Caught in a Sovereign Debt Quagmire – A Quantitative Assessment

Chia-Wei Chen Tai-kuang Ho

Oct 31, 2024

Overview

Debt Trap

A port lent for 99 years, and the emptiest ariport

國際 中 雙語 英

無力償還債務，斯里蘭卡將戰略港口移交中國

KAI SCHULTZ
2017年12月13日

位於斯里蘭卡南部海岸的漢班托塔港。 LAKRUWAN WANNIARACHCHI/AGENCE FRANCE-PRESSE — GETTY IMAGES

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Source: NYTimes

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Source: NYTimes

Source：Forbes

A Crucial Role in BRI

s: Mercator Institute for China Studies; HKTDC Research; *The Economist*

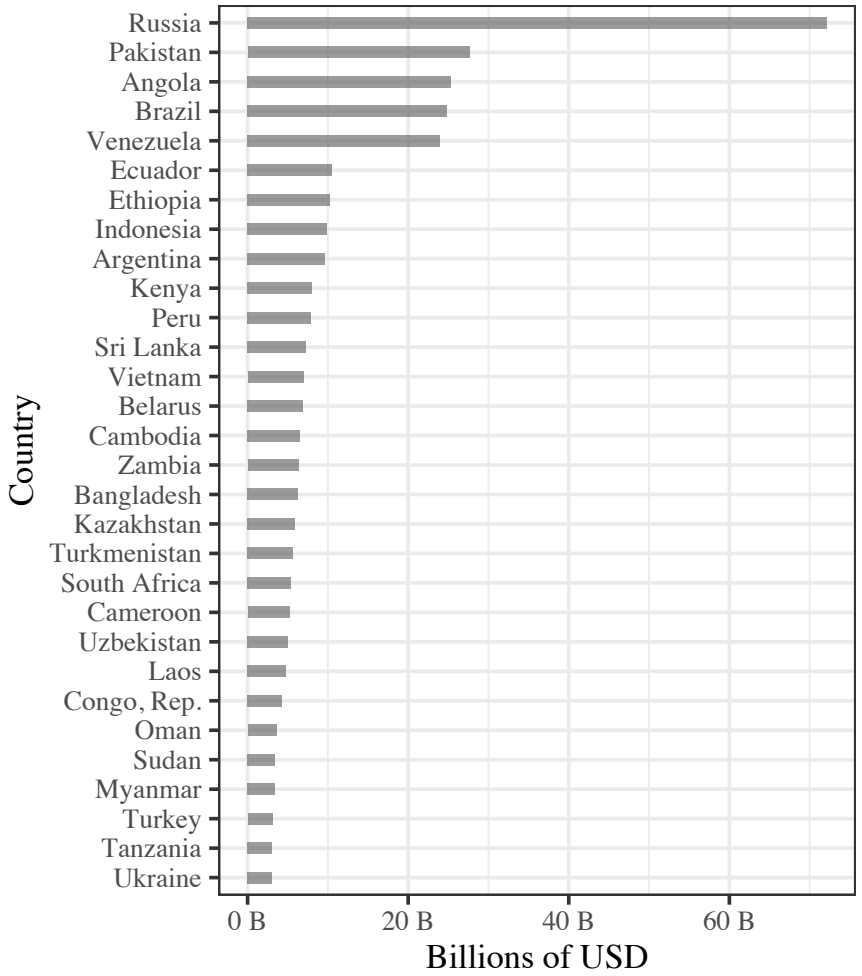
Dept-Trap Diplomacy

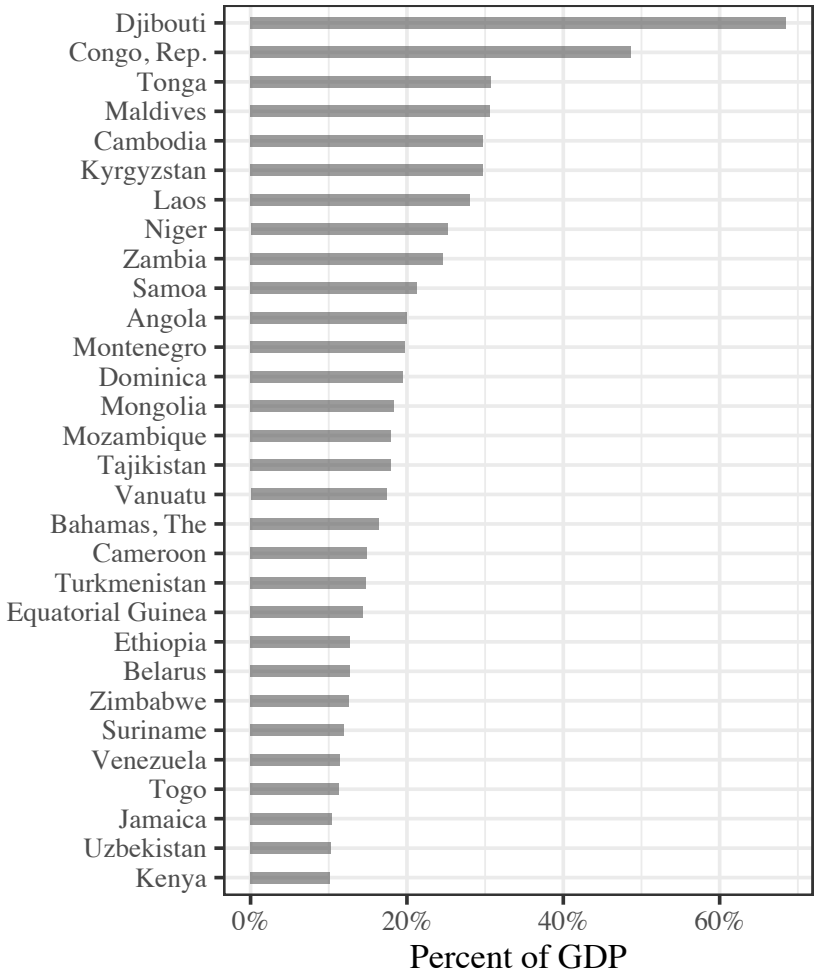
First mentioned in Chellaney (2017)

Debt-trap Diplomacy

The creditor country is said to extend excessive credit to a debtor country with the intention of extracting economic or political concessions when the debtor country becomes unable to meet its repayment obligations.

Debt to China





Sri Lanka Project List

Hambantota Port

- Initiated: 2007
- 2008: Phase I, $307 million from Chinese Exim Bank, 6% rate
- 2012: Phase II, $304 million
- 2017: 99-year lease, 70% sale to China Merchant Port

Mattala Rajapaksa International Airport

- 2009: $181 million from Chinese Exim Bank, 2% rate
- 2013: Open
- 2014: 21,000 passengers only
- "The world's emptiest airport'

Road Projects

- 2009: $1.14 billion Colombo-Katunayake Expressway (CKE)
- 2010&2011: 1.51%
- 2014: $1.99 on road construction and improvement

