Trade Credit in a Developing Country: the Role of Large Suppliers in the Production Network

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Introduction

- Trade credit is a main source of financing, especially for small sized firms with limited access to bank finance (Petersen and Rajan (1997))
- Very recent interest in the role of trade credit for the macroeconomy (Luo (2020), Altinouglu (2021), Bocola and Bornstein (2023), Reischer (2024))
- Existing models and numerical analysis are at the sectoral level
- This paper studies the role of firm-to-firm trade credit for the macroeconomy with the help of Brazilian firm-level data
- Why Brazil is interesting: high dispersion of firm-level interest rates

Literature review

- Empirical papers on trade credit: Petersen and Rajan (1997), Demirguc-Kunt and Maksimovic (2001), Garcia-Appendini and Montoriol-Garriga (2013), Jacobson and Von Schedvin (2015)
- Production network: Long and Plosser (1983), Jones (2011, 2013), Acemoglu et al. (2012), Baqaee (2018), Liu (2019), Carvalho and Tahbaz-Salehi (2019), Baqaee and Farhi (2019, 2020), Bigio and La'O (2020), Peydro, Jimenez, Kenan, Moral-Benito and Vega-Redondo (2023)
- Trade credit in general equilibrium: Luo (2020), Altinouglu (2021), Bocola and Bornstein (2023), Reischer (2020)

What we do in the paper

1. Motivating micro evidence on effect of bank rates on trade credit:
   - Shock to seller's interest rate reduces trade credit supply
   - Shock to buyers' interest rate increases trade credit supply
2. GE model with endogenous trade credit in the firms' network:
   - Heterogeneous bank interest rates
   - Rates depend on firm's risk and bank-firm frictions
   - Trade credit substitutes for bank credit when interest rates dispersion is driven by frictions
3. Calibration with firm-to-firm transactions data, firm-level trade credit data, firm-level bank credit and interest rates data
4. Numerical exercise: role of trade credit in smoothing/amplifying firm-level and aggregate dispersion financial shocks

Data sources

1. Balance sheet data for listed non-financial companies (almost 300)
2. Firm-to-firm transactions data from the CBB payment registry
    - We build the network using 2019 data
    - Transfers between accounts in different banks + boletos
    - Average (median) number of clients of listed firms is 16000 (1031)
    - Average (median) value of transaction is BRL 512 (3.4) thousands
3. Bank interest rates and size of loans from CBB credit registry
    - We focus on contracts with 1 year maximum duration

Summary Statistics

Large companies face lower interest rates (than their clients)

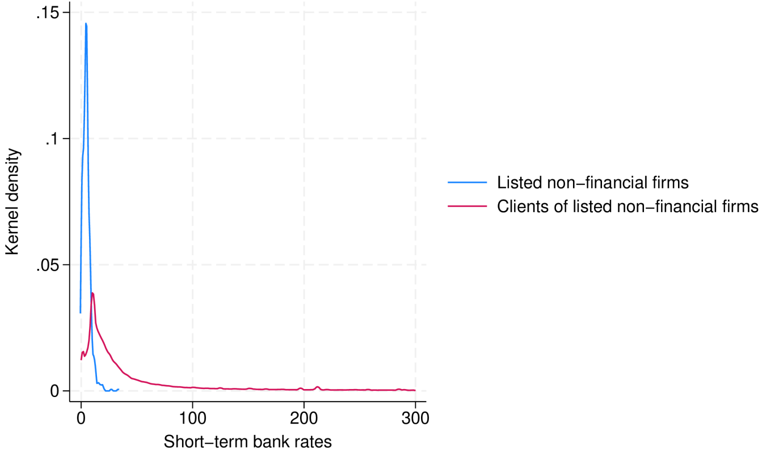


Figure: Distribution of interest rates: listed companies VS their clients (2019).

