檢視中國債務陷阱
Examining the Chinese Debt-Trap Diplomacy

陳家威

R10323045

112 年 7 月 12 日

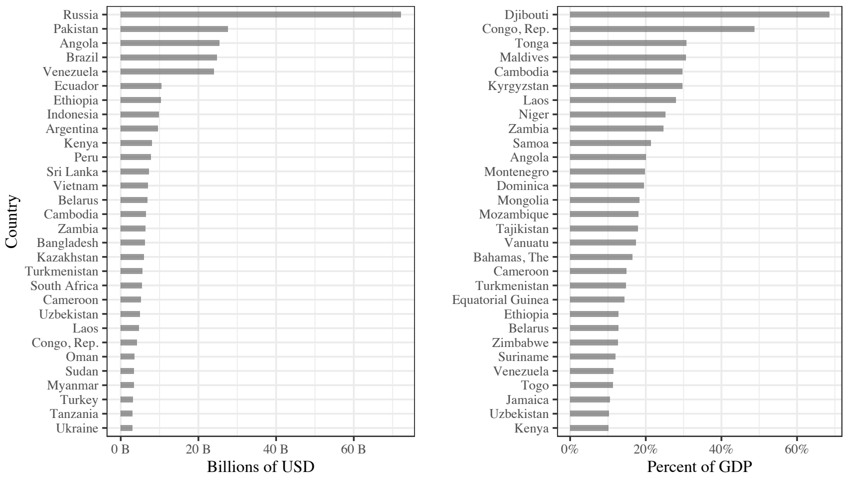
Debt Trap

Debt-trap Diplomacy

Debt-trap Diplomacy

China extends excessive loans to countries and places a debt burden upon them in exchange for political or economic concessions.

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

Pakistan Project List

Power Project 2016

- $2.7 billion on the Gwadar-Nawabshah LNG terminal and pipeline project;
- $1.26 billion on the Karot Hydropower Project;
- $1.28 billion on the Matiari to Lahore Transmission Line;
- $1.55 billion on the Pakistan Port Qasim Power Project; and $0.75 billion on the Qasim Datang Power Station (Horn, Reinhart and Trebesch, 2021).

Power Project 2017

- $1.35 billion for Suki Kinari Hydropower Project
- $1.5 billion on the Hubco Coal Power Plant Project

Gwadar Port

- 2015: 43-year lease to China Overseas Port Holding Company
- Develope Special Economic Zone (SEZ)

Model

Model Setting

- 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 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

- 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 1L $P_t^T = \mathcal{E}_t$
- 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