Zambia Project List

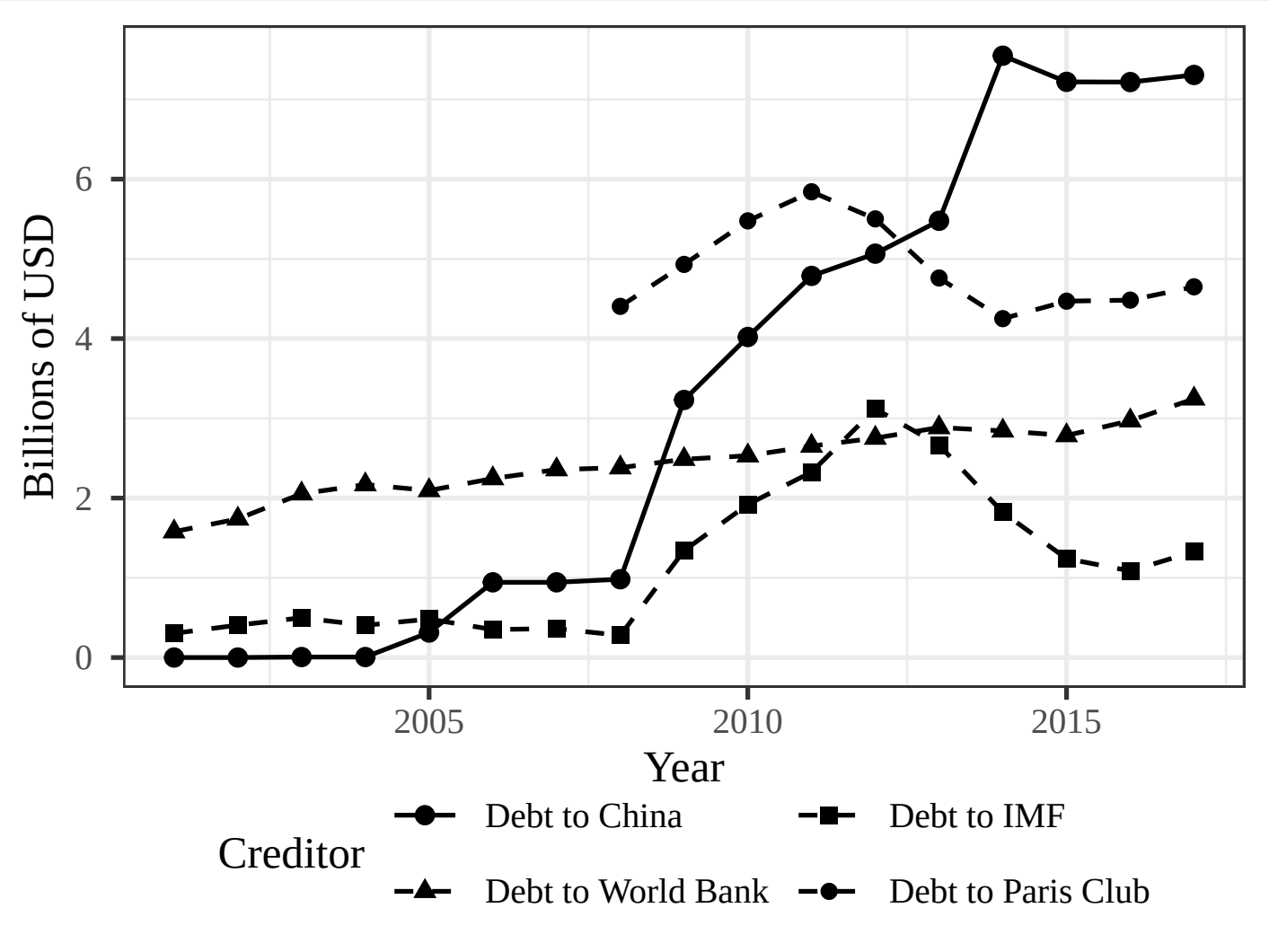
Hydropower Station

- Initiated: 2015
- 2017: $1.5 billion from Chinese Exim Bank and Industrial and Commercial Bank of China

Telecommunication

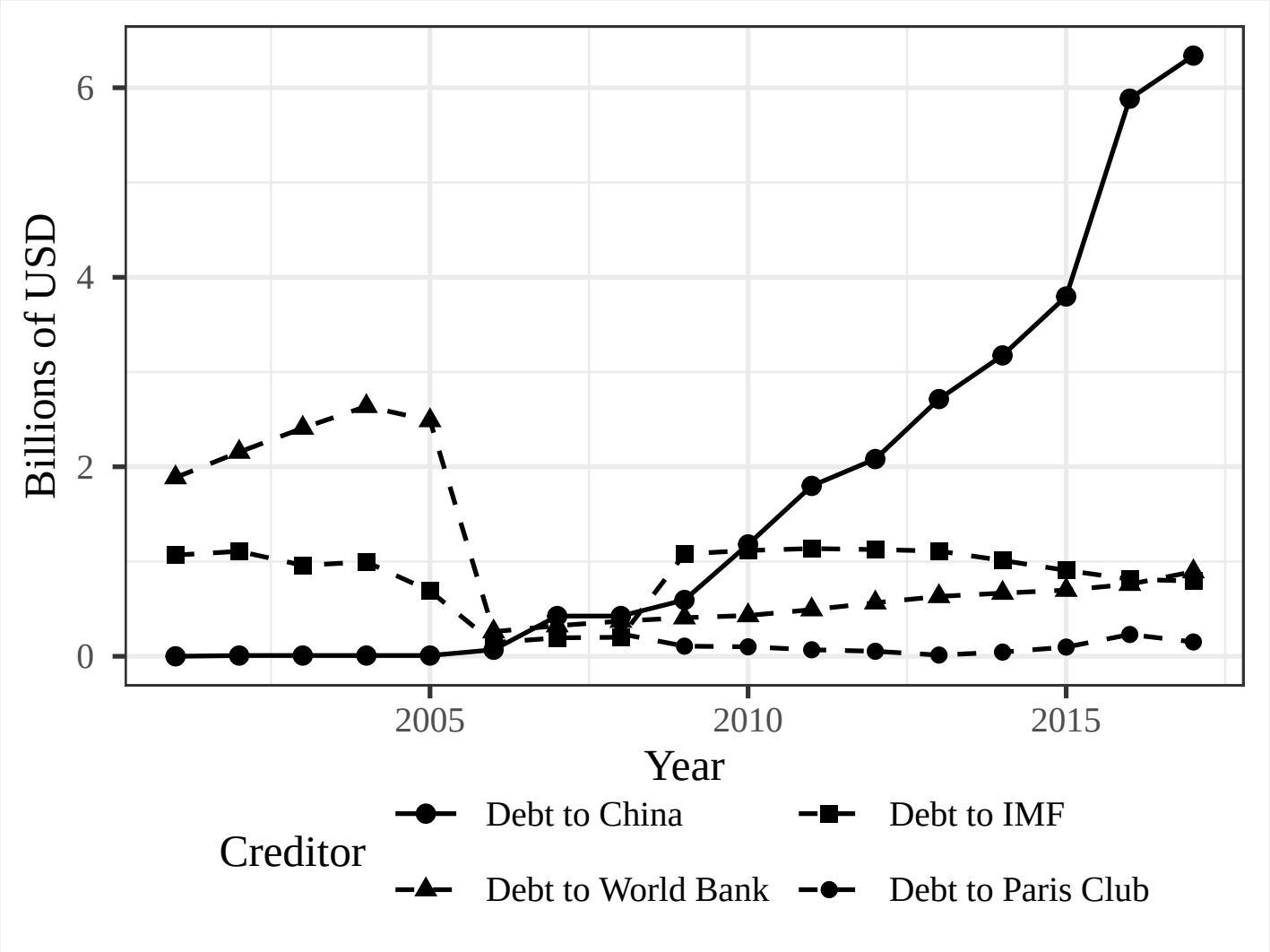
- Zambia National Broadcasting (ZNBC) and StarTimes (四達時代) joint revenue - Topstar Communications Company.
- StarTimes own 60%
- 2017: $280 million from Exim
- The first interest payment: $2.3 million due in July 2017 was not paid on time
- StarTimes has thus taken over some of ZNBC activities, and will manage Topstar until the loan has been paid in full (Ofstad and Tjønneland, 2019).

China's Lending to Sri Lanka



Source: Horn, Reinhart and Trebesch (2021)

China's Lending to Zambia



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Our question: Did China Lend too much?

Debt-trap Diplomacy

The creditor country is said to extend excessive credit to a debtor country with the intention of extracting economic or political concessions when the debtor country **becomes unable to meet its repayment obligations**.

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Key feature here is to model “default“.

