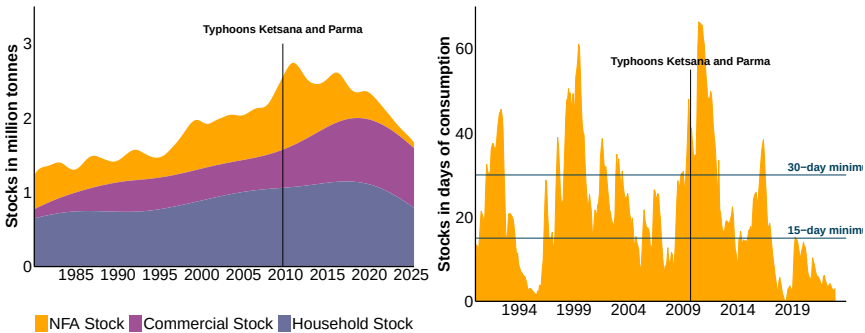
Historical decomposition I 1: 2007–08 Global Demand Shock



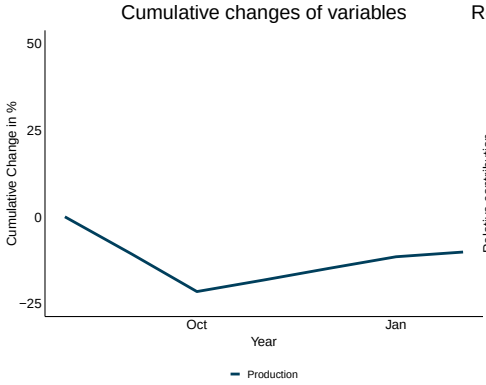
- World prices $+185\%$,
- Commercials buy and sell, NFA doubled reserves twice starting in spring of 2008
- Philippine retail **only +64%**, model attributes downward pressure to stocks

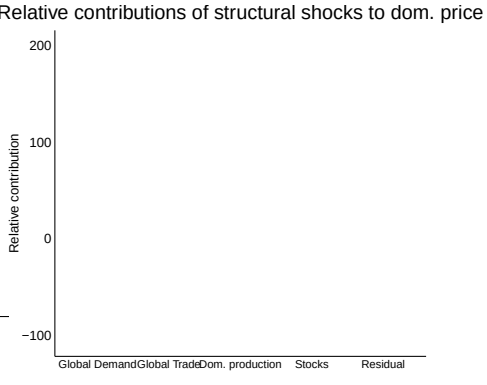
Historical decomposition II: Domestic supply Shock — Typhoons Ketsana & Parma (2009)

- Two major typhoons, Ketsana (Ondoy) and Parma (Pepeng), hit Luzon in Sept–Oct 2009
- Flooding damaged about 460,000 hectares of rice land, destroying 839,000 metric tons of paddy
- 13% shortfall in quarterly production target



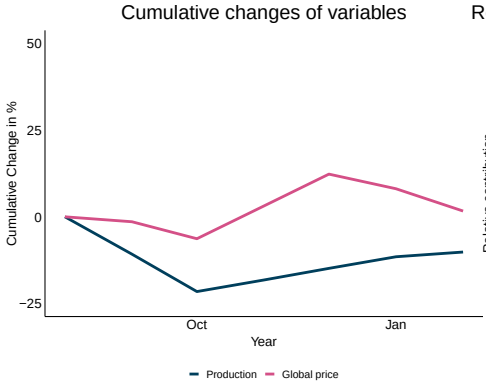
Historical decomposition II: 2009 Typhoons (Domestic Supply Shock)

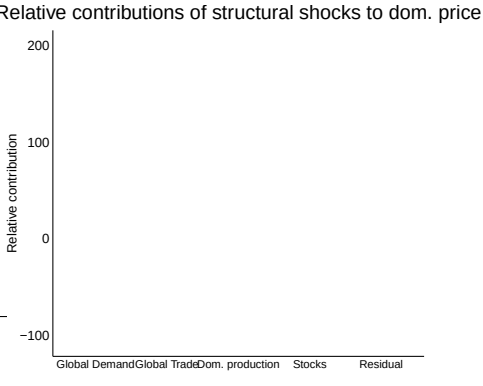




- Typhoons Ketsana and Parma reduce output by 20% in fall of 2009
- International prices were going up, yet domestic prices remained flat ($+1\%$)
- Commercials built stock, private released, aggregate effect of stocks positve on price

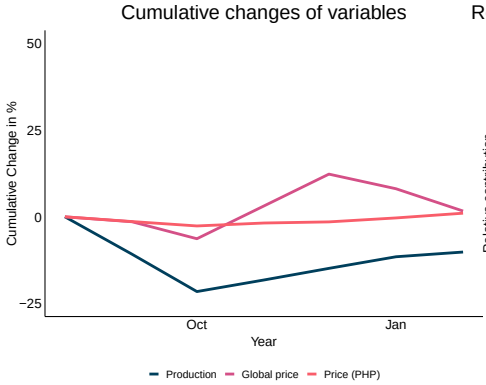
Historical decomposition II: 2009 Typhoons (Domestic Supply Shock)

