

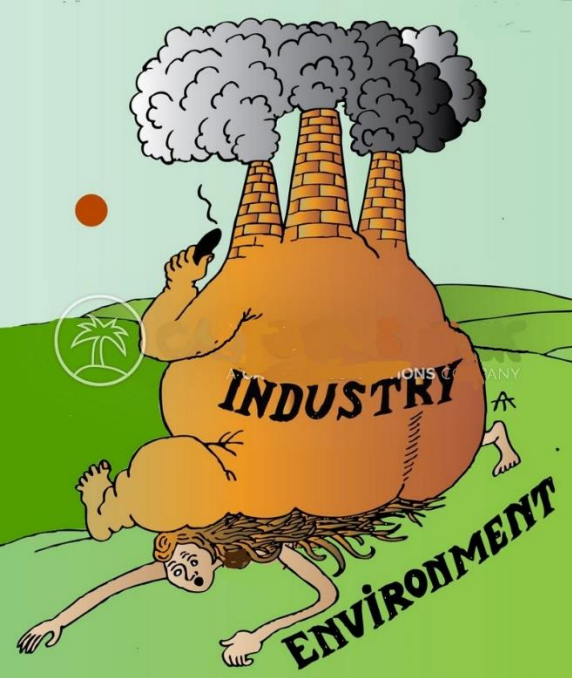
Modelling Monetary and Fiscal Policy to Achieve Climate Goals in Africa.



Yener Altunbas (Bangor University)
Xiaoxi Qu (Bangor University)
John Thornton (University of East Anglia)

Roadmap of presentation

- 01/ Motivations
- 02/ Literature review
- 03/ Model
- 04/ Calibration and steady state
- 05/ Impulse response analysis
- 06/ Conclusion

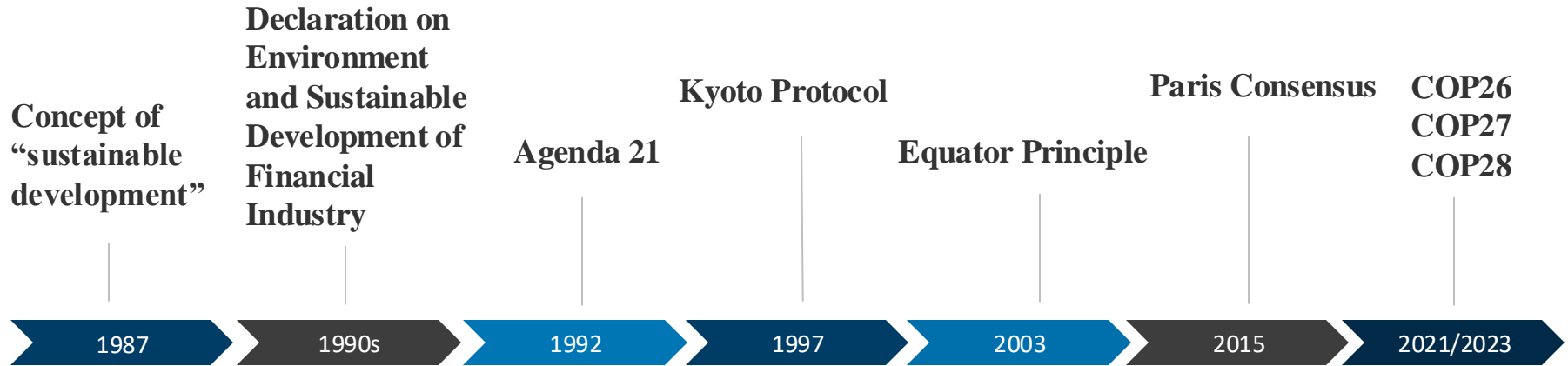


01

Motivations

- **Timeline of International efforts related with climate change and finance**
- **Nature of climate change**
- **Four Elements**
- **Three Shocks**

Motivations - Timeline of International efforts related with climate change and finance



public goods (Kotchen, 2014 and Khan 2021)

non-competitive & non-exclusive goods

Samuelson's classic definition, public goods means that the consumption of certain goods by any one person will not reduce the consumption of such goods by others.(The pure theory of public expenditure,1954)

Free Rider

Adam Smith concluded that the market cannot provide public goods, and the government must do something about it.

Motivations - Four Elements

Financial friction

There is information asymmetry in the credit market, and firms encounter external financing premium when borrowing from banks, which leads to the financial accelerator mechanism.

BGG

- Price stickiness

Implicit guarantee

Kornai (1980) proposed the idea of "soft budget constraints". The government cannot commit not to save the state-owned businesses that are operating at a loss.

Fiscal Support

- Soft Budget Constraints

Firm heterogeneity

Environmental protection green firms and polluted brown firms

Unconventional Monetary Policy

- Green Credit

Bank heterogeneity

Banks who lend money to green firms and Banks who lend money to brown firms

WHAT MAKES US DIFFERENT ?

Take the “four elements” into the DSGE model of the current mainstream macroeconomic analysis.

Motivations - Three Shocks

1

Conventional Monetary Policy (RRR)

2

Unconventional Monetary Policy (GCP)

3

Fiscal Support (SBC)

02

Literature review

- **2.1 Concept of green credit and soft budget constraints**
- **2.2 Financial development and economic growth**
- **2.3 Green financial development and sustainable economic growth**



Literature review - Concept of green credit and soft budget constraints

- Jeucken (2002) explained the connotation of green credit as follows: financing green credit mainly means that financial institutions provide preferential credit benefits to green sustainable firms, and at the same time pass on the concept of sustainable development to lending firms.
- Kornai (1980) proposed the idea of "soft budget constraints" when examining the socialist economy. The government cannot commit not to save the state-owned businesses that are operating at a loss. This is a typical situation in the socialist economy.