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

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

$$\lambda_t = U'(A(c_t^T, F(h_t)))A_1(c_t^T, c_t^N), \qquad (23)$$

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

$$I_t(q_t^d - q_t) = 0, \qquad (25)$$

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

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t}, \qquad (27)$$

$$h_t \leq \bar{h}, \qquad (28)$$

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

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

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

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

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

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

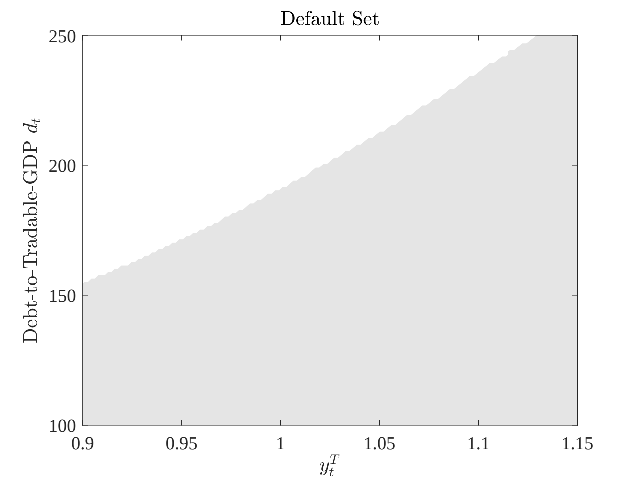
Default set

- 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

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

- Optimal devaluation rate is any ϵ_t such that

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

Calibration

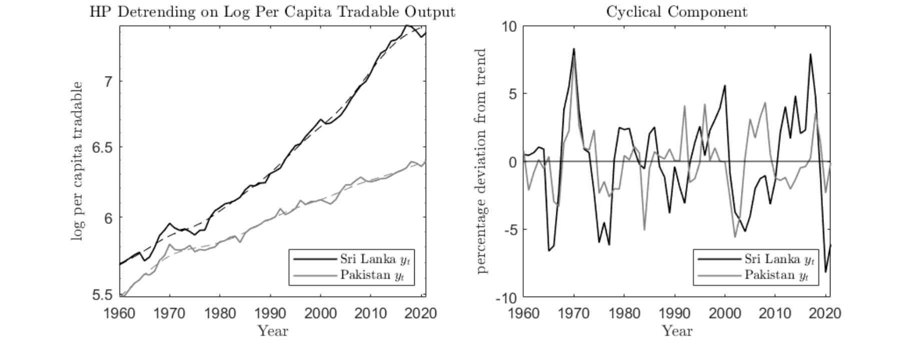
Parameters needed to be calibrated

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 1980 to 2021
- σ, ξ: Follow literature, set as (2, 0.5)
- $\beta, \delta_1, \delta_2$: match three equilibrium moment
    - Quarterly unsecured debt-to-tradable-GDP ratio
    - Default frequency per century
    - Average output loss in bad standings

- HP-filter with $\lambda = 100$ since annual data
- Also tried log-quadratic detrend
- Tradable = agriculture + forestry + fishing + industry



Output process II

Sri Lanka

Filtering	ρ	σ	Unconditional std
HP	0.9114	0.0180	4.37%
Log-Q	0.9325	0.0266	7.38%

Pakistan

Filtering	ρ	σ	Unconditional std
HP	0.8518	0.0116	2.21%
Log-Q	0.9239	0.0174	4.55%

- Time span: Before 2008, China started to provide large loans
- Reenty to international credit market: Since no default in the past, follow literature and choose 0.0385
- Debt-to-tradable-GDP ratio
  - Data: 118% average annnual
  - Haircut: use average sovereign haircut = 37% according to Cruces and Trebesch (2013)
  - times four to make it quarter
  - $118\% \times 0.37 \times 4 = 175\%$
- Default frequency per century: There is ambiguity in counting default events. Therefore, set as 2.6 following literature
- Output loss: Set as 7% following literature

Parameter	Value	Source
ρ	0.9114	Estimation of AR(1) on GDP
σ_u	0.0180	Estimation of AR(1) on GDP
r^*	0.01	U.S. 3-month treasury bill rate
θ	0.0385	Chatterjee and Eyigungor (2012)
α	0.65	Jegajeevan (2016)
a	0.35	Share of tradable goods in GPD
ξ	0.5	Na et al. (2018)
σ	2	$1/\xi$
γ	1.109	Matschke and Nie (2022)
β	0.6919	Estimated
δ_1	-0.4391	Estimated
δ_2	0.5530	Estimated
$\bar{h}$	1	Normalized to 1

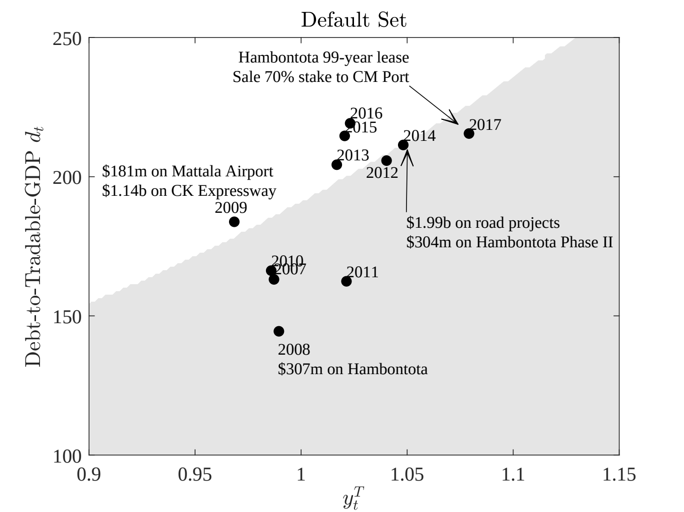
Pakistan

- Time span: Before 2013, China started to provide large loans
- reentry to international credit market: 1999 default $\rightarrow$ 2004 gain possitive flow $\rightarrow$ 6 years, or 24 quarters
- Debt-to-tradable-GDP ratio
  - Data: 69% average annnual
  - Haircut: use average sovereign haircut = 37% according to Cruces and Trebesch (2013)
  - times four to make it quarter
  - $69\% \times 0.37 \times 4 = 102\%$
  - (Typo in the thesis)
- Default frequency per century: There is ambiguity in counting default events. Therefore, set as 2.6 following literature
- Output loss: Set as 7% following literature

