DEFINE-SIMPLE

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1. Brief description

DEFINE-SIMPLE is a simplified module of DEFINE that is used to illustrate how consumption and investment decisions can affect the path of key economic variables and carbon emissions. The model assumes that a proportion of total private investment is green and that a part of bank loans is used to finance this type of investment. The higher green investment relative to conventional capital the lower the carbon intensity.

The model consists of three sectors: firms, households and banks. Firms undertake investment by using retained profits and loans. A part of firms' profits is distributed to households. Households accumulate savings in the form of deposits. Banks provide firm loans by creating deposits. Banks' profits are distributed to households. The module is calibrated using data for the global economy.

The balance sheet matrix and the transactions matrix of the model are shown below.

Balance sheet matrix

	Households	Firms	Commercial banks	Total
Deposits	$+D_t$		$-D_t$	0
Green loans		$-L_{Gt}$	$+L_{Gt}$	0
Conventional loans		$-L_{Ct}$	$+L_{Ct}$	0
Green capital		$+K_{Gt}$		$+K_{Gt}$
Conventional capital		$+K_{Ct}$		$+K_{Ct}$
Total (net worth)	$+D_t$	$+V_{Ft}$	0	$+K_t$

Transactions matrix

	Households	Firms		Commercial banks		Total
		Current	Capital	Current	Capital	
Consumption	$-C_t$	$+C_t$				0
Green investment		$+I_{Gt}$	$-I_{Gt}$			0
Conventional investment		$+I_{Ct}$	$-I_{Ct}$			0
Wages	$+s_wY_t$	$-s_wY_t$				0
Firms' profits	$+DP_t$	$-TP_t$	$+RP_t$			0
Banks' profits	$+BP_t$			$-BP_t$		0
Interest on deposits	$+int_DD_{t-1}$			$-int_DD_{t-1}$		0
Interest on green loans		$-int_GL_{Gt-1}$		$+int_GL_{Gt-1}$		0
Interest on conventional loans		$-int_CL_{Ct-1}$		$+int_CL_{Ct-1}$		0
Change in deposits	$-\Delta D_t$				$+\Delta D_t$	0
Change in green loans			$+\Delta L_{Gt}$		$-\Delta L_{Gt}$	0
Change in conventional loans			$+\Delta L_{Ct}$		$-\Delta L_{Ct}$	0
Total	0	0	0	0	0	0

2. Module equations

Households:

Disposable income of households: $Y_{Dt} = s_W Y_t + DP_t + BP_t + int_D\, D_{t-1}$ (1)

Consumption expenditures: $C_t = c_1 Y_{Dt-1} + c_2 D_{t-1}$ (2)

Deposits: $D_t = D_{t-1} + Y_{Dt} - C_t$ (3)

Firms:

Output: $Y_t = C_t + I_t$ (4)

Total profits of firms: $TP_t = Y_t - s_W Y_t - int_C\, L_{Ct-1} - int_G\, L_{Gt-1}$ (5)

Retained profits: $RP_t = s_F TP_t$ (6)

Distributed profits: $DP_t = TP_t - RP_t$ (7)

Investment: $I_t = (\alpha_0 + \alpha_1 r_{t-1}) K_{t-1}$ (8)

Rate of profit: $r_t = TP_t / K_t$ (9)

Green investment: $I_{Gt} = \beta_t I_t$ (10)

Share of green investment in total investment: $\beta_t = \beta_0 - \beta_1 (int_G - int_C)$ (11)

Conventional investment: $I_{Ct} = I_t - I_{Gt}$ (12)

Green capital stock: $K_{Gt} = K_{Gt-1} + I_{Gt}$ (13)

Conventional capital stock: $K_{Ct} = K_{Ct-1} + I_{Ct}$ (14)

Capital stock: $K_t = K_{Ct} + K_{Gt}$ (15)

Green loans: $L_{Gt} = L_{Gt-1} + I_{Gt} - \beta_t RP_t$ (16)

Conventional loans: $L_{Ct} = L_{Ct-1} + I_{Ct} + I_{Gt} - RP_t - (L_{Gt} - L_{Gt-1})$ (17)

Total loans: $L_t = L_{Ct} + L_{Gt}$ (18)

Banks:

Profits of banks: $BP_t = int_C\, L_{Ct-1} + int_G\, L_{Gt-1} - int_D\, D_{t-1}$ (19)

Deposits (redundant identity): $D_{redt} = L_t$ (20)

Emissions:

Industrial CO_2 emissions: $EMIS_{INt} = CI_t Y_t$ (21)

Carbon intensity: $CI_t = CI_{max} - \frac{CI_{max} - CI_{min}}{1 + ci_1 e^{-ci_2 (K_{Gt-1}/K_{Ct-1})}}$ (22)

Auxiliary equations:

Potential output: $Y_t^* = vK_t$ (23)

Capacity utilisation: $u_t = Y_t / Y_t^*$ (24)

Growth rate of output: $g_{Yt} = (Y_t - Y_{t-1})/Y_{t-1}$ (25)

Leverage ratio: $lev_t = L_t / K_t$ (26)

3. Module symbols and values

Symbol	Description	Value/calculation
	Parameters	
c_1	Propensity to consume out of disposable income	0.9373; calculated such that the model is at a steady state
c_2	Propensity to consume out of deposits	0.0498
g_K	Growth rate of capital	0.027
int_D	Interest rate on deposits	0.025
CI_{max}	Maximum potential value of carbon intensity	0.6
CI_{min}	Minimum potential value of carbin intensity	0.05
int_C	Interest rate on conventional loans	0.08
int_G	Interest rate on green loans	0.08
s_F	Retention rate of firms	0.5668; calculated such that the model is at a steady state
s_W	Wage share	0.54
v	Capital productivity	Calculated using equations (23) and (24)
α_o	Parameter in the investment function	0.02037; calculated such that the model is at a steady state
α_1	Parameter in the investment function (related to the sensitivity to the rate of profit)	0.1
β_o	Autonomous share of green investment in total investment	Calculated using equation (11)
β_1	Sensitivity of the green investment share to the interest rate differential	1
ci_1	Parameter linking the green to conventional capital ratio with carbon intensity	3.24
ci_2	Parameter linking the green to conventional capital ratio with carbon intensity	3.72
	Endogenous variables (initial values)	
Y_D	Disposable income of households (US$ trillion)	Calculated from equation (1)
C	Consumption expenditures (US$ trillion)	Calculated from equation (4)
D	Deposits (US$ trillion)	Calculated from equation (20)
Y	Output (US$ trillion)	85.93; 2018 value for the global economy (in US$ trillion)
TP	Total profits of firms (US$ trillion)	Calculated from equation (5)
RP	Retained profits (US$ trillion)	Calculated from equation (6)
DP	Distributed profits (US$ trillion)	Calculated from equation (7)
I	Investment (US$ trillion)	Calculated from $I=0.24*Y$; 0.24 is the investment-to-output ratio
r	Rate of profit	Calculated from equation (9)
I_G	Green investment (US$ trillion)	0.7; 2018 value for the global economy (in US$ trillion)
β	Share of green investment in total investment	Calculated using equation (10)
I_C	Conventional investment (US$ trillion)	Calculated from equation (12)
K_G	Green capital stock (US$ trillion)	Calculated from $K_G=\beta*K$
K_C	Conventional capital stock (US$ trillion)	Calculated from equation (15)
K	Capital stock (US$ trillion)	Calculated from $K=8.515862*Y$; 8.515862 is the capital-to-output ratio given by $(0.24*(1+g_K))/g_K$
L_G	Green loans (US$ trillion)	Calculated from $L_G=\beta*L$
L_C	Conventional loans (US$ trillion)	Calculated from equation (18)
L	Loans (US$ trillion)	Calculated from $L=0.914*Y$; 0.914 is the credit-to-output ratio
BP	Profits of banks (US$ trillion)	Calculated from equation (19)
D_{red}	Deposits (redundant)	Calculated from equation (20)
$EMIS_{IN}$	Industrial CO_2 emissions (GtCO2)	36.6; 2018 value for the global economy
CI	Carbon intensity (GtCO2/US$ trillion)	Calcumated from equation (21)
Y^*	Potential output (US$ trillion)	Calculated from equation (23)
u	Capacity utilisation rate	0.72; 2018 value for the global economy
g_Y	Growth rate of output	0.029
lev	Leverage ratio	Calculated from equation (26)