Literature review - Financial development and economic growth

- Bagehot (1873) first proposed that financial development played a prominent role in economic growth. He believed that in the British industrial revolution, the financial system played an important role in promoting the financing of industrial projects.
- Krugman (2009) strongly questioned the view that financial development is beneficial to economic growth. After the financial crisis in 2008, he believed that financial innovation products were excessively complex, which would lead to financial crisis and make the economy retrogress.

- Bernanke et al.(1999) embedded the “financial accelerator” theory into the New Keynesian model.
- Gertler and Karadi (2011) introduced the banking sector into the DSGE model to examine the role of bank credit intermediary after the financial crisis.



Literature review - Financial development and economic growth

- Bernanke, B.S. (2008). ‘The **Financial accelerator** and the **credit channel**’, remarks at the conference on The Credit Channel of Monetary Policy in the Twenty First Century, Federal Reserve Bank of Atlanta.
- Bernanke, B. and A.S. Blinder (1988). ‘Is it money or credit, or both or neither? **Credit, money** and **aggregate demand**’, American Economic Review, 78(2), 435-9.
- Bernanke, B. and M. Gertler (1989). ‘**Agency Costs, Net Worth, and Business Fluctuations**’, American Economic Review, 79(1), 14-31.
- Bernanke, B.S. and M. Gertler (1995). ‘Inside the black box: The **credit channel of monetary policy transmission**’, Journal of Economic Perspectives, 9(1), 27-48.



Literature review - Green financial development and sustainable economic growth

- White and Labatt (2002) studied the relationship between financial innovation and industrial structure, and pointed out that the purpose of exploring environmental finance is to penetrate the development concept of environmental protection into the whole environmental protection industry and achieve sustainable economic growth.
- Faulkender (2006) and Biddle (2006) explain when the green credit policy is implemented, companies must disclose environmental information. The higher the quality of nonfinancial information is, the closer the amount of external financing obtained is to the optimal financing amount, which not only alleviates underinvestment but also avoids overinvestment.

03

Model

- **3.1 Households**
- **3.2 The retailer sector**
- **3.3 The wholesaler sector**
- **3.4 The capital sector**
- **3.5 Entrepreneur sector with loan demand**
- **3.6 Banking sector**
- **3.7 Government sector**
- **3.8 Market clearing**

Model - Framework



Model

3.2 The retailer sector

$$\max_{Y_{g,t}, Y_{b,t}} \left[(\varphi)^{\frac{1}{\chi}} (Y_{g,t})^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}} (Y_{b,t})^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}}$$

$$s.t. P_{g,t} Y_{g,t} + P_{b,t} Y_{b,t} = P_t^m Y_t$$

$$\frac{P_t^*}{P_t} = \frac{\epsilon_p}{\epsilon_p - 1} \frac{f_t^1}{f_t^2}$$

$$f_t^1 = \lambda_t m c_t Y_t + \beta \theta_p E_t \pi_{t+1}^{\epsilon_p} f_{t+1}^1$$

$$f_t^2 = \lambda_t Y_t + \beta \theta_p E_t \pi_{t+1}^{\epsilon_p - 1} f_{t+1}^2$$

3.1 Households

$$\max_{C_t, M_t, L_t} E_t \sum_{k=0}^{\infty} \beta^k \left[\frac{C_{t+k}^{1-\sigma_c}}{1-\sigma_c} + \zeta \frac{\left(\frac{M_{t+k}}{P_{t+k}}\right)^{1-\sigma_m}}{1-\sigma_m} - \xi \frac{L_{t+k}^{1+\sigma_l}}{1+\sigma_l} \right]$$

$$s.t. C_t + \frac{(M_t - M_{t-1})}{P_t} + D_t = \frac{W_t}{P_t} L_t - T_t + r_{t-1} D_{t-1} + PRO_t$$

Labor supply equation:

$$\xi L_t^{\sigma_l} = \frac{W_t}{P_t} C_t^{-\sigma_c}$$

Euler equation of consumption decision:

$$\frac{1}{r_t} = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}$$

Money demand equation:

$$\left(\frac{M_t}{P_t}\right)^{\sigma_m} = \zeta \left(\frac{r_t}{r_{t-1}}\right) C_t^{\sigma_c}$$

Lagrange multiplier λ_t :

$$\lambda_t = C_t^{-\sigma_c}$$

Model



3.3 The wholesaler sector

$$\max_{L_{g,t}, K_{g,t}} \Pi_t = P_{g,t} Y_{g,t} - W_{g,t} L_{g,t} - R_{g,t}^k Q_{t-1} K_{g,t} + Q_t (1 - \delta) K_{g,t}$$

$$s. t. Y_{g,t} = A_{g,t} K_{g,t}^{\alpha_g} L_{g,t}^{1-\alpha_g}$$



3.4 The capital sector

$$\max_{I_t} E_t \sum_{s=0}^{\infty} \beta^s \Lambda_{t,t+s} \left\{ Q_{t+s} \left[1 - \psi \left(\frac{I_{t+s}}{I_{t+s-1}} \right) - 1 \right] \right\} I_{t+s}$$

$$s. t. K_t = (1 - \delta) K_{t-1} + \left[1 - \frac{\psi_1}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right] I_t$$