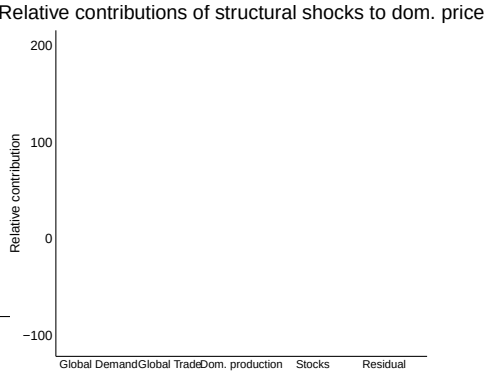




- Typhoons Ketsana and Parma reduce output by 20% in fall of 2009
- International prices were going up, yet domestic prices remained flat ($+1\%$)
- Commercials built stock, private released, aggregate effect of stocks positve on price

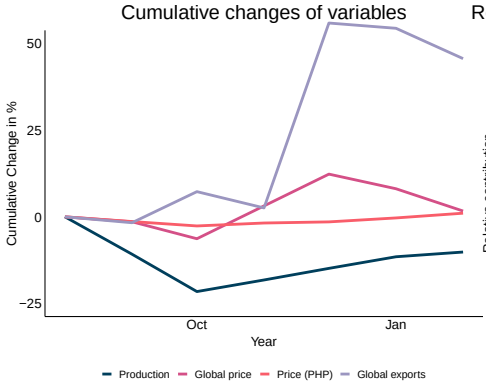
Historical decomposition II: 2009 Typhoons (Domestic Supply Shock)

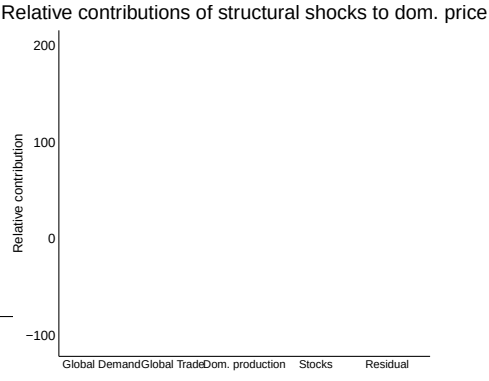




- Typhoons Ketsana and Parma reduce output by 20% in fall of 2009
- International prices were going up, yet domestic prices remained flat ($+1\%$)
- Commercials built stock, private released, aggregate effect of stocks positve on price

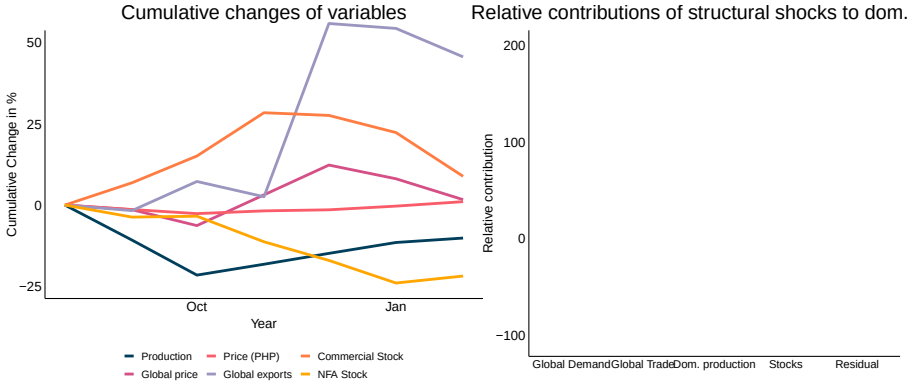
Historical decomposition II: 2009 Typhoons (Domestic Supply Shock)





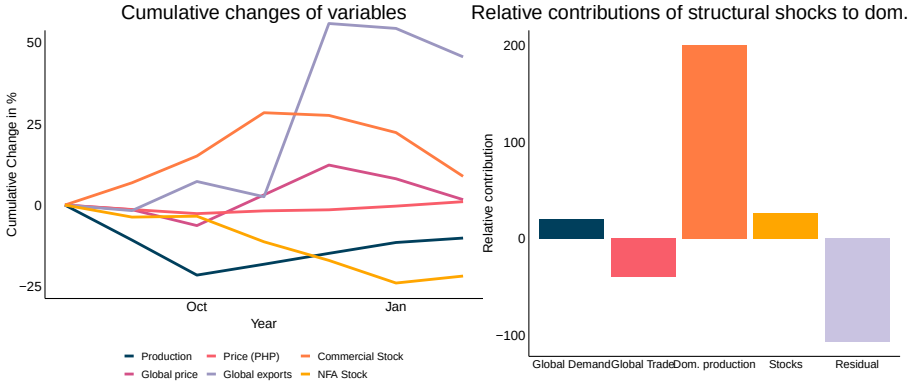
- Typhoons Ketsana and Parma reduce output by 20% in fall of 2009
- International prices were going up, yet domestic prices remained flat ($+1\%$)
- Commercials built stock, private released, aggregate effect of stocks positve on price

Historical decomposition II: 2009 Typhoons (Domestic Supply Shock)



- Typhoons Ketsana and Parma reduce output by 20% in fall of 2009
- International prices were going up, yet domestic prices remained flat ($+1\%$)
- Commercials built stock, private released, aggregate effect of stocks positve on price