Past Studies on the Narative

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- Hurley et al. (2019) : Evaluate the debt sustainability in BRI countries by examining their dept-to-GDP ratio versus their share of China's debt
  - Following the threshold of 50-6% rising debt-to-GDP ratio constructed by Chudik et al. (2015), they identify eight countries that are particularly risky.
  - threshold is cross-country panel threshold output growth model

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  - threshold is cross-country panel threshold output growth model
- Bandiera and Tsiropoulos (2020) analyze the growth effects of BRI investment and estimates the potential increase in debt vulnerabilities for certain countries through a model-based growth projection.

Model

Model Setting

- Na et al. (2018)
- Decentralized version of Eaton-Gersovitz model
- Tradable vs Nontradable goods
- Household, Firm, Government, Foreign lender

Household

- Maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t) \tag{1}$$

- Utility function

$$U(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma} \tag{2}$$

- Aggregation function for consumption

$$c_t = A(c_t^T, c_t^N) = \left[a \left(c_t^T\right)^{1-\frac{1}{\xi}} + (1-a) \left(c_t^N\right)^{1-\frac{1}{\xi}} \right]^{\frac{1}{1-\frac{1}{\xi}}} \tag{3}$$

- Budget constraint

$$P_t^T c_t^T + P_t^N c_t^N + P_t^T d_t = P_t^T \tilde{y}_t^T + W_t h_t + (1-\tau_t^d) P_t^T q_t^d d_{t+1} + F_t + \Phi_t \tag{4}$$

- Working hours

$$h_t \leq \bar{h} \tag{5}$$

HH F.O.C

Notation: $p_t \equiv \frac{P_t^N}{P_t^T}$, $w_t = \frac{W_t}{P_t^T}$, $f_t = \frac{F_t}{P_t^T}$, and $\phi_t = \frac{\Phi_t}{P_t^T}$

$$p_t = \frac{A_2(c_t^T, c_t^N)}{A_1(c_t^t, c_t^N)} \tag{6a}$$

$$\lambda_t = U'(c_t) A_1(c_t^T, c_t^N) \tag{6b}$$

$$(1 - \tau_t^d) q_t^d \lambda_t = \beta E_t \lambda_{t+1} \tag{6c}$$

Firms

- Technology

$$y_t^N = F(h_t) \tag{7}$$

- Profit

$$\Phi_t(h_t) = P_t^N F(h_t) - W_t h_t \tag{8}$$

- F.O.C

$$p_t F'(h_t) = w_t \tag{9}$$

Downward Wage Rigidity

$$W_t \geq \gamma W_{t-1}, \qquad \gamma > 0 \tag{10}$$

This implies that the growth rate $\frac{W_t - W_{t-1}}{W_{t-1}} \geq \gamma - 1$

Slackness condition

$$(\bar{h} - h_t)(W_t - \gamma W_{t-1}) = 0 \tag{11}$$

Government

Government decides to default of not for the economy

- If repay $(I = 1)$: able to lend in $t+1$, or $d_{t+1} > 0$
- If default $(I = 0)$: excluded from international credit market, $d_{t+1} = 0$

Written as slackness condition

$$(1 - I_t)\, d_{t+1} = 0 \tag{12}$$

Government returns tax to household via lump-sum transfer

$$f_t = \tau_t^d q_t^d d_{t+1} + (1 - I_t)\, d_t \tag{13}$$

- If repay $(I = 1)$: gives back $\tau_t^d q_t^d d_{t+1}$
- If default $(I = 0)$: further distribute current debt d_t

Foreign lender

- Risk neutral
- If country in good standing, offer price q_t for debt that returns 1 unit of $d_{t+1} \rightarrow$ return on debt $= \frac{1}{q_t}$
- take future default events into evaluation

$$\frac{\Pr(I_{t+1} = 1 \mid I_t = 1)}{q_t} = 1 + r^* \tag{14}$$

- Slackness condition

$$I_t \left[q_t - \frac{E_t I_{t+1}}{1 + r^*} \right] = 0$$

Competitive Equilibrium I

Output

- Nontradable goods

$$c_t^N = y_t^N \tag{15}$$

- tradable goods

$$\ln(y_t^T) = \rho \ln(y_{t-1}^T) + \mu_t \tag{16}$$

- Endowment loss under bad standing $(I_t = 0)$

$$\tilde{y}_t^T = \begin{cases} y_t^T - L(y_t^T) & \text{if } I_t = 0 \\ y_t^T & \text{otherwise.} \end{cases} \tag{17}$$

- $L(y_t^T) = \max\{0, \delta_1 y_t^T + \delta_2 (y_t^T)^2\}$

Competitive Equilibrium II

- price demand $=$ price supply during good standing

$$I_t(q_t^d - q_t) = 0 \tag{18}$$

- combine above with budget constraint

$$c_t^T = y_t^T - (1 - I_t)L(y_t^T) + I_t(q_t d_{t+1} - d_t) \tag{19}$$

Competitive Equilibrium III

- law of one price $P_t^T = P_t^{T*}\mathcal{E}_t$
- normalize foreign currency price to 1: $P_t^T = \mathcal{E}_t$
- devaluation rate

$$\epsilon_t \equiv \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} = \frac{P_t^T}{P_{t-1}^T}. \tag{20}$$

CE I

$\left\{ c_t^T, h_t, w_t, d_{t+1}, \lambda_t, q_t, q_t^d \right\}$ satisfying:

CE II

$$c_t^T = y_t^T - (1 - I_t)L(y_t^T) + I_t(q_t d_{t+1} - d_t), \tag{21}$$

$$(1 - I_t)d_{t+1} = 0, \tag{22}$$

$$\lambda_t = U'(A(c_t^T, F(h_t)))A_1(c_t^T, F(h_t)), \tag{23}$$

$$(1 - \tau_t^d)q_t^d \lambda_t = \beta E_t \lambda_{t+1}, \tag{24}$$

$$I_t(q_t^d - q_t) = 0, \tag{25}$$

$$\frac{A_2(c_t^T, F(h_t))}{A_1(c_t^t, F(h_t))} = \frac{w_t}{F'(h_t)}, \tag{26}$$

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t}, \tag{27}$$

$$h_t \leq \bar{h}, \tag{28}$$

$$\left(h_t - \bar{h}\right)\left(w_t - \gamma \frac{w_{t-1}}{\epsilon_t}\right) = 0, \tag{29}$$

$$I_t\left[q_t - \frac{E_t I_{t+1}}{1 + r^*}\right] = 0, \tag{30}$$

CE III

given processes $\left\{ y_t^T, \epsilon_t, \tau_t^d, I_t \right\}$ and initial conditions w_{-1} and d_0.

Default decision

$$v^c(y_t^T, d_t) = \max_{\left\{c_t^T, h_t, d_{t+1}\right\}} \left\{ U\left(A\left(c_t^T, F(h_t)\right)\right) + \beta E_t v^g\left(y_{t+1}^T, d_{t+1}\right)\right\}$$
$$\text{s.t} \quad c_t^T + d_t = y_t^T + q(y_t^T, d_{t+1})\, d_{t+1} \tag{31}$$
$$h_t \leq \bar{h}.$$

$$v^b(y_t^T) = \max_{\{h_t\}} \left\{ U\left(A\left(y_t^T - L(y_t^T), F(h_t)\right)\right) + \right.$$
$$\left. \beta E_t\left[\theta v^g\left(y_{t+1}^T, 0\right) + (1-\theta) v^b\left(y_{t+1}^T\right)\right] \right\} \tag{32}$$
$$\text{s.t} \quad h_t \leq \bar{h}.$$