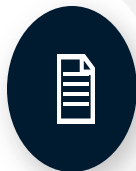


Expected rate of return on capital goods:

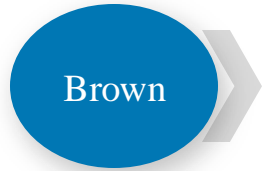
$$E_t \{ R_{g,t+1}^k \} = E_t \left[\alpha_g mc_{g,t+1} \frac{Y_{g,t+1}}{K_{g,t}} + Q_{t+1} (1 - \delta) \right] / Q_t$$

Marginal cost equation:

$$P_{g,t} = mc_{g,t}$$



Model - 3.5 Entrepreneur sector with loan demand



$$Q_t K_{i,t} = N_{i,t} + B_{i,t}$$

$$LEV_{i,t} = Q_t K_{i,t} / N_{i,t}$$

$$\bar{\omega}_{b,t+1} R_{b,t+1}^k Q_t K_{b,t} = R_{b,t+1}^l B_{b,t}$$

$$[1 - F(\bar{\omega}_{b,t+1}, \sigma_{\omega_b})] R_{b,t+1}^l B_{b,t} + \int_0^{\bar{\omega}_{b,t+1}} [(1 - \tau) \omega_b R_{b,t+1}^k Q_t K_{b,t}] dF(\omega_b, \sigma_{\omega_b}) = i_{t+1} B_{b,t}$$

$$\max_{LEV_b, \bar{\omega}_{b,t+1}} E_t [1 - \Gamma(\bar{\omega}_{b,t+1}, \sigma_{\omega_b})] R_{b,t+1}^k Q_t K_{b,t}$$

$$s. t. [\Gamma(\bar{\omega}_{b,t+1}, \sigma_{\omega_b}) - \tau G(\bar{\omega}_{b,t+1}, \sigma_{\omega_b})] R_{b,t+1}^k Q_t k_{b,t} = i_{t+1} (Q_t k_{b,t} - N_{b,t})$$

- $\bar{\omega}_{b,t+1}$: threshold value
- $R_{b,t+1}^k$: Average return on capital
- $R_{b,t+1}^l$: Non-default loan rate
- i_{t+1} : Opportunity cost

Model - 3.5 Entrepreneur sector with loan demand

$$Q_t K_{i,t} = N_{i,t} + B_{i,t}$$

$$LEV_{i,t} = Q_t K_{i,t} / N_{i,t}$$

$$G_{t+1} + \bar{\omega}_{g,t+1} R_{g,t+1}^k Q_t K_{g,t} = R_{g,t+1}^l B_{g,t}$$

$$[1 - F(\bar{\omega}_{g,t+1}, \sigma_{\omega_g})] R_{g,t+1}^l B_{g,t} + \int_0^{\bar{\omega}_{g,t+1}} [G_{t+1} + (1 - \tau) \omega_g R_{g,t+1}^k Q_t K_{g,t}] dF(\omega_g, \sigma_{\omega_g}) = i_{t+1} B_{g,t}$$

$$\max_{LEV_g, \bar{\omega}_{g,t+1}} E_t [1 - \Gamma(\bar{\omega}_{g,t+1}, \sigma_{\omega_g}) - g_{t+1}] R_{g,t+1}^k Q_t K_{g,t}$$

$$s.t. [\Gamma(\bar{\omega}_{g,t+1}, \sigma_{\omega_g}) - \tau G(\bar{\omega}_{g,t+1}, \sigma_{\omega_g}) + g_{t+1}] R_{g,t+1}^k Q_t K_{g,t} = i_{t+1} (Q_t K_{g,t} - N_{g,t})$$

- $\bar{\omega}_{g,t+1}$: threshold value
- $R_{g,t+1}^k$: Average return on capital
- $R_{g,t+1}^l$: Non-default loan rate
- i_{t+1} : Opportunity cost

Green

Model - 3.6 Banking sector

$$(B_{g,t} + B_{b,t}) + R_t^r D_t = D_t + H_{g,t}$$

$$\max_{B_{g,t}} \Pi_{Bg} = E_t \sum_{t=0}^{\infty} \beta^t [(1 - o_g) R_{g,t}^l B_{g,t} - i_t D_{g,t} - R_{g,t}^h H_{g,t} - \text{Adcost}_{g,t}]$$

$$\text{s.t. } \text{Adcost}_{g,t} = \frac{\psi_2}{2} \left(\frac{B_{g,t}}{B_{g,t-1}} - 1 \right)^2 B_{g,t} + \frac{\psi_3}{2} \left(\frac{D_{g,t}}{D_{g,t-1}} - 1 \right)^2 D_{g,t} + \frac{\psi_4}{2} \left(\frac{H_{g,t}}{H_{g,t-1}} - 1 \right)^2 H_{g,t}$$

$$\text{s.t. } B_{g,t} = (1 - R_t^r) D_{g,t} + H_{g,t}$$

$$\text{s.t. } H_{g,t} = \varpi_t B_{g,t}$$

Green

$$\max_{B_{b,t}} \Pi_{Bb} = E_t \sum_{t=0}^{\infty} \beta^t [(1 - o_b) R_{b,t}^l B_{b,t} - i_t D_{b,t} - \text{Adcost}_{b,t}]$$

$$\text{s.t. } \text{Adcost}_{b,t} = \frac{\psi_5}{2} \left(\frac{B_{b,t}}{B_{b,t-1}} - 1 \right)^2 B_{b,t} + \frac{\psi_6}{2} \left(\frac{D_{b,t}}{D_{b,t-1}} - 1 \right)^2 D_{b,t}$$

$$\text{s.t. } B_{b,t} = (1 - R_t^r) D_{b,t}$$

Brown

Model - 3.7 Government sector & 3.8 Market clearing

$$Gov_t + G_{t+1} = \frac{M_t - M_{t-1}}{P_t} + T_t$$

$$Gov_t = \psi_7 Y_t^f$$

$$Y_t^f = C_t + Gov_t + G_{t+1} + I_t + \left[\begin{array}{l} \tau G(\bar{\omega}_{g,t+1}, \sigma_{\omega g}) R_{g,t+1}^k Q_t K_{g,t} \\ + \tau G(\bar{\omega}_{b,t+1}, \sigma_{\omega b}) R_{b,t+1}^k Q_t K_{b,t} \end{array} \right]$$