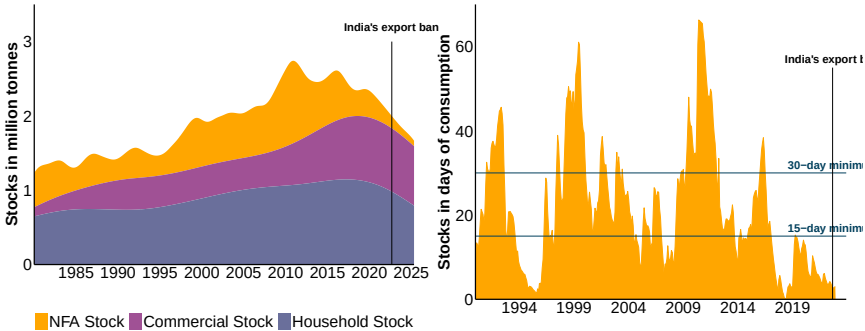
Historical decomposition II: 2009 Typhoons (Domestic Supply Shock)



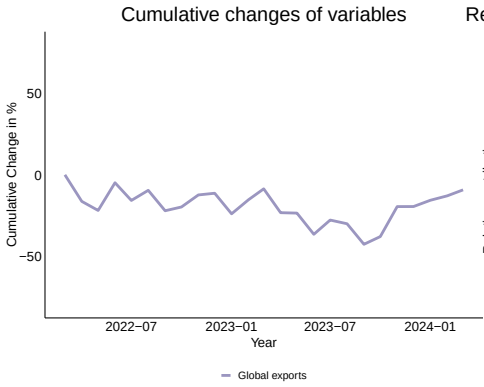
- Typhoons Ketsana and Parma reduce output by 20% in fall of 2009
- International prices were going up, yet domestic prices remained flat ($+1\%$)
- Commercials built stock, private released, aggregate effect of stocks positve on price

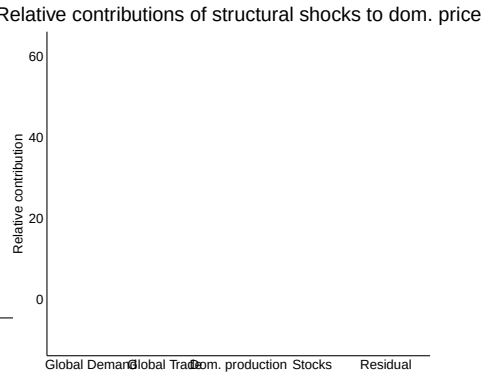
Historical decomposition III: Global trade shock — India's Export Ban (2022–2023)

- Sept 2022: India bans exports of *broken rice*; July 2023: ban extends to most non-basmati white rice
- Domestic inflation, El Niño risk; limited country-specific exemptions.
- NFA restricted to domestic procurement; public reserves down to 3–5 days (below legal minimum).



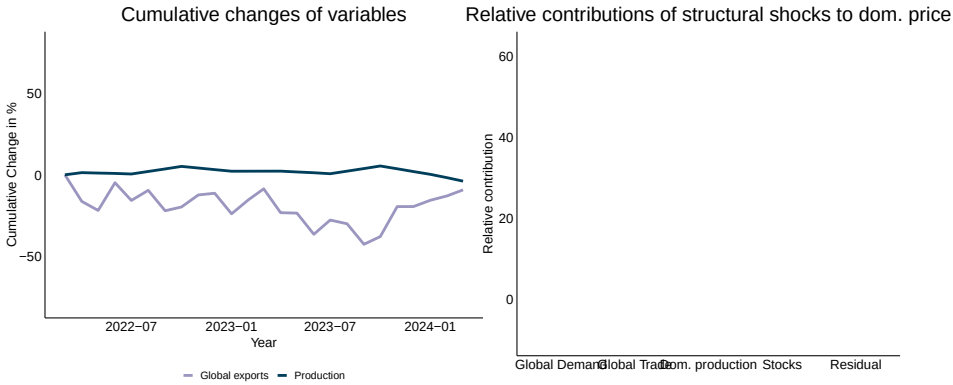
Historical decomposition III: India Export Ban (2022–23)





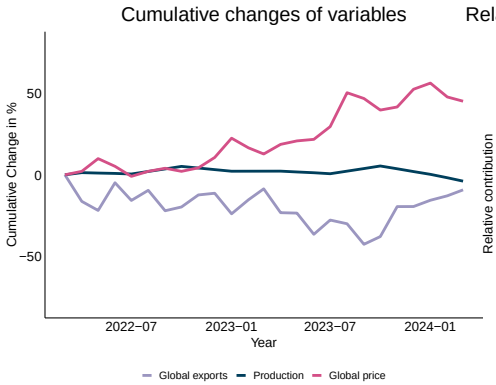
- Global exports –35%
-
-

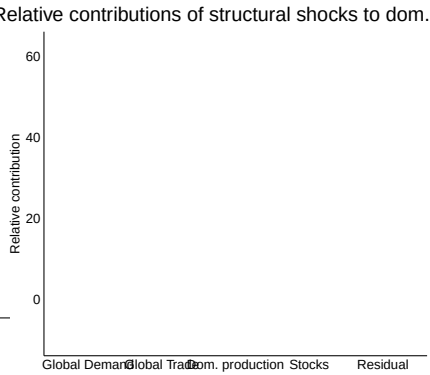
Historical decomposition III: India Export Ban (2022–23)