$$v^g(y_t^T, d_t) = \max\left\{v^c(y_t^T, d_t), v^b(y_t^T)\right\}. \tag{33}$$

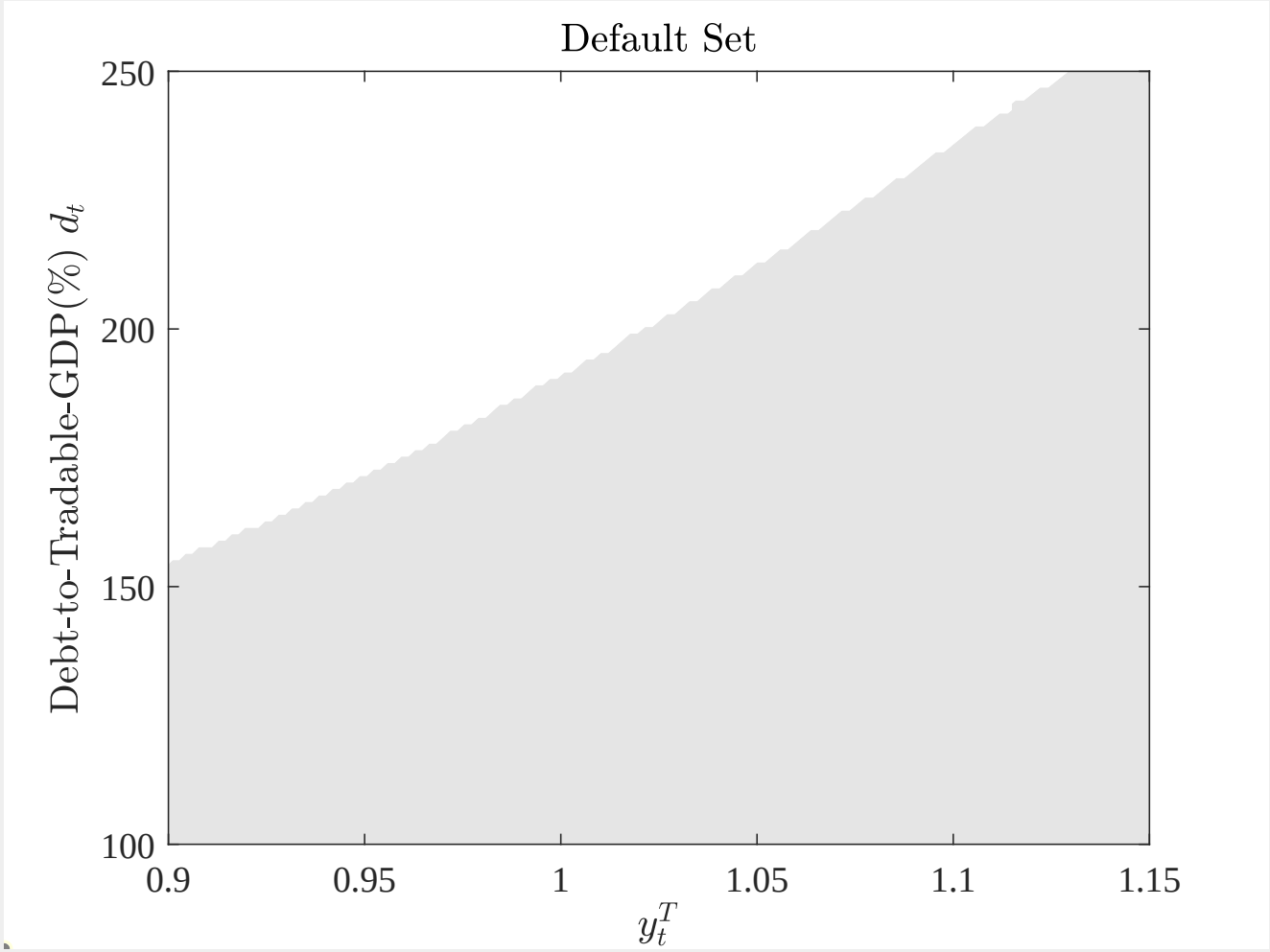
Default set

- Given a debt level d_t, the output under which default is optimal

$$D(d_t) = \left\{ y_t^T : v^b(y_t^T) > v^c(y_t^T, d_t) \right\}. \tag{34}$$

Plotting the default set

- Gray: Non-default set
- White: Default set



Price of Debt

- $\Pr(I_{t+1} = 1 \mid I_t = 1)$ is probability that next period output falls into default set

$$q(y_t^T, d_{t+1}) = \frac{1 - \Pr\left\{y_{t+1}^T \in D(d_{t+1}) \mid y_t^T\right\}}{1 + r^*} \tag{35}$$

- Since y_t^T is AR(1), output today is enough information about tomorrow $\rightarrow$ function of y_t^T

Optimal Devaluation Rate

- Optimal labor supply: $h_t = \bar{h}$ or full employment
- To ensure full employment, wage must be

$$w_t = w^f(c_t^T) \equiv \frac{A_2(c_t^T, F(\bar{h}))}{A_1(c_t^T, F(\bar{h}))} F'(\bar{h}) \tag{36}$$

- Because downward rigidity

$$\gamma \leq \frac{W_t}{W_{t-1}} = \frac{w_t}{w_{t-1}} \frac{P_t^T}{P_{t-1}^T} = \epsilon \frac{w_t}{w_{t-1}}$$

- Optimal devaluation rate is any ϵ_t such that

$$\epsilon_t \geq \gamma \frac{w_{t-1}}{w^f(c_t^T)} \tag{37}$$

Calibration

Parameters needed to be calibrated

Param.	Description
ρ	Autocorrelation of output
σ_u	Standard deviation of output
r^*	Risk-free rate
θ	Probability of reentry
α	Labor share in nontradable goods sector
a	Share of tradable consumption
ξ	Intratemporal elasticity of substitution of consumptin
σ	1/(intertemperal elasticity of substitution of consumption)
γ	Downward wage rigidity
β	Discount factor
δ_1	Coefficient of the linear term in loss function
δ_2	Coefficient of the quadratic term in loss function

General procedure

- ρ, σ_u: Per capita tradable GDP $\rightarrow$ HP-filter $\rightarrow$ cyclical component $\rightarrow$ AR(1) estimation $\rightarrow \hat{\rho}, \hat{\sigma}_u$
  - Since model period is quarter, data period is year
  - $\rho = 1 - \frac{1-\hat{\rho}}{4}$, $\sigma_u = \frac{\hat{\sigma}_u}{\sqrt{4}}$
- r^*: US 3-month T-bill $\approx 4\%$ per year
- θ: 1 / average years till reentry
- α: Follow calibration of literature
- a: mean of tradable-to-GDP ratio over 2001 to 2022
- σ, ξ: Follow literature, set as (2, 0.5)
- β, δ_1: match three equilibrium moment
  - Quarterly unsecured debt-to-tradable-GDP ratio
  - Default frequency per century
  - Average output loss in bad standings (As check)
- $\delta_2 = (1 - \delta_1)/(2 \max(y_t^T))$ to ensure output monotonicity during autarky.

Output process I

- HP-filter with $\lambda = 100$ since annual data
- Tradable = agriculture + forestry + fishing + industry