Interest rate dispersion is high in Brazil

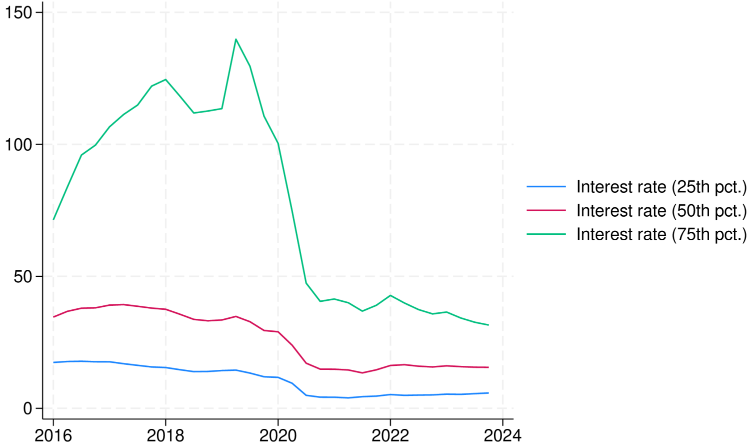


Figure: Quartiles of bank interest rates for short-term loans to firms

Net TC supply changes with interest rate gap w.r.t. clients

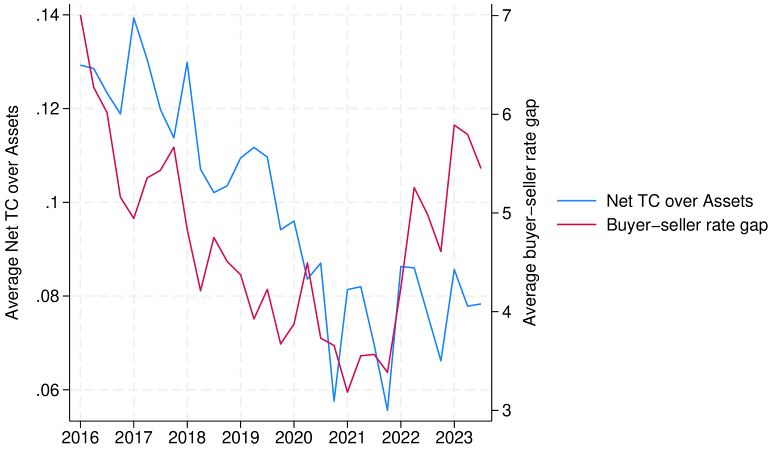


Figure: Net TC of listed firms and rate difference with respect to their clients.

Motivating analysis at the micro-level

- $AR_{n,t}$ are the accounts receivable over CA of firm n in quarter t
- $r_{n,t}$ is the weighted average interest rate of firm n in quarter t
- $\bar{r}^c_{n,t} = \sum_{m \in N_n} s^m_{n,2019} r_{m,t}$ is the average interest rate of firm n's clients
- $s^m_{n,2019}$ is the share of sales of firm n purchased by firm m
- Two linear regressions:

$$\Delta AR_{n,t} = \phi \Delta r_{n,t} + \rho D_n + \sigma D_t + \varepsilon_{n,t}, \tag{1}$$

$$\Delta AR_{n,t} = \varphi \Delta \bar{r}^c_{n,t} + \rho D_n + \varsigma D_t + \varepsilon_{n,t}. \tag{2}$$

- Shift-Share IV to identify exogenous shock to interest rates:

$$\Delta f_{n,t} = \sum_b z_{n,b,2019} \Delta R_{b,t}. \tag{3}$$

- $R_{b,t}$ is the average interest rate offered by bank b
- $z_{n,b,2019}$ is the share of credit of firm n from bank b in 2019

Results

Table: Effect of bank interest rates on Accounts Receivables

	Δ Accounts Receivables					
	OLS	1st Stage	2nd Stage	OLS	1st Stage	2nd Stage
$\Delta f^c_{n,t}$		0.055*** (0.016)				
$\Delta r_{n,t}$	0.009** (0.005)		-0.166** (0.078)			
$\Delta \bar{f}^c_{n,t}$					0.529*** (0.095)	
$\Delta \bar{r}^c_{n,t}$				0.000 (0.001)		0.002** (0.001)
firm FE	Y	Y	Y	Y	Y	Y
year FE	Y	Y	Y	Y	Y	Y
Observations	2545	2545	2545	3333	3333	3333

Notes: Quarterly data for 2019-2023. Standard errors are clustered at the firm level.

$^{*}\ p < 0.1$; $^{**}\ p < 0.05$; $^{***}\ p < 0.01$.