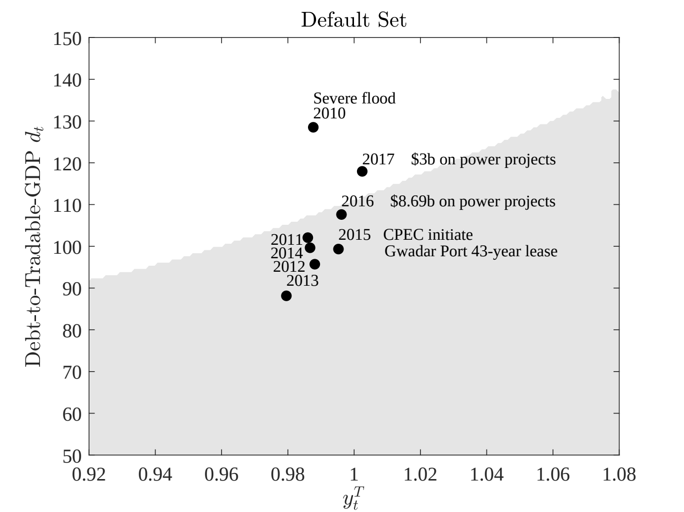
Parameter	Value	Source
ρ	0.8518	Estimation of AR(1) on GDP
σ_u	0.0116	Estimation of AR(1) on GDP
r^*	0.01	3 month treasury bill rate
θ	0.0417	Trebesch (2011)
α	0.4	Rehman et al. (2020)
a	0.33	Share of tradable goods in GDP
ξ	0.5	Na et al. (2018)
σ	2	$1/\xi$
γ	1.048	Matschke and Nie (2022)
β	0.6252	Estimated
δ_1	-0.5148	Estimated
δ_2	0.5789	Estimated
$\bar{h}$	1	Normalized to 1