Output process II

Sri Lanka

Filtering	ρ	σ	Unconditional std
HP	0.8922	0.0198	4.38%

Zambia

Filtering	ρ	σ	Unconditional std
HP	0.6592	0.0278	3.69%

Sri Lanka

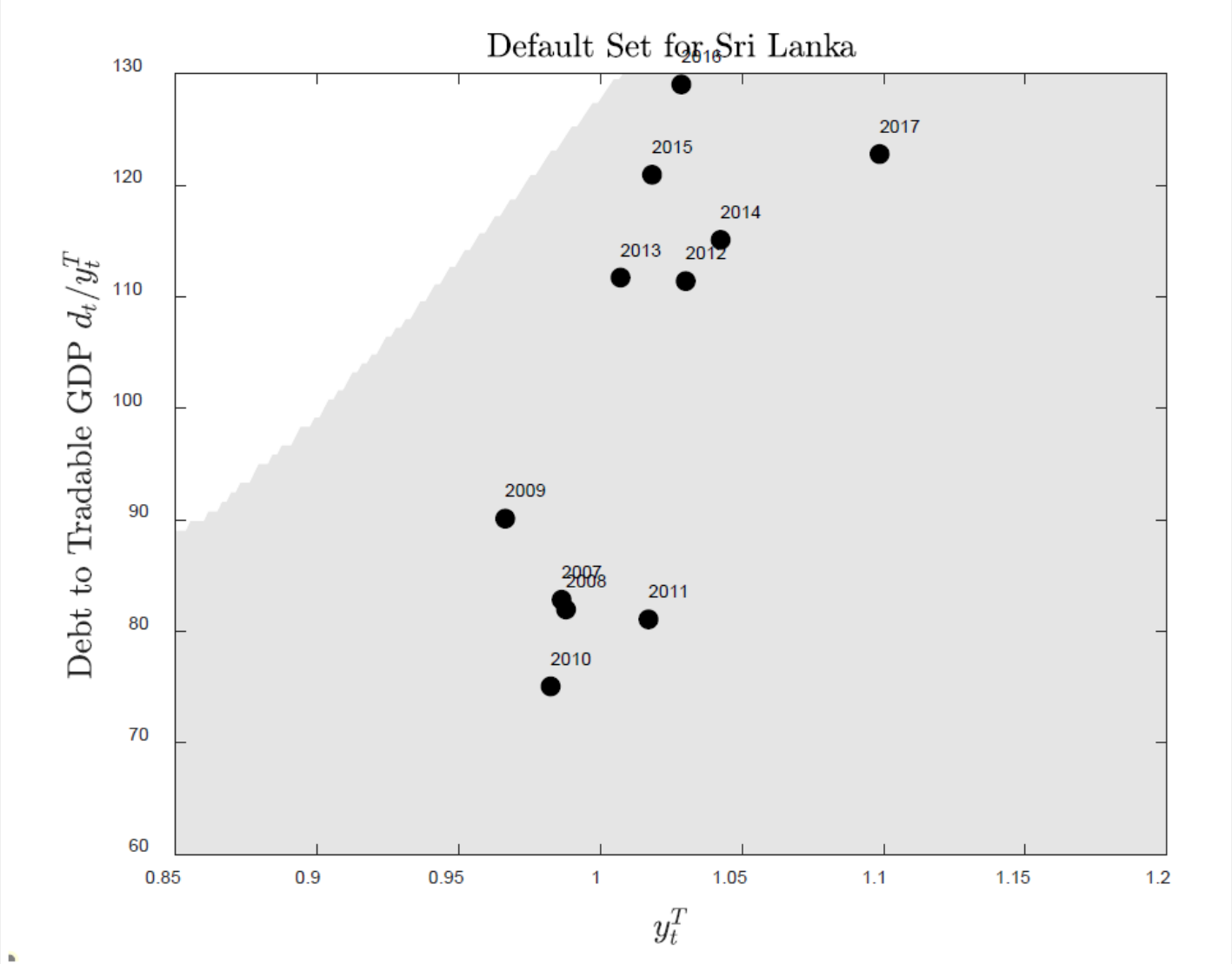
Parameter	Value	Source
ρ	0.8922	Estimation of AR(1) on GDP
σ_u	0.0198	Estimation of AR(1) on GDP
r^*	0.01	U.S. 3-month treasury bill rate
θ	0.0385	Chatterjee and Eyigungor (2012)
α	0.75	Jegajeevan (2016)
a	0.4	Share of tradable goods in GPD
ξ	0.5	Na et al. (2018)
σ	2	$1/\xi$
γ	0.95	Matschke and Nie (2022)
β	0.6959	Estimated
δ_1	-0.5265	Estimated
δ_2	0.6349	Set to ensure monotonicity
$\bar{h}$	1	Normalized to 1

Zambia

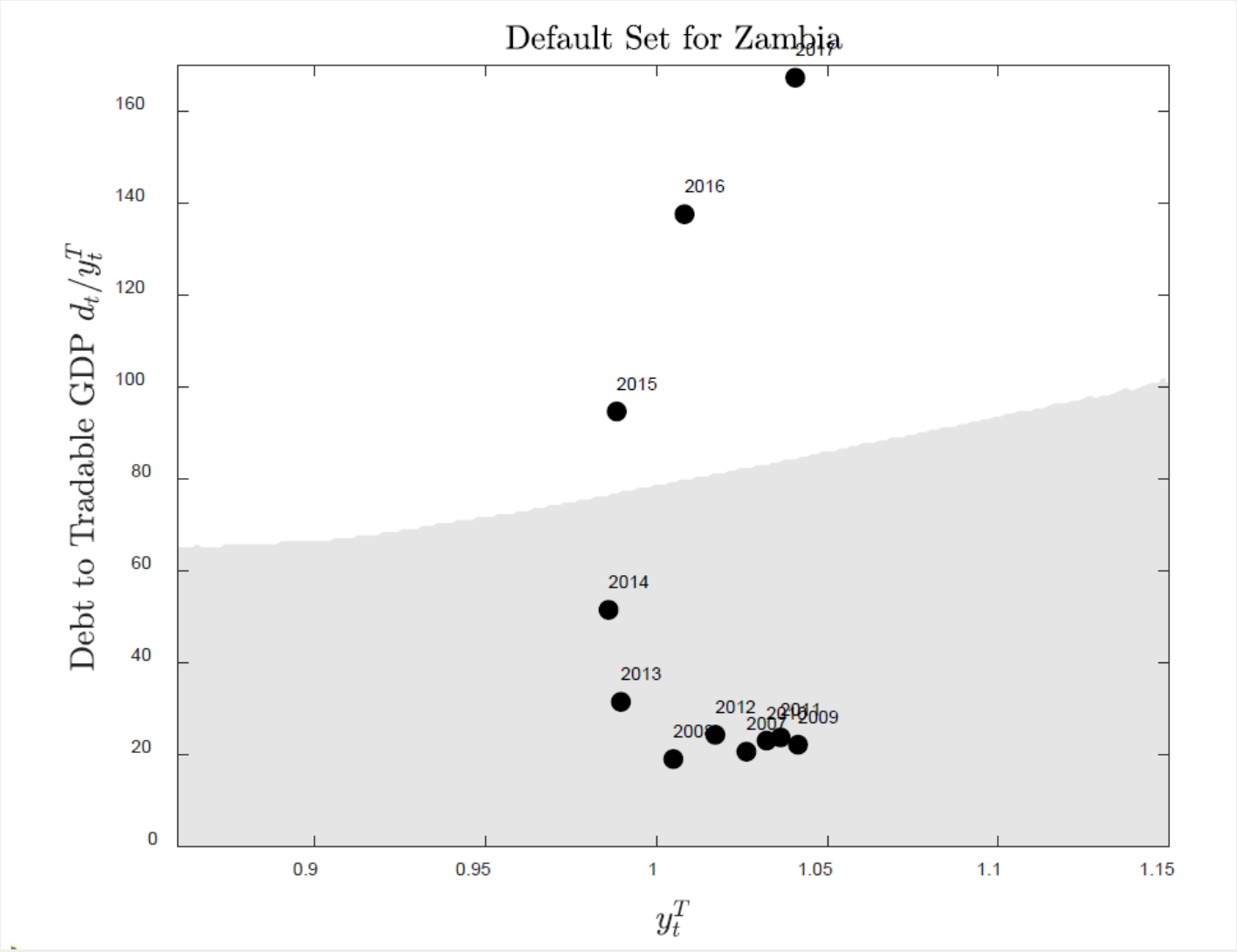
Parameter	Value	Source
ρ	0.6592	Estimation of AR(1) on GDP
σ_u	0.0278	Estimation of AR(1) on GDP
r^*	0.01	3 month treasury bill rate
θ	0.0333	Trebesch (2011)
α	0.66	
a	0.41	Share of tradable goods in GDP
ξ	0.5	Na et al. (2018)
σ	2	$1/\xi$
γ	0.87	Matschke and Nie (2022)
β	0.6257	Estimated
δ_1	-0.6374	Estimated
δ_2	0.7010	Set to ensure monotonicity
$\bar{h}$	1	Normalized to 1