Model

- Static environment with set N of intermediate good firms indexed by n
- Intermediate goods are used as inputs for production of other intermediate and a final consumption good
- A representative final firm aggregates all intermediate inputs:

$$Q = \prod_{n \in N} (q_n)^{\psi_n}, \quad \text{with} \quad \sum_{n \in N} \psi_n = 1. \tag{4}$$

Intermediate good firms

- Firms are heterogeneous in productivity, a_n, bank interest rate, r_n, and probability of default, $(1-\pi_n)$
- The production network is exogenous
- A firm n sells to a subset of firms $N_n \in N$ of firms and purchases from a subset of firms $N^n \in N$
- The production function of an intermediate firm is:

$$y_n = a_n (h_n)^{\alpha_n} \prod_{m \in N^n} (x_m^n)^{\sigma_m^n}, \quad \text{with} \quad \alpha_n + \sum_{m \in N^n} \sigma_m^n = 1 \tag{5}$$

- h_n is the labor hired by the firm n; labor supply is fixed
- x_m^n is the amount of intermediate goods that firm n purchases from firm m

Working capital constraint and trade credit

- Timing friction between payment of inputs and selling of output:

$$\sum_{m \in N^n} (1-\theta_m^n) p_m^n x_m^n + w_n h_n \leq \sum_{m \in N_n} \kappa_n (1-\theta_n^m) p_n^m x_n^m + \kappa_n p_n^F q_n + D_n. \quad (6)$$

- The left hand side is the total advanced payment of inputs
- The right hand side is the total advanced payment received from output sales plus bank credit D_n
- θ_n^m is the share of trade credit offered by n to m
- κ_n, with $0 \leq \kappa_n \leq 1$, is a parameter representing the looseness of the working capital constraint
- The supply of trade credit makes the constraint (6) tighter
- We also assume a monitoring cost to recover the delayed payment:

$$c_n (\theta_n^m)^\gamma (\theta_n^m p_n^m x_n^m) = c_n (\theta_n^m)^{1+\gamma} p_n^m x_n^m \text{ with } \gamma > 0 \quad (7)$$

Banks

- We model banks in a stylized way
- They are risk-neutral and have large pockets
- Their outside option is a risk-free return r
- We add exogenous idiosyncratic frictions ζ_n reducing the actual payment that banks receive from a firm n
- The indifference conditions are:

$$R_n \equiv \pi_n r_n = r\zeta_n \tag{8}$$

- Dispersion of interest rates r_n can be associated to
  1. dispersion of R_n (due to frictions)
  2. dispersion of π_n (keeping R_n constant)

Problem of an intermediate good firm

- The firm n maximizes expected profits

$$\sum_{m\in N_n} [(1-\theta_n^m)+\pi_m\theta_n^m]\, p_n^m x_n^m + p_n^F q_n - w_n h_n - \sum_{m\in N^n} [(1-\theta_m^n)+\pi_n\theta_m^n]\, p_m^n x_m^n - R_n D_n - c_n \sum_{m\in N_n} (\theta_n^m)^{1+\gamma} p_n^m x_n^m, \quad (9)$$

subject to working capital contraint (6), $D_n \geq 0$, and technology restriction

$$y_n = \sum_{m\in N_n} x_n^m + q_n. \quad (10)$$

- Given $R_n > 0$, the w.c.c. is always binding if $D_n > 0$
- We focus on equilibria with $D_n > 0$ (in the data, the firms used in our calibration all have $D_n > 0$)
- The firm chooses h_n and D_n as a price-taker
- It chooses q_n as a monopolist, internalizing demand $q_n = \frac{\psi_n Q}{p_n^F}$

Firm-to-firm transactions

- x_n^m, p_n^m, and θ_n^m are set through Nash Bargaining between seller n and buyer m, given all other inputs:

$$\left\{ \left[1+R_n\kappa_n(1-\theta_n^m)-(1-\pi_m)\theta_n^m - c_n\left(\theta_n^m\right)^{1+\gamma}\right] p_n^m x_n^m - (1+R_n\kappa_n)p_n^F x_n^m \right\}^{\beta_n}$$
$$\left\{ (1+R_m\kappa_m)p_m^F \left(y_m - \sum_{k\in N_m} x_m^k \right) - [1+R_m(1-\theta_n^m)-(1-\pi_m)\theta_n^m] p_n^m x_n^m + E_n^m \right\}^{1-\beta_n} \quad (11)$$

- Inside second curly brackets: total profits of buyer
- For the seller, supplying trade credit is costly for 3 reasons:
  1. risk of no repayment if buyer defaults
  2. w.c.c. more binding $\rightarrow$ needs more bank credit
  3. monitoring cost
- For the buyer, receiving trade credit is beneficial for 2 reasons:
  1. lower expected repayment
  2. w.c.c. less binding $\rightarrow$ needs less bank credit