Model - Shocks

1

Conventional Monetary Policy (RRR)

$$\log R_t^r = (1 - \rho_r) \log R_{ss}^r + \rho_r \log R_{t-1}^r + \varepsilon_t^{R^r}, \varepsilon_t^{R^r} \sim N(0, \sigma_{R^r}^2)$$

2

Unconventional Monetary Policy (GCP)

$$\log R_{g,t}^h = (1 - \rho_h) \log R_{ss}^h + \rho_h \log R_{t-1}^h + \varepsilon_t^h, \varepsilon_t^h \sim N(0, \sigma_h^2)$$

3

Fiscal Support (SBC)

$$\log g_t = (1 - \rho_g) \log g_{ss} + \rho_g \log g_{t-1} + \varepsilon_t^g, \varepsilon_t^g \sim N(0, \sigma_g^2)$$

04/

Calibration and steady state

Calibration and steady state

We calibrate the parameters common in the New Keynesian literature to standard values, data, Bayesian estimation, authoritative papers.

There are 59 equations for 59 endogenous variables:

Var: $C_t, L_t, W_t, P_t, r_t, M_t, \lambda_t, \pi_t, Y_{g,t}, Y_{b,t}, A_{g,t}, A_{b,t}, K_{g,t}, K_{b,t}, L_{g,t}, L_{b,t}, mc_{g,t}, mc_{b,t}, W_{g,t}, W_{b,t}, R_{g,t+1}^k, R_{b,t+1}^k, Q_t, P_t^*, P_{g,t}, P_{b,t}, i_t, K_t, Y_t, P_t^m, f_t^1, f_t^2, mc_t, d_t^P, Y_t^f, I_t, N_{g,t}, N_{b,t}, B_{g,t}, B_{b,t}, G_{t+1}, g_{t+1}, LEV_{g,t}, LEV_{b,t}, \eta_{g,t}, \eta_{b,t}, R_{g,t}^l, R_{b,t}^l, \bar{\omega}_g, \bar{\omega}_b, D_t, R_{g,t}^h, \varpi_t, R_t^r, Gov_t, T_t, D_{g,t}, D_{b,t}, H_{g,t}$

The model features 3 exogenous shocks:

Varexo: $\varepsilon_t^{R^r}, \varepsilon_t^h, \varepsilon_t^g$

Table 1: Calibrated parameters

Parameter	Description	Value
β	Discount factor	0.978
σ_c	Inverse of elasticity intertemporal substitution of consumption	2
σ_m	Inverse of elasticity intertemporal substitution of cash balance	1
σ_l	The inverse of the Frisch elasticity of labor supply	1
ζ	The share of real money balance in household utility	1
ξ	The share of labor supply in household utility	1.5045
α_g	Share of capital in production in green firms	0.37
α_b	Share of capital in production in brown firms	0.35
δ	Depreciation rate	0.019
θ_p	Price stickiness parameter	0.75
χ	Elasticity of substitution brown-green goods	2
ϵ_p	Elasticity of firms' substitution between intermediate goods	8
φ	Weight of green goods	0.5093
γ_g	Natural survival rate of green firms	0.9219
γ_b	Natural survival rate of brown firms	0.9864
τ	supervision costs	0.21
$LEV_{g,t}$	The leverage ratio of non-financial firms (green)	1.39
$LEV_{b,t}$	The leverage ratio of non-financial firms (brown)	1.54
ϖ_t	Pledge rate	0.7
ψ_1	Investment adjustment cost	2.48
ψ_2	Adjustment cost of green firms' loan	2.47
ψ_3	Adjustment cost of green credit bank deposits	2.48

Calibration parameters

ψ_4	Adjustment cost of refinancing (green credit)	2.5
ψ_5	Adjustment cost of brown firms' loan	2.53
ψ_6	Adjustment cost of brown credit bank deposits	2.48
ψ_7	Ration of government expenditure to GDP	0.1775
μ_1	Response parameters of refinancing rate to the proportion of green credit	0.4412
μ_2	Response parameters of pledge rate to green industry credit ratio	2.1309
ϕ_Y	Response coefficient of deposit rate to output gap	0.1798
ϕ_π	Response coefficient of RRR to inflation gap	1.3507
ρ_r	Smoothing coefficient of deposit reserve ratio	0.743
ρ_h	Smoothing coefficient of refinancing rate	0.33
ρ_ω	Smoothing coefficient of refinancing pledge rate	0.0536
ρ_{ga}	Persistence of technical impact of green firms	0.9583
ρ_{ba}	Persistence of technical impact of brown firms	0.7348