Result

Sri Lanka Default Set

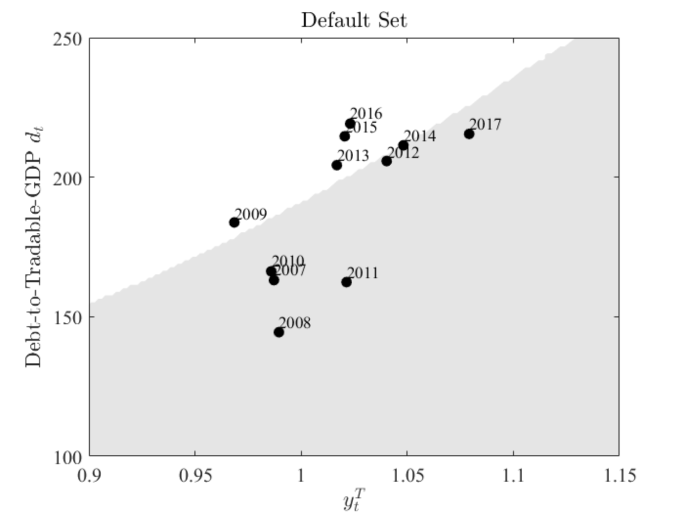


Pakistan Default Set



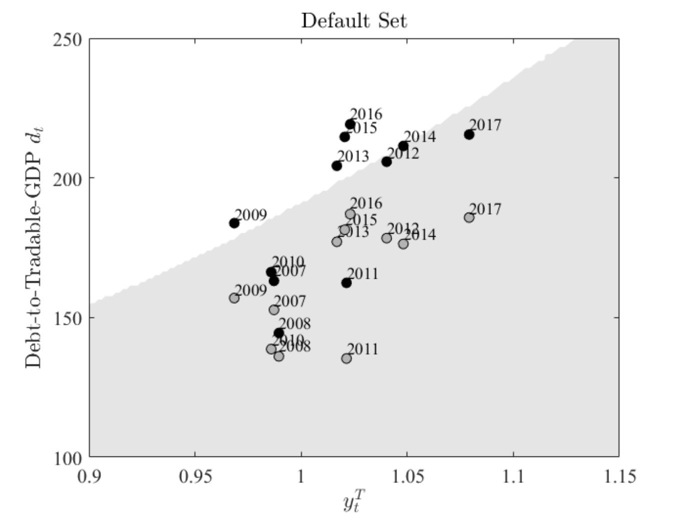
Removing China's Debt

Sri Lanka

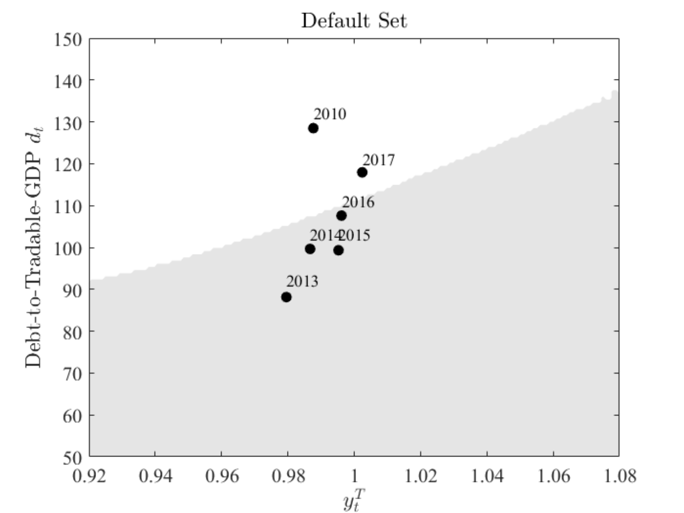


Removing China's Debt

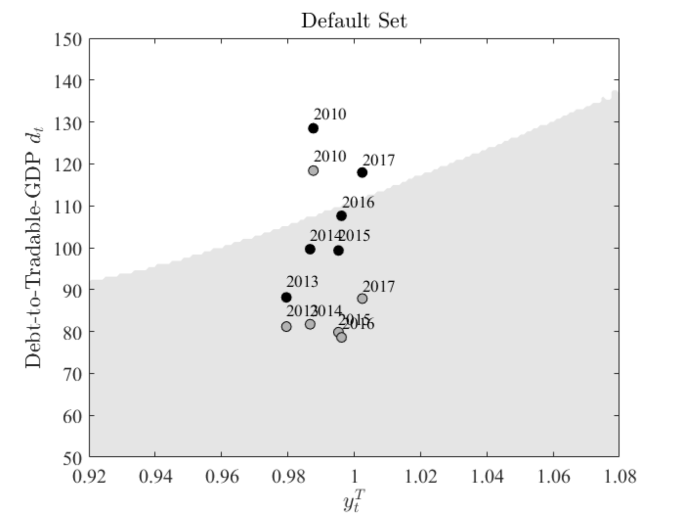
Sri Lanka



pakistan


Default Set
150
140
130
120
110
100
90
80
70
60
50
0.92
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
Debt-to-Tradable-GDP d_t
y_t^T
2010
2017
2016
2014
2015
2013

pakistan


Default Set
Debt-to-Tradable-GDP d_t
y_t^T
150
140
130
120
110
100
90
80
70
60
50
0.92
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
2010
2010
2017
2016
2014
2015
2013
2017
2013
2014
2015
2016