Optimal quantities and prices

- The optimal traded quantity x_n^m is such that

$$p_n^F x_n^m = \phi_n^m \sigma_n^m p_m^F y_m. \tag{12}$$

with

$$\phi_n^m = \underbrace{\frac{1+R_m\kappa_m}{1+R_m(1-\theta_n^m)-(1-\pi_m)\theta_n^m}}_{\text{increases in } \theta_n^m} \underbrace{\frac{1+R_n\kappa_n(1-\theta_n^m)-(1-\pi_m)\theta_n^m-c_n(\theta_n^m)^{1+\gamma}}{1+R_n\kappa_n}}_{\text{decreases in } \theta_n^m} \tag{13}$$

- With no w.c.c., it would be $\phi_n^m = 1$
- The optimal price is:

$$p_n^m = \left\{\beta_n\left[\frac{y_m - \sum_{k\in N_m} x_m^k}{\sigma_n^m y_m} + \frac{E_n^m}{(1+R_m\kappa_m)\sigma_n^m p_m^F y_m}\right] + (1-\beta_n)\right\} \frac{1+R_n\kappa_n}{1+R_n\kappa_n(1-\theta_n^m)-(1-\pi_m)\theta_n^m-c_n(\theta_n^m)^{1+\gamma}} p_n^F. \tag{14}$$

Optimal level of trade credit

- The optimal θ_n^m solves

$$c_n \left[(1+R_m)(1+\gamma)(\theta_n^m)^\gamma - (1+R_m-\pi_m)\gamma(\theta_n^m)^{1+\gamma} \right] = (R_m - R_n\kappa_n)\pi_m \tag{15}$$

- This θ_n^m maximizes $\phi_n^m \rightarrow$ buyer and seller try to minimize distortion

Proposition

If the optimal level of trade credit is $0 < \theta_n^m < 1$, it is

- $\frac{\partial \theta_n^m}{\partial R_m} > 0 \rightarrow$ *trade credit increases in expected bank rate of buyer*
- $\frac{\partial \theta_n^m}{\partial R_n} < 0 \rightarrow$ *trade credit decreases in expected bank rate of seller*
- $\frac{\partial \theta_n^m}{\partial \pi_m} > 0 \rightarrow$ *trade credit increases in probability of repayment*

Equilibrium

- The Domar weights (firm's sales as GDP share) are $\lambda_n \equiv \frac{p_n^F y_n}{Q}$

Proposition

The aggregate output is given by

$$\log Q = \sum_{m \in N} \psi_m \log \psi_m + \underbrace{\sum_{m \in N} \lambda(1)_m \log A_m}_{\text{productivity \& labor allocation}} + \underbrace{\sum_{m \in N} \lambda(1)_m \sum_{n \in N^m} \sigma_n^m \log(\sigma_n^m \phi_n^m)}_{\text{input-output distortions}} \tag{16}$$

with

$$A_m = a_m \left(\frac{h_m}{\lambda_m}\right)^{\alpha_m}, \tag{17}$$

$$\Lambda = \left(\mathbb{I}_{|N|} - \Sigma' \circ \Phi'\right)^{-1} \psi, \tag{18}$$

and

$$\Lambda(1) = \left(\mathbb{I}_{|N|} - \Sigma'\right)^{-1} \psi. \tag{19}$$

Does trade credit amplify or smooth shocks?

Proposition

Consider an equilibrium with $\theta_n^m < \min\left[\frac{1-\kappa_m}{1-(1-\pi_m)\kappa_m}, \left(\frac{\pi_m}{c_n}\right)^{\frac{1}{\gamma}}\right]$ *(higher interest rates reduce production) and small labor shares* ($\alpha_n \to 0$). *The presence of trade credit:*

- *smoothes shocks to buyer's expected rate* R_m;
- *amplifies shocks to seller's expected rate* R_n;
- *amplifies shocks to buyer's risk* π_m.

Calibration: technology parameters

- We calibrate the model using data from 2019
- We selected the 100 largest listed firms
- Rest of the economy: one representative firm for each of 16 sectors
- The interest rates r_n are taken from CBB registry (short-term loans)
- The σ_n^m are computed using CBB transaction data and I-O matrix
- The ψ_n are computed as the GDP shares of value added

Network structure

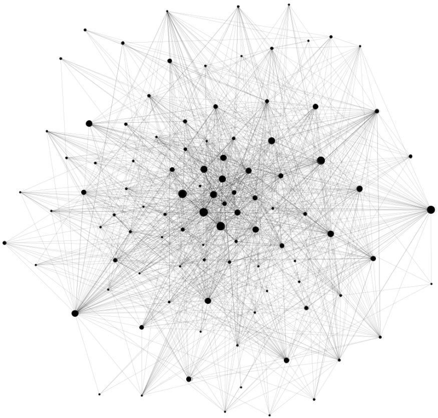


Figure: Network of input-output links among the large listed companies used in our calibration. Information are from the payment registry of the Central Bank of Brazil.