Steady State

$$L_{g,ss} = \frac{1}{3}$$

$$L_{b,ss} = \frac{1}{3}$$

$$L_{ss} = L_{g,ss} + L_{b,ss}$$

$$P_{g,ss} = 1$$

$$P_{ss} = 1$$

$$A_{g,ss} = 1$$

$$r_{ss} = \frac{1}{\beta}$$

$$\pi_{ss} = 1$$

$$Q_{ss} = 1$$

$$Y_{b,ss} = 1$$

$$i_{ss} = r_{ss}\pi_{ss}$$

$$P_{ss}^* = \left[\frac{1 - \theta_p (\pi_{ss})^{\epsilon_p - 1}}{(1 - \theta_p)} \right]^{\frac{1}{1 - \epsilon_p}}$$

$$d_{ss}^p = \frac{(1 - \theta_p) (P_{ss}^*)^{-\epsilon_p}}{(1 - \theta_p \pi_{ss}^{\epsilon_p})}$$

$$mc_{ss} = \frac{\epsilon_p - 1}{\epsilon_p} \frac{(1 - \beta \theta_p \pi_{ss}^{\epsilon_p})}{(1 - \beta \theta_p \pi_{ss}^{\epsilon_p - 1})} P_{ss}^*$$

$$P_{ss}^m = mc_{ss}$$

$$mc_{g,ss} = P_{g,ss}$$

$$\varphi = \frac{P_{ss}^{m^{1-\chi}}}{\frac{(1-\alpha_g)mc_{g,ss}L_{b,ss}}{(1-\alpha_b)L_{g,ss}P_{g,ss}^\chi} + (P_{g,ss})^{1-\chi}}$$

$$P_{b,ss} = \left[\frac{(1-\varphi)}{P_{ss}^{m^{1-\chi}} - \varphi(P_{g,ss})^{1-\chi}} \right]^{\frac{1}{\chi-1}}$$

$$mc_{b,ss} = P_{b,ss}$$

$$W_{b,ss} = (1 - \alpha_b) mc_{b,ss} \frac{Y_{b,ss}}{L_{b,ss}}$$

$$W_{ss} = W_{b,ss}$$

$$W_{g,ss} = W_{ss}$$

$$Y_{g,ss} = \frac{L_{g,ss} W_{g,ss}}{(1 - \alpha_g) mc_{g,ss}}$$

$$Y_{ss} = \frac{Y_{g,ss}}{\varphi} \left(\frac{P_{g,ss}}{P_{ss}^m} \right)^\chi$$

$$Y_{ss}^f = \frac{Y_{ss}}{d_{ss}^p}$$

$$K_{g,ss} = \left(\frac{Y_{g,ss}}{A_{g,ss} L_{g,ss}^{1-\alpha_g}} \right)^{\frac{1}{\alpha_g}}$$

$$R_{g,ss}^k = \left[\alpha_g mc_{g,ss} \frac{Y_{g,ss}}{K_{g,ss}} + Q_{ss}(1 - \delta) \right] / Q_{ss}$$

$$LEV_{b,ss} = 2$$

$$\frac{LEV_{b,ss} - 1}{[\Gamma(\bar{\omega}_{b,ss}, \sigma_{\omega b}) - \tau G(\bar{\omega}_{b,ss}, \sigma_{\omega b})]} = \frac{1 - F(\bar{\omega}_{b,ss}, \sigma_{\omega b})}{[1 - F(\bar{\omega}_{b,ss}, \sigma_{\omega b}) - \tau \bar{\omega}_{b,ss} F_{\omega}(\bar{\omega}_{b,ss}, \sigma_{\omega b})][1 - \Gamma(\bar{\omega}_{b,ss}, \sigma_{\omega b})]}$$

$$R_{b,ss}^k = \frac{i_{ss} [LEV_{b,ss} - 1]}{LEV_{b,ss} [\Gamma(\bar{\omega}_{b,ss}, \sigma_{\omega b}) - \tau G(\bar{\omega}_{b,ss}, \sigma_{\omega b})]}$$

$$\eta_{b,ss} = \frac{1 - F(\bar{\omega}_{b,ss}, \sigma_{\omega b})}{1 - F(\bar{\omega}_{b,ss}, \sigma_{\omega b}) - \tau \bar{\omega}_{b,ss} F_{\omega}(\bar{\omega}_{b,ss}, \sigma_{\omega b})}$$

$$K_{b,ss} = \frac{\alpha_b mc_{b,ss} Y_{b,ss}}{R_{b,ss}^k Q_{ss} - Q_{ss}(1 - \delta)}$$

$$A_{b,ss} = \frac{Y_{b,ss}}{K_{b,ss}^{\alpha_b} L_{b,ss}^{1-\alpha_b}}$$

$$N_{b,ss} = Q_{ss} K_{b,ss} / LEV_{b,ss}$$

$$B_{b,ss} = Q_{ss} K_{b,ss} - N_{b,ss}$$

$$R_{b,ss}^l = \frac{\bar{\omega}_{b,ss} R_{b,ss}^k Q_{ss} K_{b,ss}}{B_{b,ss}}$$

$$K_{ss} = K_{g,ss} + K_{b,ss}$$

$$I_{ss} = \delta K_{ss}$$

$$\gamma_b = \frac{1/LEV_{b,ss}}{[R_{b,ss}^k (1 - \tau G(\bar{\omega}_{b,ss}, \sigma_{\omega b})) - i_{ss} (1 - 1/LEV_{b,ss})]}$$