Result

Sri Lanka Default Set

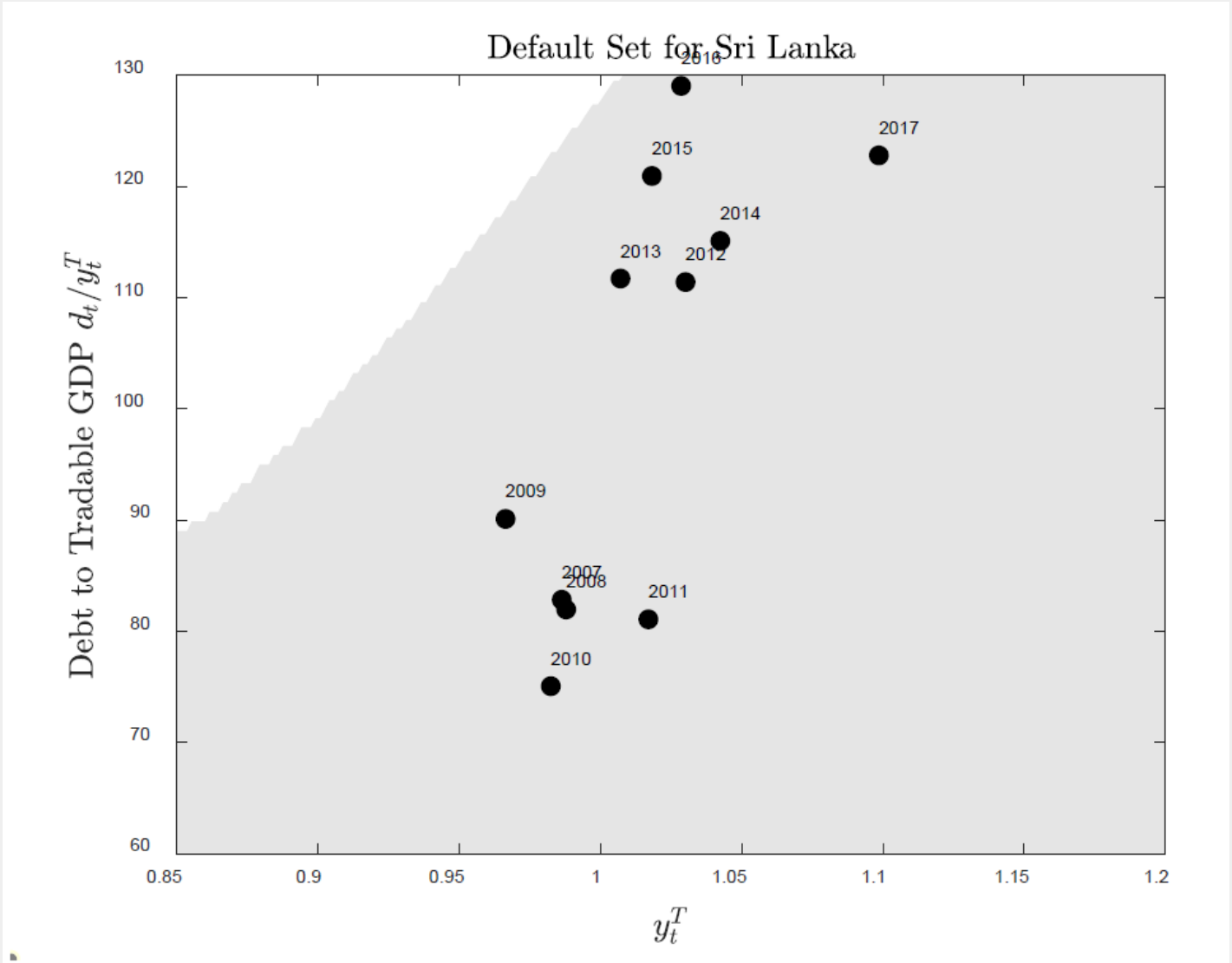


Zambia Default Set



Removing China's Debt

Sri Lanka



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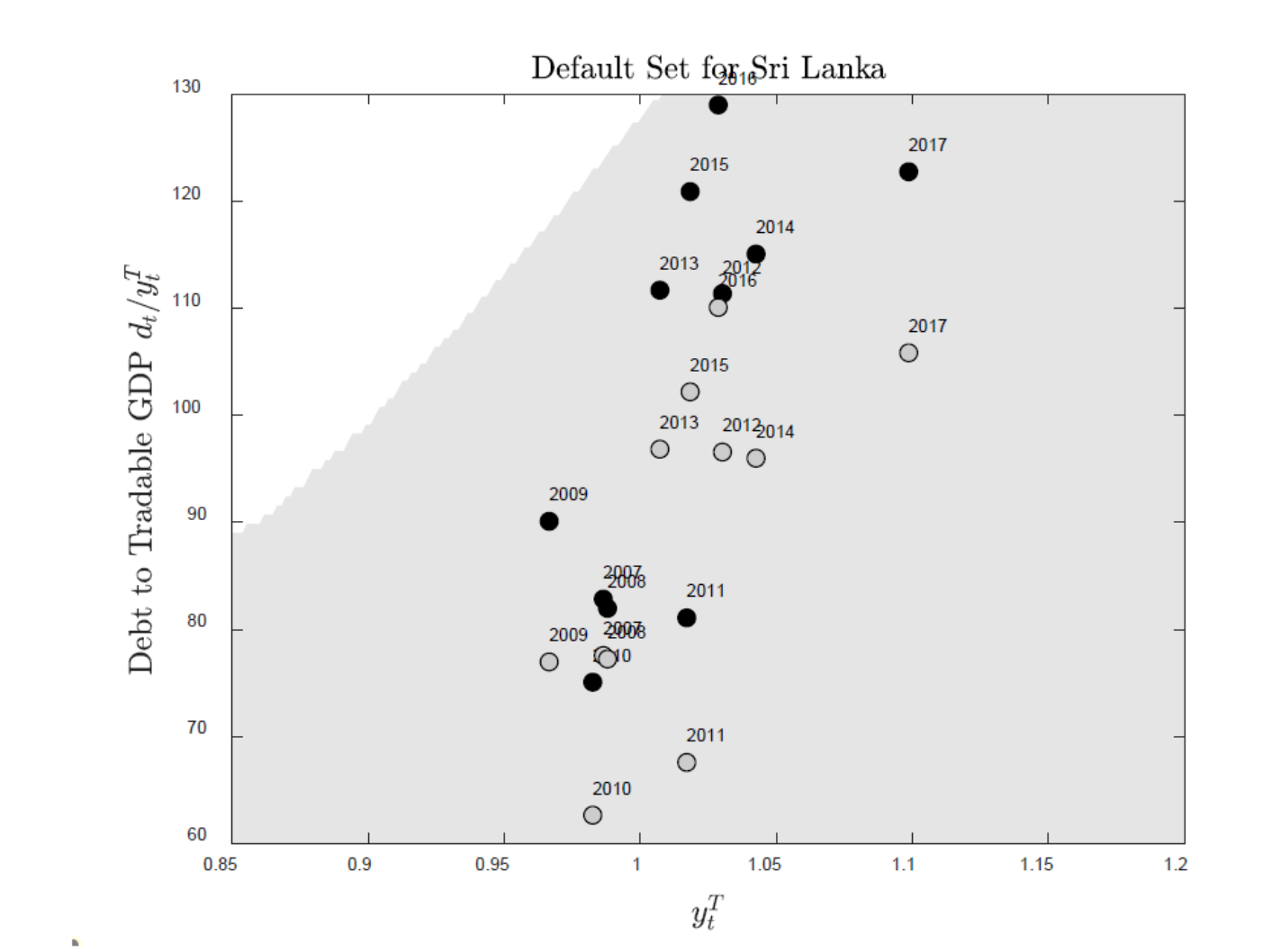