- Global exports –35%
-
-

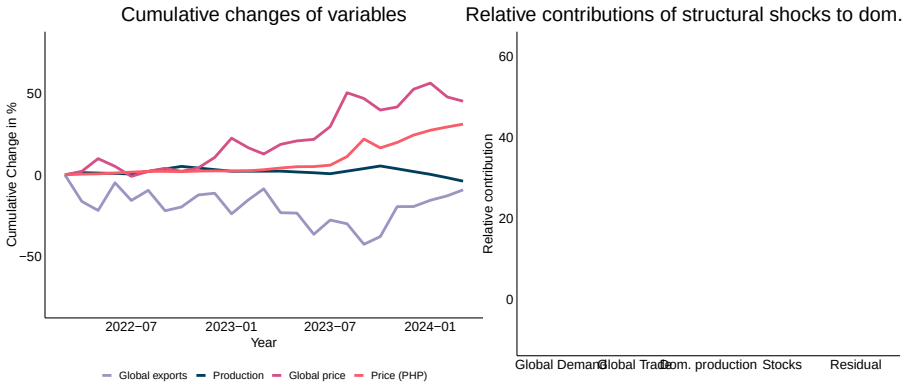
Historical decomposition III: India Export Ban (2022–23)





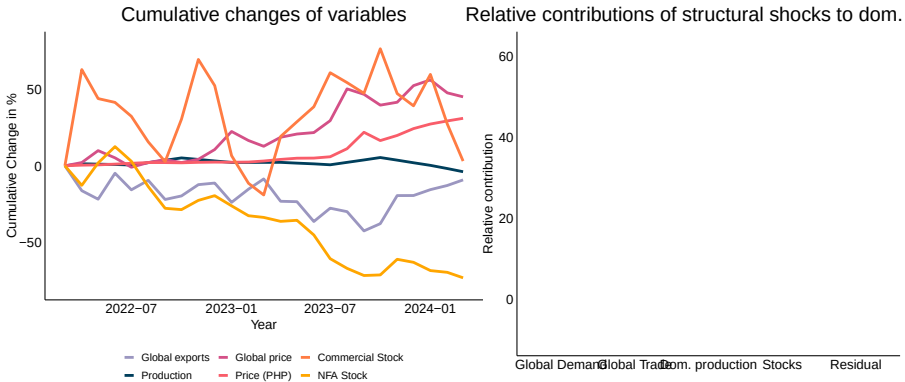
- Global exports –35%, prices +45%.
-
-

Historical decomposition III: India Export Ban (2022–23)



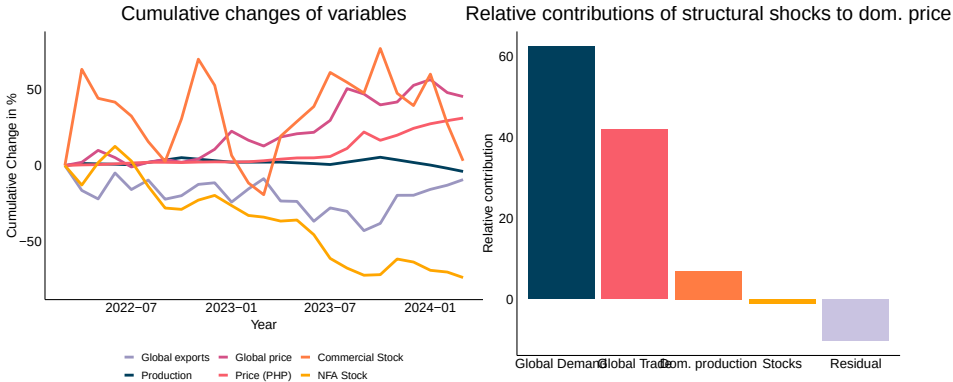
- Global exports –35%, prices +45%.
- Philippine price increases by 31%
-

Historical decomposition III: India Export Ban (2022–23)



- Global exports –35%, prices +45%.
- Philippine price increases by 31%, strong commercial storage activity, NFA releases
-

Historical decomposition III: India Export Ban (2022–23)



- Global exports –35%, prices +45%.
- Philippine price increases by 31%, strong commercial storage activity, NFA releases
- Contribution of stocks negligible

Policy Lessons

1. NFA stock policy worked well during a global demand shock (2007/2008) and a domestic production shock (2009)
2. Stocks exerted substantial downward pressure during 2007 and 2009
3. Commercial stocks helped push prices upwards during domestic supply shock
4. Stocks had no effect, in spite of strong activity, during the trade shock of 2023, when NFA had no import mandate and less financing options

Back-of-the-Envelope fiscal comparison

- Welfare analysis is an expected utility problem and needs to consider producers and consumers
- So far, beyond the scope of the paper
- Back-of-the envelop calculation for the case of the Indian export ban - consumer only:
  - RTL savings: have been about 5 billion PHP/year compared to pre-RTL level
  - 2023 consumer loss from price surge was 162 billion PHP.
  - The policy is worth paying for as long as there is an extreme global shock every 32.5 years

Lessons for stock policy design

- Our study design relies on structural shock identification and event studies related to a policy change in one large importing country
- Public stocks should not follow competitive storage mechanism, but complement it
- Instead of *buy low and sell high*, public stocks should *buy high and sell low*
- Rule-based small buffer size (Consistent with (Gouel and Jean, 2013))
- Allow import flexibility during global price lows
- Separate farm-support goals from stabilization function
- Sufficient budget allocation (**Whatever-it-takes**), anecdotally, this is likely cheaper than the alternative

Conclusions

- Inventories, tied to trade policy mitigate volatility but effectiveness depends on stock holder and size.
- Public and private stocks have distinct purposes,
  - Commercial stocks smooth prices, help keep prices high after domestic production shocks
  - Public stocks counter act, buy when nobody else can buy ("whatever it takes")
- Modest, flexible public stocks are complements to private storage and do not crowd out
- Stock programs should address price stability, farm policy and trade policy elements can distort the buffering effect

Anderson, T. W. and Rubin, H. (1949). Estimation of the parameters of a single equation in a complete system of stochastic equations. *The Annals of mathematical statistics*, 20(1):46–63.