Calibration: risk and credit parameters

- The κ_n, π_n, c_n, β_n, and γ are internally calibrated (465 parameters)
- The target moments are
  - Accounts Receivable as share of total assets (116 moments)
  - Accounts Payable as share of total assets (116 moments)
  - Short-term debt as a fraction of revenues (116 moments)
  - Profits as share of GDP (116 moments)
  - Total aggregate sales over GDP (1 moment)

Model Fit and Parameters

Effect of firm-level interest rate shock: endogenous trade credit VS no trade credit

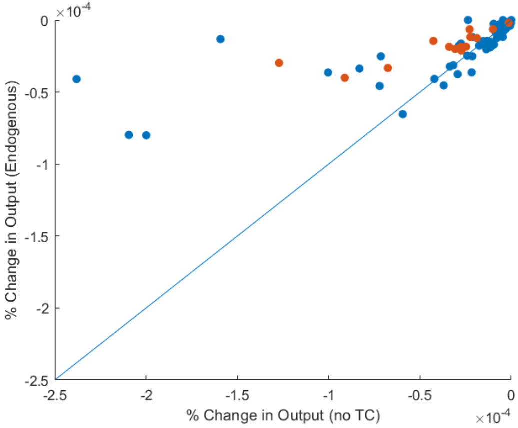


Figure: Output effect of an increase in bank interest rate for a specific firm

How about the years after 2019?

- We re-calibrate the κ_n, π_n and ζ_n for 2020, 2021, 2022 and 2023 feeding the model with new r_n and matching new AR, AP and debt
- All other parameters are kept at 2019 levels
- We compare the benchmark to the scenarios with constant or no trade credit

Evolution of output: endogenous, exogenous, and no TC

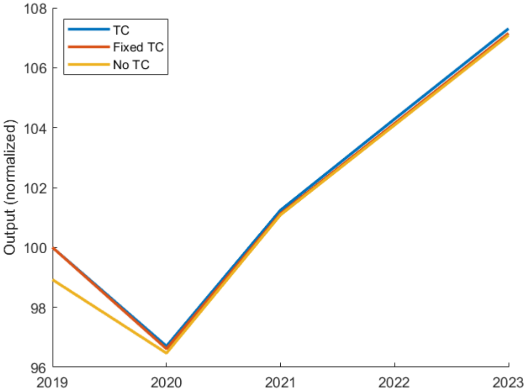


Figure: Evolution of output (2019-2023).

Role of trade credit and interest rate dispersion

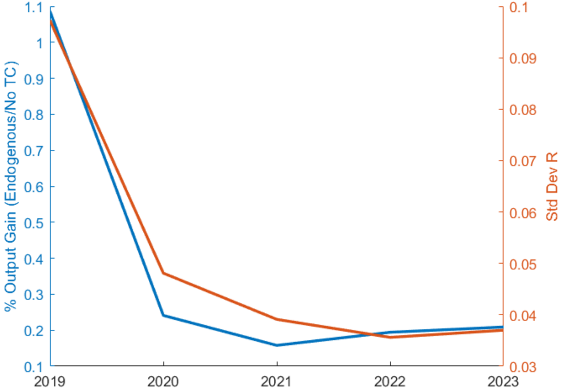


Figure: Relative output (endogenous VS no trade credit) and estimated dispersion of R_n.

Role of each channel

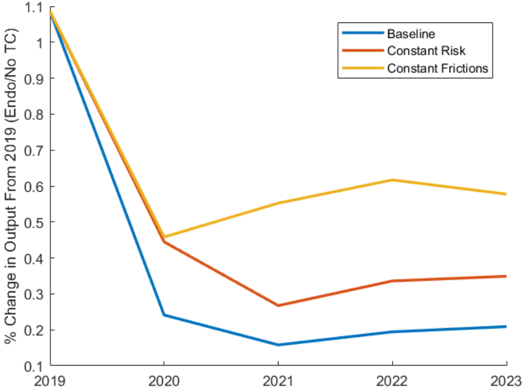


Figure: Relative output (endogenous VS no trade credit) if changes in R_n are explained keeping risk or frictions at the 2019 level