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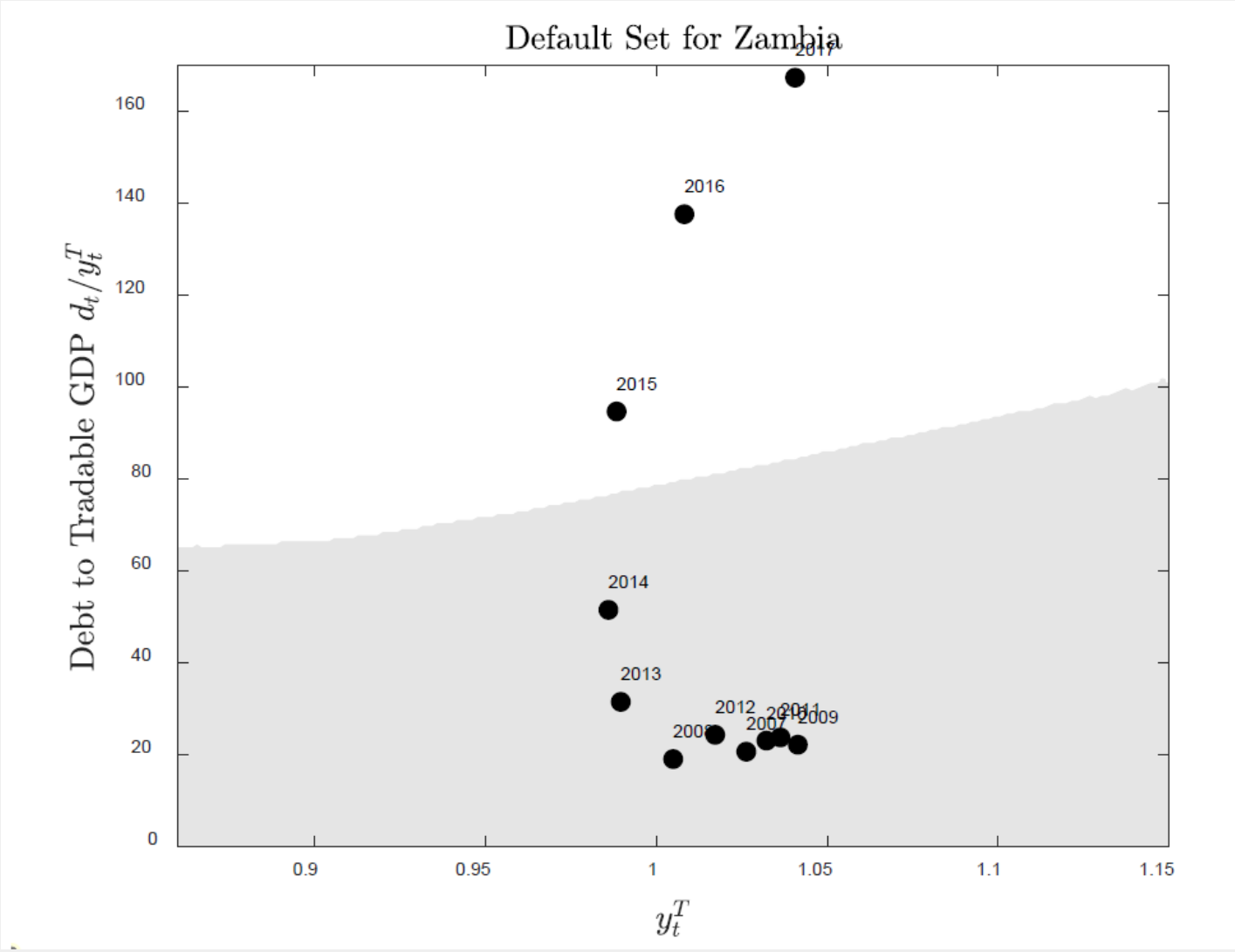

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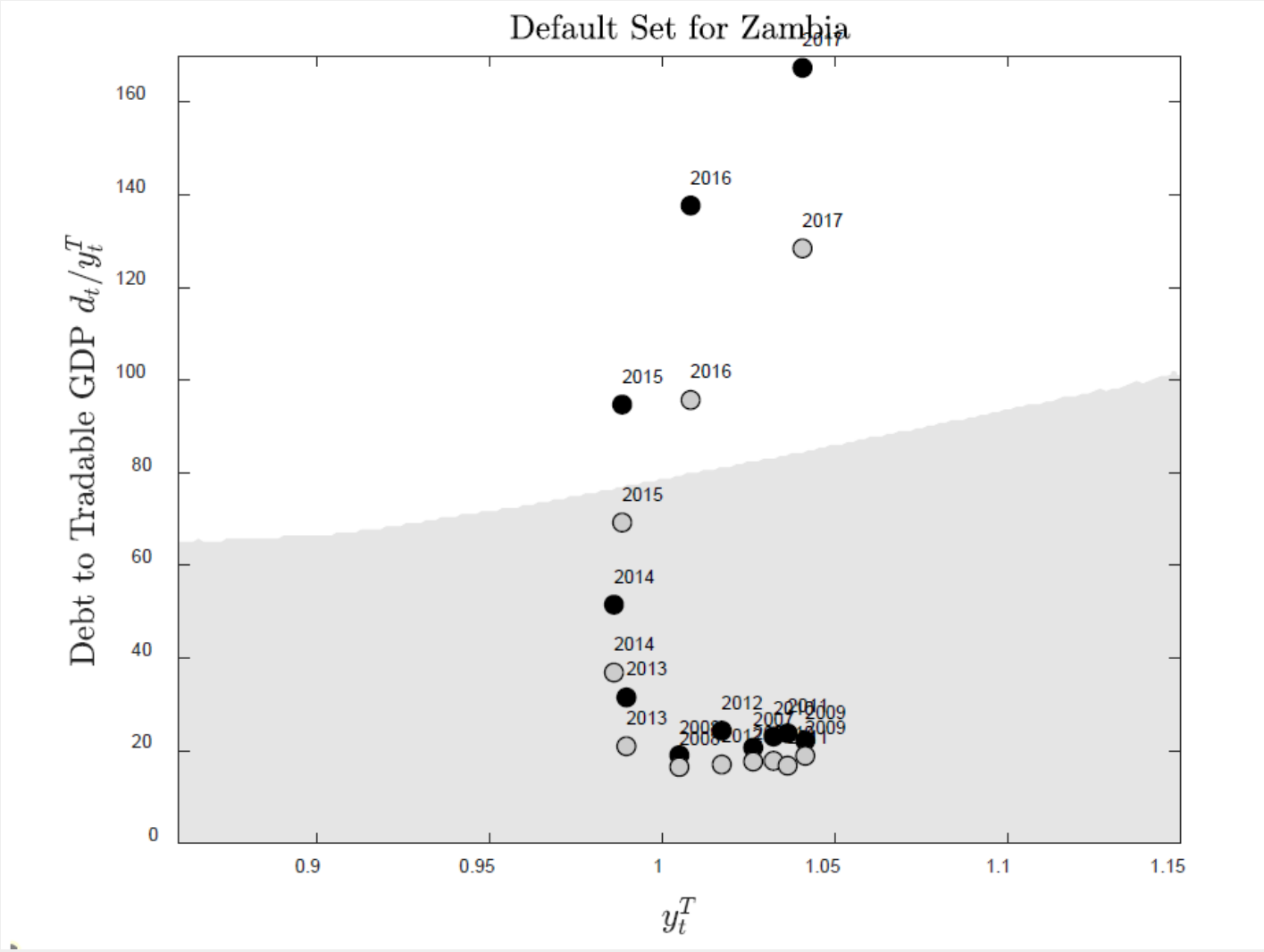
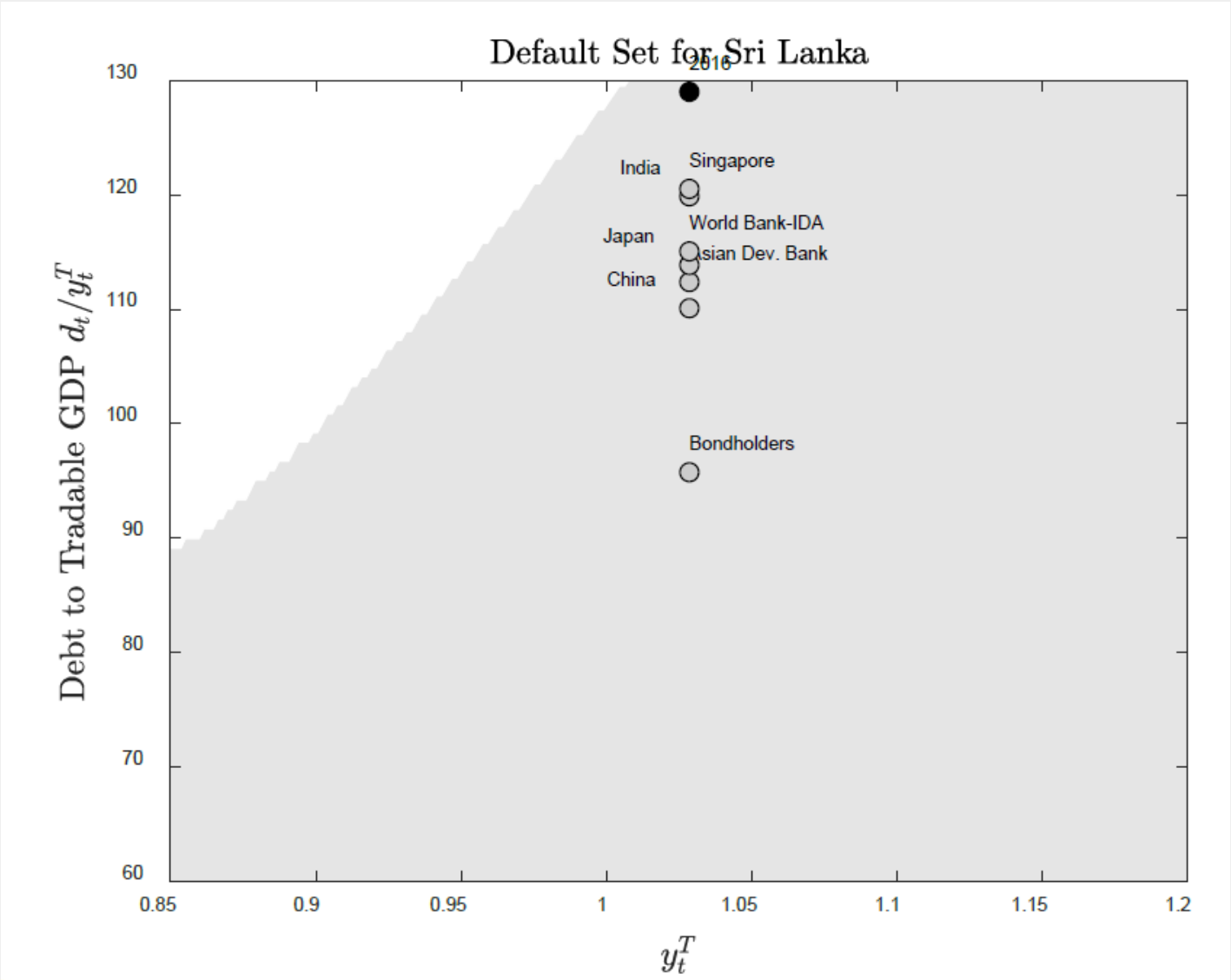