$$g_{ss} = 0.3$$

$$1 - [g_{ss} + \Gamma(\bar{\omega}_{g,ss}, \sigma_{\omega g}) - \tau G(\bar{\omega}_{g,ss}, \sigma_{\omega g})] \frac{R_{g,ss}^k}{i_{ss}} = \frac{[1 - \Gamma(\bar{\omega}_{g,ss}, \sigma_{\omega g}) - g_{ss}] [1 - F(\bar{\omega}_{g,ss}, \sigma_{\omega g}) - \tau \bar{\omega}_{g,ss} F_{\omega}(\bar{\omega}_{g,ss}, \sigma_{\omega g})] R_{g,ss}^k}{1 - F(\bar{\omega}_{g,ss}, \sigma_{\omega g})} \frac{R_{g,ss}^k}{i_{ss}}$$

$$\eta_{g,ss} = \frac{1 - F(\bar{\omega}_{g,ss}, \sigma_{\omega g})}{1 - F(\bar{\omega}_{g,ss}, \sigma_{\omega g}) - \tau \bar{\omega}_{g,ss} F_{\omega}(\bar{\omega}_{g,ss}, \sigma_{\omega g})}$$

$$G_{ss} = R_{g,ss}^k Q_{ss} K_{g,ss} g_{ss}$$

$$LEV_{g,ss} = \frac{i_{ss} \eta_{g,ss}}{[1 - \Gamma(\bar{\omega}_{g,ss}, \sigma_{\omega g}) - g_{ss}] R_{g,ss}^k}$$

$$N_{g,ss} = \frac{Q_{ss} K_{g,ss}}{LEV_{g,ss}}$$

$$B_{g,ss} = Q_{ss} K_{g,ss} - N_{g,ss}$$

$$R_{g,ss}^l = \frac{G_{ss} + \bar{\omega}_{g,ss} R_{g,ss}^k Q_{ss} K_{g,ss}}{B_{g,ss}}$$

$$\gamma_g = \frac{N_{g,ss}}{[R_{g,ss}^k Q_{ss} K_{g,ss} (1 - \tau G(\bar{\omega}_{g,ss}, \sigma_{\omega g}) + g_{ss}) - i_{ss} B_{g,ss}]}$$

$$Gov_{ss} = \psi_7 Y_{ss}^f$$

$$C_{ss} = (1 - \psi_7) Y_{ss}^f - [G_{ss} + I_{ss} + \tau G(\bar{\omega}_{g,ss}, \sigma_{\omega g}) R_{g,ss}^k Q_{ss} K_{g,ss} + \tau G(\bar{\omega}_{b,ss}, \sigma_{\omega b}) R_{b,ss}^k Q_{ss} K_{b,ss}]$$

Steady State

$$\xi = \frac{W_{ss}}{L_{ss}^{\sigma_l} P_{ss}} C_{ss}^{-\sigma_c}$$

$$M_{ss} = \left[\zeta \left(\frac{r_{ss}}{r_{ss} - 1} \right) C_{ss}^{\sigma_c} \right]^{\frac{1}{\sigma_m}}$$

$$\lambda_{ss} = C_{ss}^{-\sigma_c}$$

$$f_{ss}^1 = \frac{\lambda_{ss} m c_{ss} Y_{ss}}{(1 - \beta \theta_p \pi_{ss}^{\chi})}$$

$$f_{ss}^2 = \frac{\lambda_{ss} Y_{ss}}{(1 - \beta \theta_p \pi_{ss}^{\chi - 1})}$$

$$T_{ss} = Gov_{ss} + G_{ss}$$

$$\omega_{ss} = 0.7$$

$$R_{ss}^r = 0.16$$

$$o_b = 1 - \frac{i_{ss}}{(1 - R_{ss}^r) R_{b,ss}^l}$$

$$R_{g,ss}^h = \frac{(1 - o_g) R_{g,ss}^l - i_{ss} \frac{(1 - \bar{\omega}_{g,ss})}{(1 - R_{ss}^r)}}{\omega_{ss}}$$

$$D_{ss} = \frac{B_{b,ss} + (1 - \bar{\omega}_{ss}) B_{g,ss}}{1 - R_{ss}^r}$$

$$D_{b,ss} = \frac{B_{b,ss}}{1 - R_{ss}^r}$$

$$D_{g,ss} = D_{ss} - D_{b,ss}$$

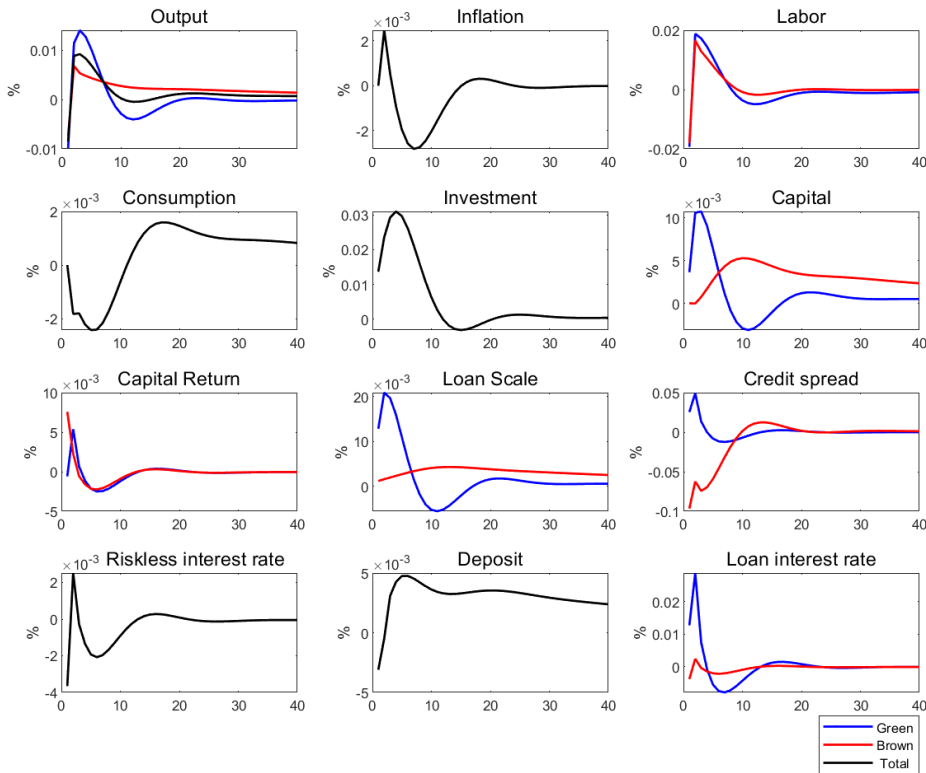
$$H_{g,ss} = B_{g,ss} - (1 - R_{ss}^r) D_{g,ss}$$