Balié, J. and Valera, H. G. (2020). Domestic and international impacts of the rice trade policy reform in the philippines. *Food Policy*.

Baumeister, C. and Kilian, L. (2014). Do oil price increases cause higher food prices? *Economic Policy*, 29(80):691–747.

Berger, J., Dalheimer, B., and Brümmer, B. (2021). Effects of variable eu import levies on corn price volatility. *Food Policy*, page 102063.

Bobenrieth, E., Wright, B., and Zeng, D. (2013). Stocks-to-use ratios and prices as indicators of vulnerability to spikes in global cereal markets. *Agricultural Economics*, 44(s1):43–52.

Bobenrieth, E. S., Bobenrieth, J. R., Guerra, E. A., Wright, B. D., and Zeng, D. (2021). Putting the empirical commodity storage model back on track: Crucial implications of a "negligible" trend. *American Journal of Agricultural Economics*, 103(3):1034–1057.

Briones, R. M. (2018). The rice economy and the role of policy in southeast asia. *Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA)*.

Cafiero, C., Wright, B. D., et al. (2011). The empirical relevance of the competitive storage model. *Journal of Econometrics*, 162(1):44–54.

Dalheimer, B., Herwartz, H., and Lange, A. (2021). The threat of oil market turmoils to food price stability in sub-saharan africa. *Energy Economics*, 93:105029.

Dong, F., Beckman, J., and Arita, S. (2025). Unraveling demand and supply shocks in the us nitrogen market. *Applied Economic Perspectives and Policy*.

Dorosh, P. A. (2008). Food price stabilisation and food security: International experience. *Bulletin of Indonesian Economic Studies*, 44(1):93–114.

Gouel, C. (2013). Rules versus discretion in food storage policies. *American Journal of Agricultural Economics*, 95(4):1029–1044.

Gouel, C. (2014). Food price volatility and domestic stabilization policies in developing countries. In *The economics of food price volatility*, pages 261–306. University of Chicago Press.

Gouel, C. (2016). Trade policy coordination and food price volatility. *American Journal of Agricultural Economics*, 98(4):1018–1037.

Gouel, C., Gautam, M., and Martin, W. J. (2016). Managing food price volatility in a large open country: the case of wheat in india. *Oxford Economic Papers*, 68(3):811–835.

Gouel, C. and Jean, S. (2013). Optimal Food Price Stabilization in a Small Open Developing Country. *The World Bank Economic Review*, 29(1):72–101.

Jayne, T. S., Zulu, B., and Nijhoff, J. (2006). Stabilizing food markets in eastern and southern africa. *Food Policy*, 31(4):328–341.

Larch, M., Luckstead, J., and Yotov, Y. V. (2024). Economic sanctions and agricultural trade. *American Journal of Agricultural Economics*.

Larson, D. F., Lampietti, J., Gouel, C., Cafiero, C., and Roberts, J. (2014). Food security and storage in the middle east and north africa. *The World Bank Economic Review*, 28(1):48–73.

Pieters, H. and Swinnen, J. (2016). Trading-off volatility and distortions? food policy during price spikes. *Food Policy*, 61:27–39.

Rude, J. and An, H. (2015). Explaining grain and oilseed price volatility: The role of export restrictions. *Food Policy*, 57:83–92.

Tripathi, A. K. and Mishra, A. K. (2024). Effect of public stockholding on wheat price dynamics in india: A quantile autoregression approach. *Australian Journal of Agricultural and Resource Economics*, 68(1):168–185.

Ubilava, D., Valera, H. G., and Pede, V. (2022). The rice market reaction to el nino southern oscillation shocks. *MPRA Paper No. 123384, University Library of Munich, Germany*.

Valera, H. G., Mayorga, J., Pede, V. O., and Mishra, A. K. (2022). Estimating food demand and the impact of market shocks on food expenditures: The case for the philippines and missing price data. *Q Open*, 2(2):qoac030.

Valera, H. G., Yamano, T., and Pede, V. O. (2021). Impact of rice trade policy in southeast asia. *International Association of Agricultural Economists Conference*.

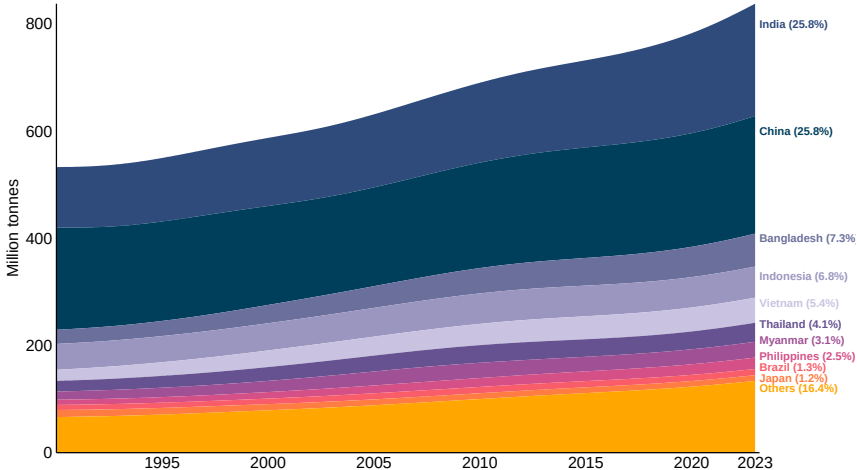
Wright, B. D. and Williams, J. C. (1982). The economic role of commodity storage. *The Economic Journal*, 92(367):596–614.