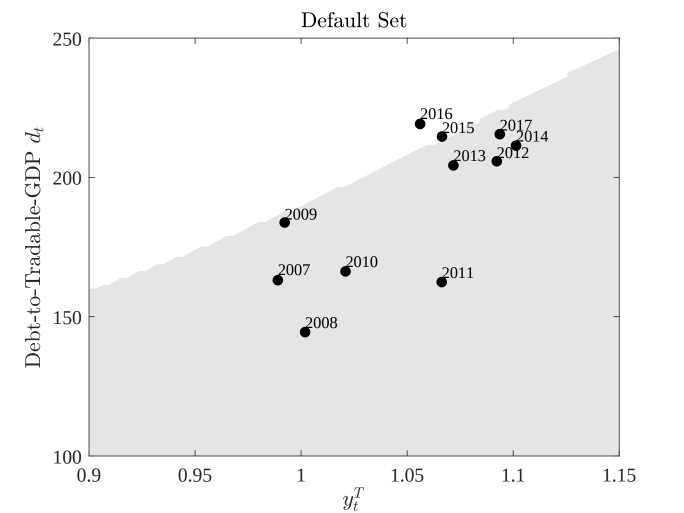
Problems with Removing China's Debt

- 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.

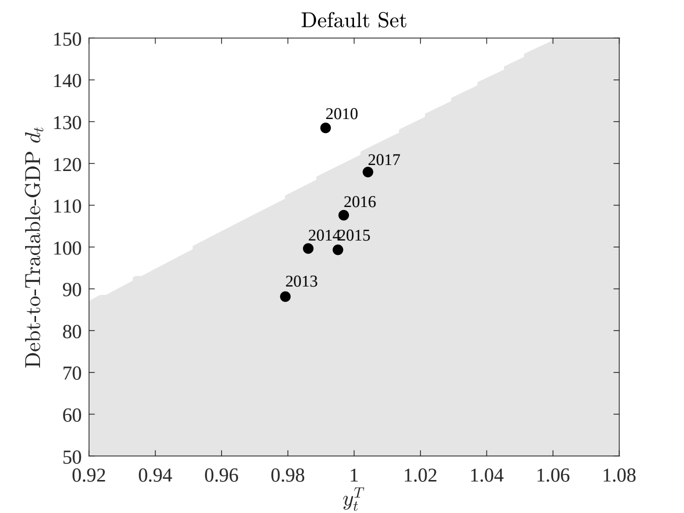
- HP-filter or Log-Quadratic?

	Sri Lanka			Pakistan		
Filtering	β	δ_1	δ_2	β	δ_1	δ_2
HP	0.6919	-0.4391	0.5530	0.6252	-0.5148	0.5789
Log-Q	0.6320	-0.2878	0.4248	0.8627	-0.4167	0.4973
	d/y^T	freq	L	d/y^T	freq	L
Target	*1.75*	*2.6*	*0.07*	*1.02*	*2.6*	*0.07*
HP	1.73	1.26	0.102	1.02	1.26	0.057
Log-Q	1.70	1.8	0.122	1.00	1.06	0.067

Sri Lanka – Log-quadratic



Pakistan – Log-quadratic



References I

Chatterjee, Satyajit and Burcu Eyigungor (2012) "Maturity, Indebtedness, and Default Risk," *American Economic Review*, 102 (6), 2674–99.

Cruces, Juan J. and Christoph Trebesch (2013) "Sovereign Defaults: The Price of Haircuts," *American Economic Journal: Macroeconomics*, 5 (3), 85–117.

Horn, Sebastian, Carmen M. Reinhart, and Christoph Trebesch (2021) "China's Overseas Lending," *Journal of International Economics*, 133, 103539.

Jegajeevan, Sujeetha (2016) "Understanding Sri Lankan Business Cycles Through an Estimated DSGE Model," in *Conference Proceedings, 9th International Research Conference (2016), Central Bank of Sri Lanka, Colombo*.

References II

Matschke, Johannes and Jun Nie (2022) "Downward Wage Rigidities and Recession Dynamics in Advanced and Emerging Economies," *Federal Reserve Bank of Kansas City Working Paper* (22-10).

Na, Seunghoon, Stephanie Schmitt-Grohé, Martín Uribe, and Vivian Yue (2018) "The Twin Ds: Optimal Default and Devaluation," *American Economic Review*, 108 (7), 1773–1819.

Rehman, Muhammad, Sajawal Khan, Zafar Hayat, and Faruk Balli (2020) "A Small Open Economy DSGE Model with Workers' Remittances," *Journal of Economic Studies*, 47 (6), 1339–1361.

Trebesch, Christoph (2011) "Sovereign Default and Crisis Resolution," Ph.D. thesis.