Problems with Removing China's Debt

- Debt is endogenous in the model — Might borrow from other countries
  - Hambantota Port is originally the former President's idea
  - Pakistan is under severe power shortage, might borrow money for infrastructure constructions
- GDP might be lower — BRI investment might have cause the counties' GDP to grow
  - BRI investment may increase labor demand on industrial sectors
- Counterfactual analysis must account for the two factor.

Is it all China to Blame?



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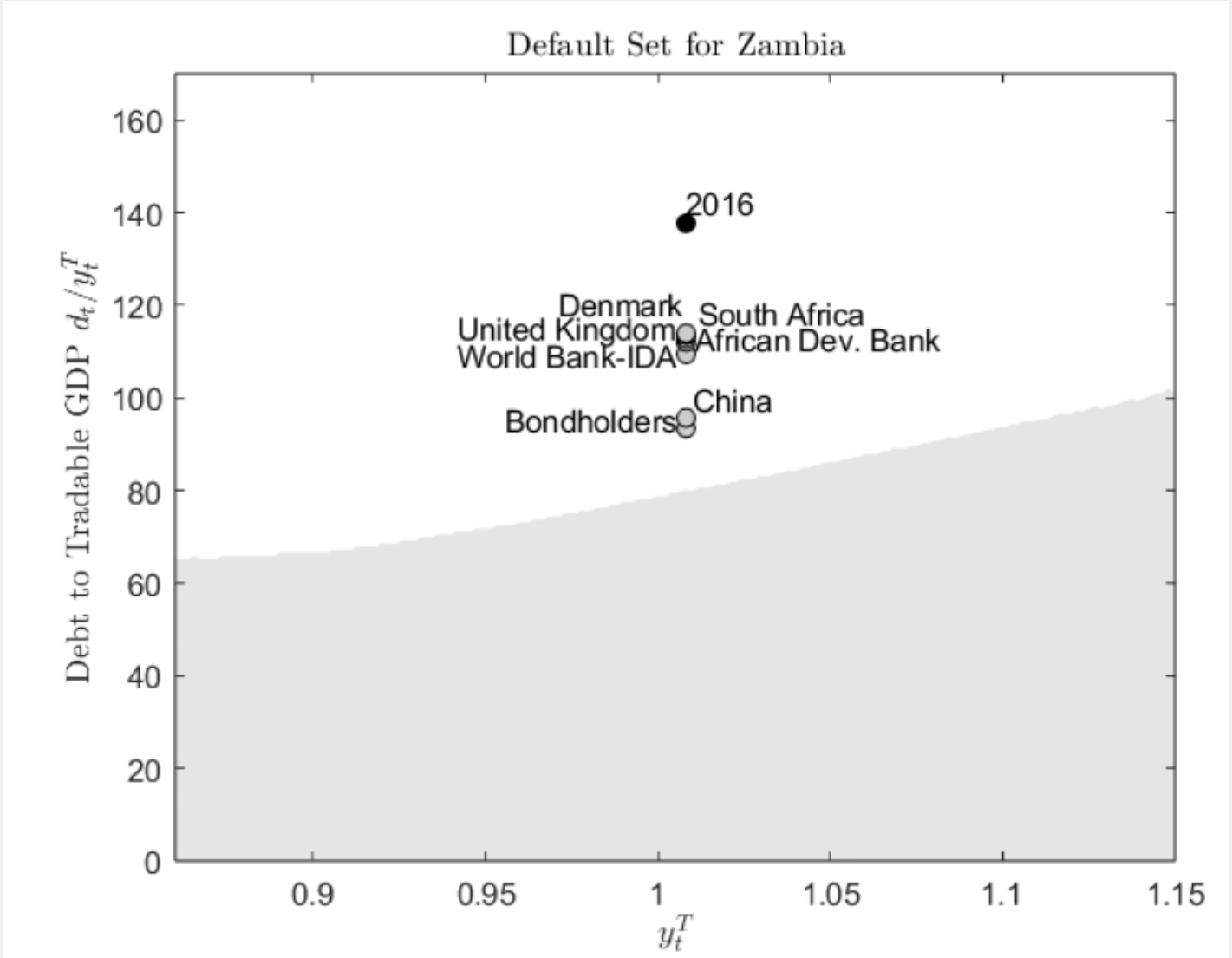

Foreign Bonds as a Major Component

Moramudali and Panduwawala (2022):

- Debt service on international sovereign bonds amounted to 47% of Sri Lanka s government external debt servicing in 2021
- the share of Chinese debt was 20%

Brautigam (2022):

- Nov 2022: Default on its foreign bonds

While much discussion on the debt trap thesis has focused on China, there are clearly other overlooked big fish in the debt pond.

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