Yao, R. T., Shively, G. E., and Masters, W. A. (2005). How successful are government interventions in food markets? insights from the philippine rice market. *Philippine Journal of Development*, 1(34):35:59.

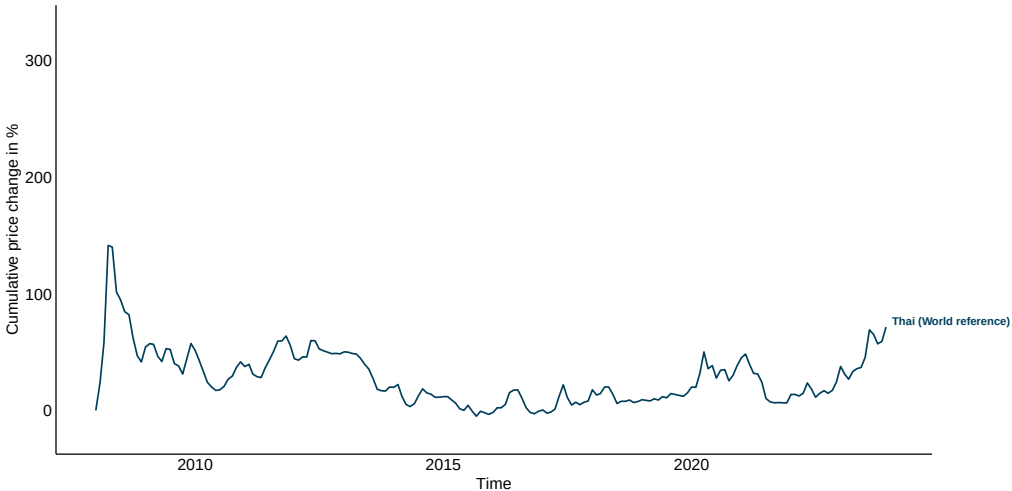
B matrix

$$\widetilde{\widetilde{\mathrm{B}}} = \begin{bmatrix} 4.676 \\ (10.291) & -0.53 \\ (-0.988) & 0.731 \\ (0.392) & -0.424 \\ (-0.946) & 0.446 \\ (0.666) \\ 1.402 \\ (0.958) & 12.176 \\ (40.441) & 1.711 \\ (1.722) & 1.433 \\ (1.278) & 1.275 \\ (0.712) \\ 0.105 \\ (0.167) & -0.096 \\ (-0.636) & 1.647 \\ (10.426) & -0.05 \\ (-0.52) & -0.034 \\ (-0.155) \\ 0.081 \\ (0.294) & -0.332 \\ (-1.268) & -0.037 \\ (-0.22) & 2.917 \\ (108.296) & -0.123 \\ (-0.597) \\ -0.992 \\ (-0.894) & -0.312 \\ (-0.284) & -1.098 \\ (-1.119) & 0.482 \\ (0.901) & 7.5 \\ (31.188) \end{bmatrix} \quad (1)$$