Conclusions

- We built a model of endogenous trade credit in a production network
- In line with micro evidence, trade credit increases with the interest rate of buyers, while decreases with interest rate of sellers
- Trade credit can smooth or amplify interest rate shocks, depending on the position of a firm in the production network
- Endogenous trade credit is particularly beneficial when the "frictional" interest rate spread between buyers and sellers gets larger
- The importance of TC has declined in the last 4 years because of the reduction in bank rates' dispersion

Summary statistics

Table: Summary statistics

	Mean	Standard Deviation	Observations
Accounts Receivable over CA	0.29	0.15	2,545
Average interest rate	5.03	7.4	2,545
Average interest rate of clients	12.73	5.05	2,545
Shares of bank-to-firm loans	0.52	0.43	3,341,646
Average interest rate of banks	18.97	39.08	14,121

Note: Observations for the first three variables refer to a company in a quarter (from 2020 to 2023). Each observation for the shares of bank-to-firm loans refers to one bank-to-firm link in 2019. The average interest rate of banks is the weighted average interest rate that each bank offered in a quarter from 2020 to 2023.

Back

Comparing endogenous to exogenous trade credit

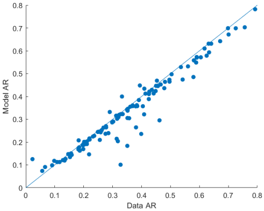
Proposition

Consider an equilibrium with $\theta_n^m < \min\left[\frac{1-\kappa_m}{1-(1-\pi_m)\kappa_m}, \left(\frac{\pi_m}{c_n}\right)^{\frac{1}{\gamma}}\right]$ *(higher interest rates reduce production) and small labor shares* ($\alpha_n \to 0$). *The first-order effects of a change in the expected interest rates R are identical if trade credit levels can endogenously change or not. Considering second-order effects, output is larger in the endogenous change scenario if*

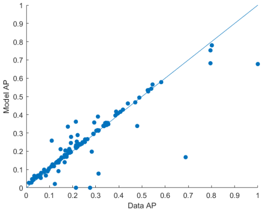
$$\sum_{m\in N} \lambda(1)_m \sum_{n\in N^m} \sigma_n^m \frac{\pi_m}{[1+R_m-(1+R_m-\pi_m)\theta_n^m]^2} \underbrace{\left(-\frac{\partial \theta_n^m}{\partial R_n}\right)}_{\geq 0} R_n \left[(\hat{R}_m)(\hat{R}_n)\right] < 0. \quad (20)$$

Fit of the model

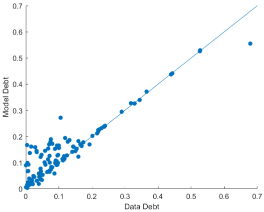
(a) Accounts Receivable



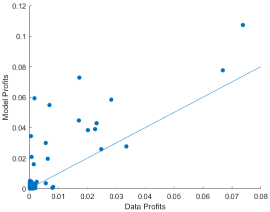
(b) Accounts Payable



(c) Debt to Revenue

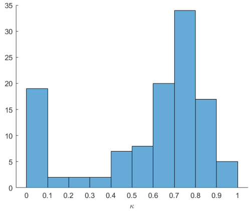


(d) Profit shares

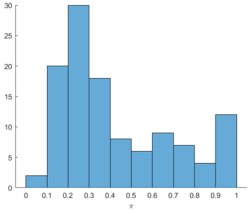


Parameter Distributions

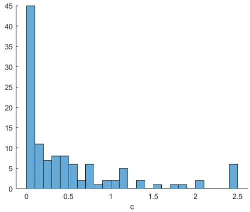
(a) κ



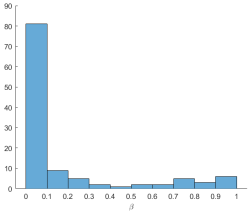
(b) π



(c) c



(d) β



Estimated R_n

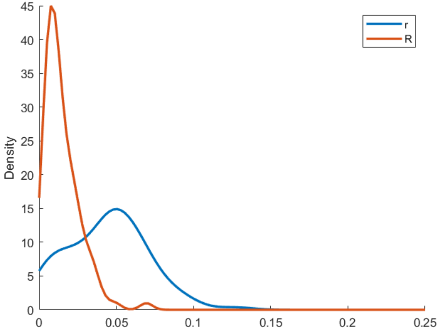


Figure: Kernel density of observed r_n and estimated R_n.

Back