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Impulse response analysis

- **5.1 Conventional Monetary Policy**
- **5.2 Unconventional Monetary Policy**
- **5.3 Fiscal Support**
- **5.4 Comparison of Three Policies**

Impulse response analysis – Conventional Monetary Policy



RRR drop 1 unit

Short-term

- ✓ Loan scale
- ✓ Riskless interest rate → Output → Labor → Nominal & real wage → family's net wealth → Deposit

Long-term

- ✓ Capital return → Non-default rate → Banks net assets → Deposit → Loan scale

Figure 1. Reserve Requirement Ratio Shock

Impulse response analysis - Unconventional Monetary Policy

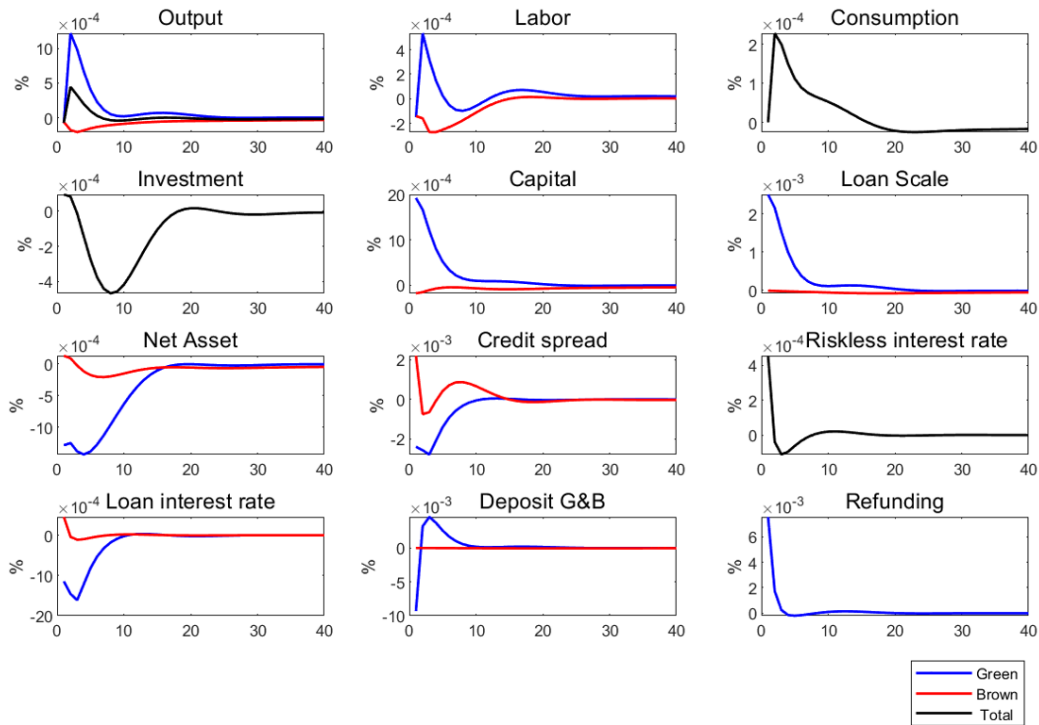


Figure 2. Green Credit Policy Shock

Refinancing rate drop 1 unit

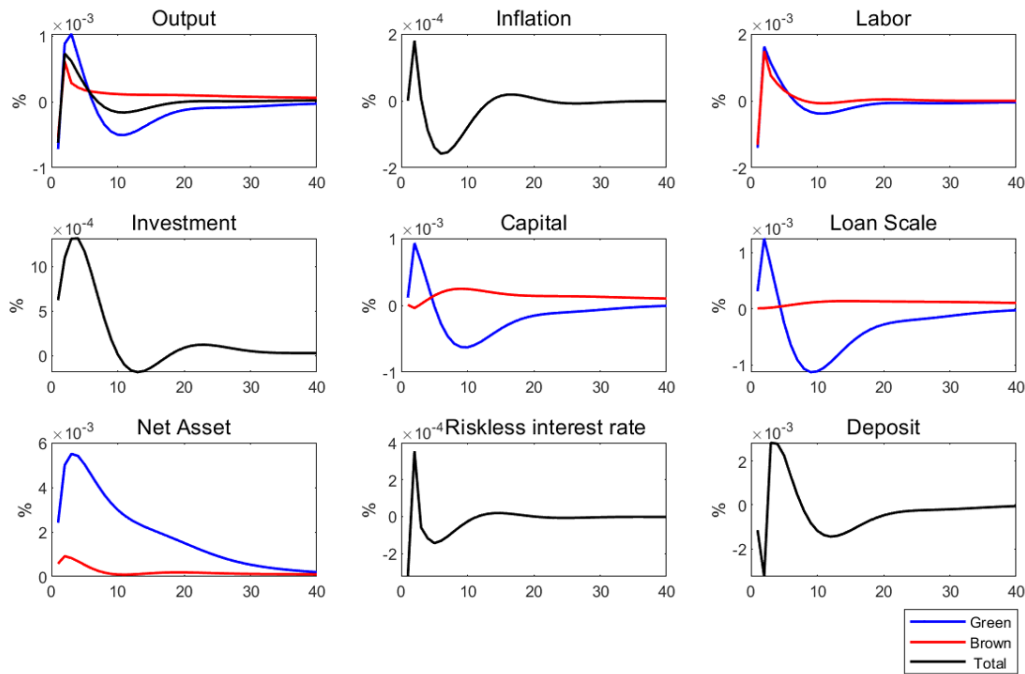
Short-term

- ✓ Loan scale \rightarrow Leverage
- ✓ Financing cost \rightarrow Output \rightarrow Labor & Capital
- ✓ Nominal & real wage \rightarrow Consumption
- ✓ Deposit

Long-term

- ✓ Leverage \rightarrow Non-default rate \rightarrow External financing \rightarrow Financing cost \rightarrow Loan scale \rightarrow Labor & Capital \rightarrow Output \rightarrow Consumption

Impulse response analysis - Fiscal Support



Fiscal support increase 1 unit

Short-term

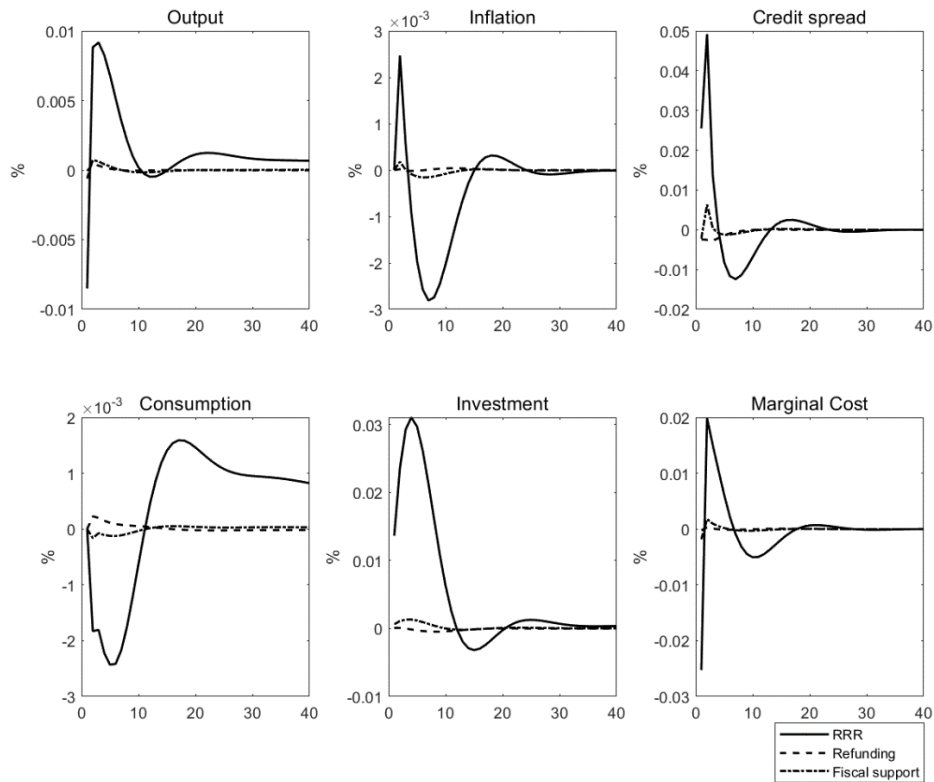
- ✓ Non-default rate \rightarrow Risk \rightarrow Financing cost \rightarrow Loan scale
- ✓ Banks net assets \rightarrow Riskless interest rate
- ✓ Mismatch & distortion \rightarrow Output

Long-term

- ✓ Capital return \rightarrow Non-default rate
- Banks net assets \rightarrow Deposit \rightarrow Loan scale

Figure 3. Soft Budget Constraint Shock

Impulse response analysis - Comparison of Three Policies



- ✓ Conventional monetary policy has the weakest economic stability effect, which leads to large fluctuations in output and inflation.
- ✓ Unconventional monetary policy can stabilize economic fluctuations more quickly. Similarly, unconventional monetary policy has reduced the long-term negative impact on the economy.
- ✓ Fiscal support to green entrepreneurs, resulting in the mismatch of resources and price distortion, which leads to the inefficient use of resources and the negative impact on the overall output level.

Figure 4. RRR, GCP & SBC

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Conclusion



Conclusion

In the model, central bank refinancing and reserve requirements were employed to support lending for **lower carbon projects** at lower rates of interest than for other projects. Based on *calibrated parameters from quarterly data for the African economy*, **central bank refinancing is shown to be the most effective tool to influence bank lending that supports environment goals**. By focusing on reserve requirements and rediscount policy as the monetary policy tools to support these goals our model may be particularly relevant to policymaking in middle- and low-income, where these tools have long played an important role in policymaking.



Thanks

Looking for your comments