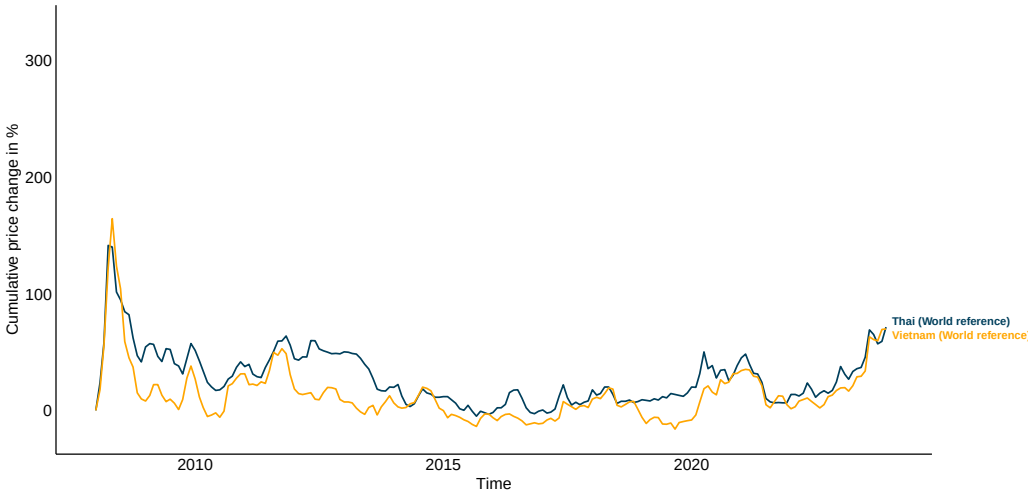
World Rice Production



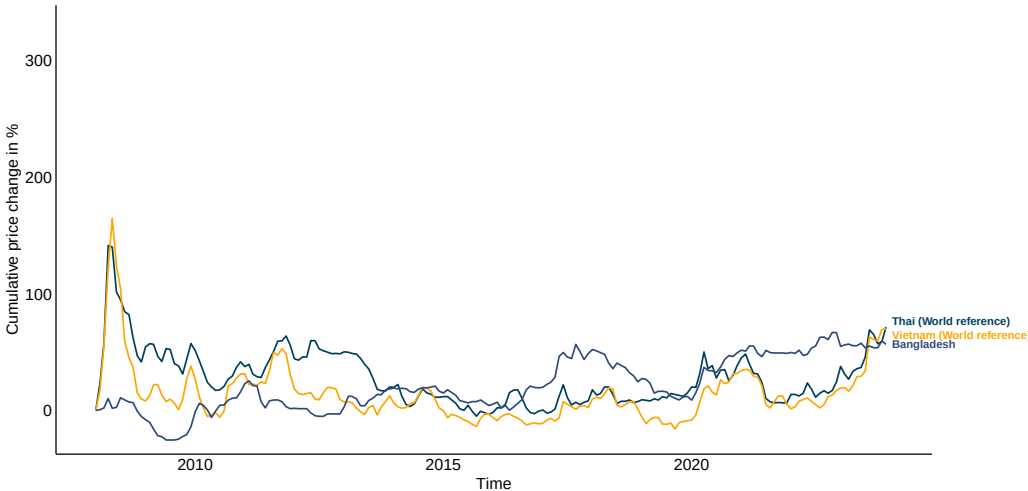
International Rice Prices



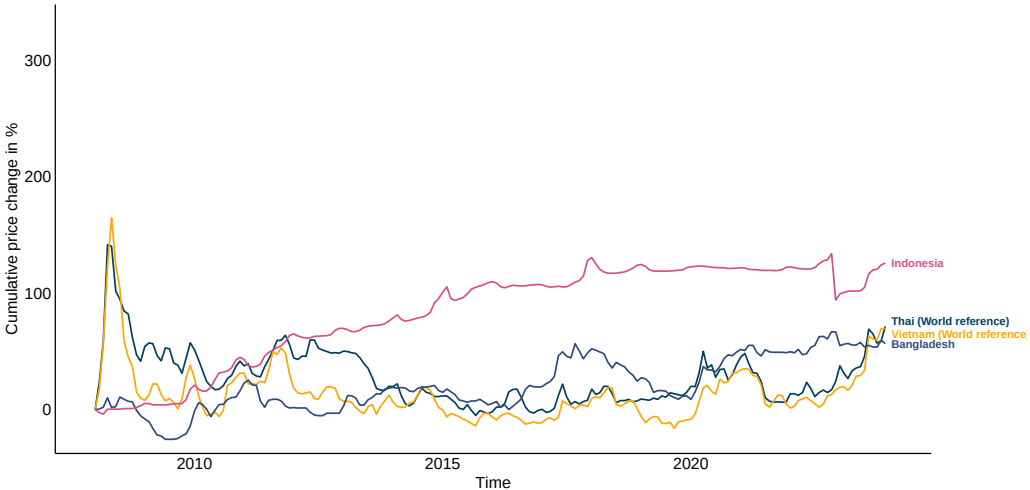
International Rice Prices



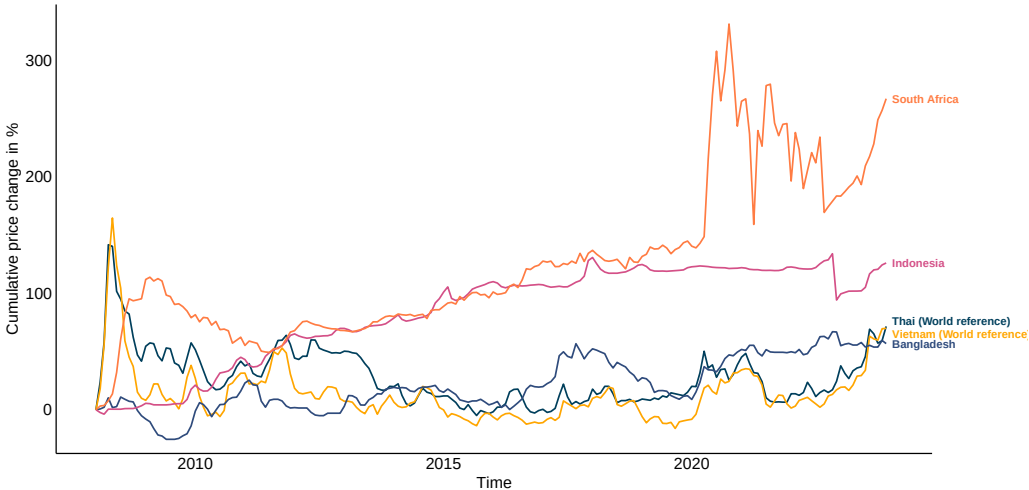
International Rice Prices



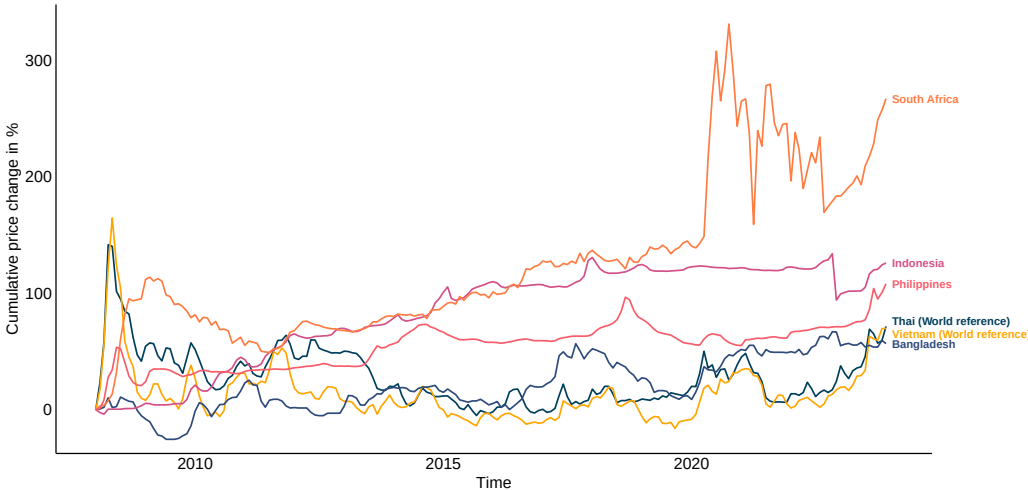
International Rice Prices



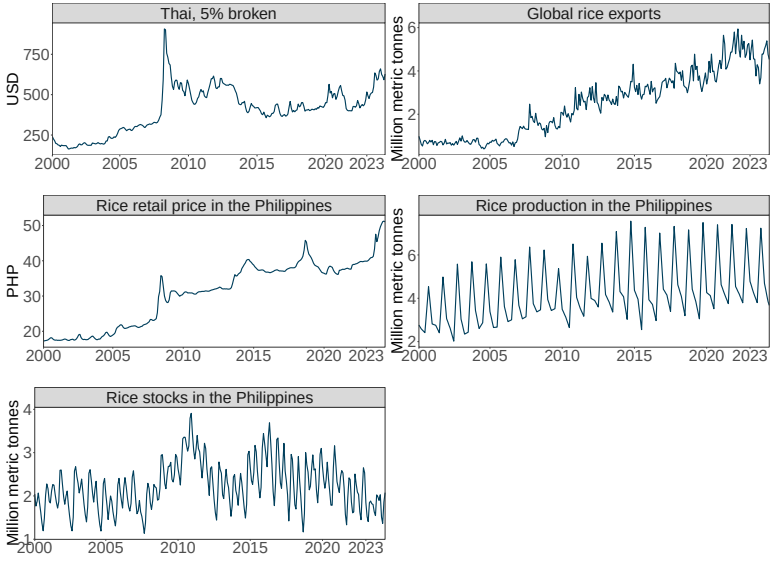
International Rice Prices



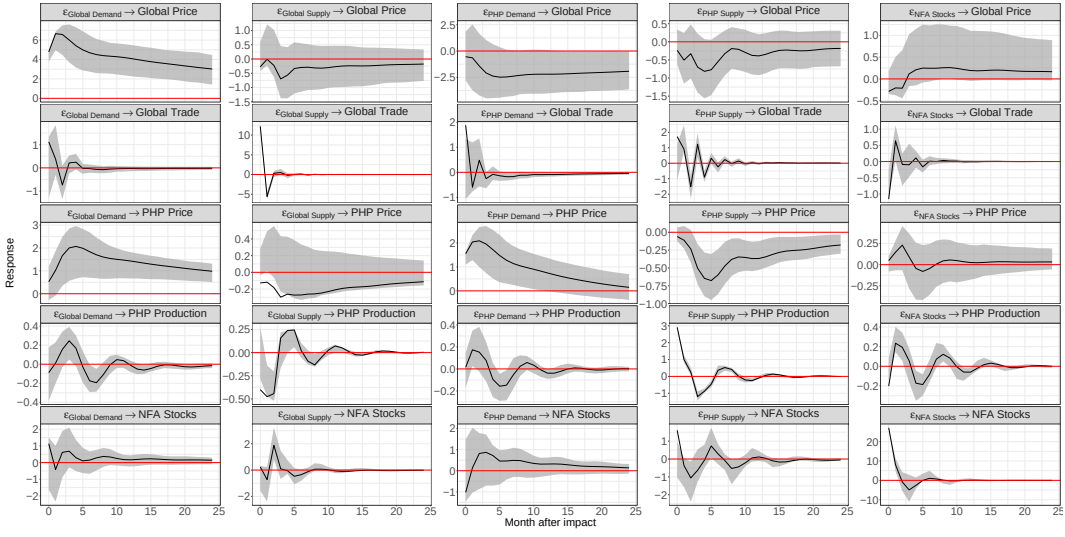
International Rice Prices



Data


Thai, 5% broken
USD
750
500
250
2000
2005
2010
2015
2020
2023
Global rice exports
Million metric tonnes
6
4
2
Rice retail price in the Philippines
PHP
50
40
30
20
Rice production in the Philippines
Million metric tonnes
Rice stocks in the Philippines
Million metric tonnes
4
3
2
1

SVAR with NFA stocks



Independence diagnostics

Table: Shapiro-Wilk test for normality of rice market shocks

Shock	ε_{p_t}	ε_{X_t}	$\varepsilon_{p_t^{PHP}}$	ε_{q_t}	ε_{S_t}
W	0.95^{***}	0.99^{**}	0.86^{***}	0.89^{***}	0.99
	(0.00)	(0.02)	(0.00)	(0.00)	(0.14)

Notes: The Shapiro–Wilk test evaluates H_0: the sample is drawn from a normal distribution; H_1: non-normality. W ranges from 0 to 1, with larger values indicating closer conformity to normality. Two-sided p-values are reported.

Independence diagnostics