C3A / COSEFIN / ECLAC model session

Financial Sector Mitigation and Adaptation Tool (FSMAT)

Sebastian Valdecantos and

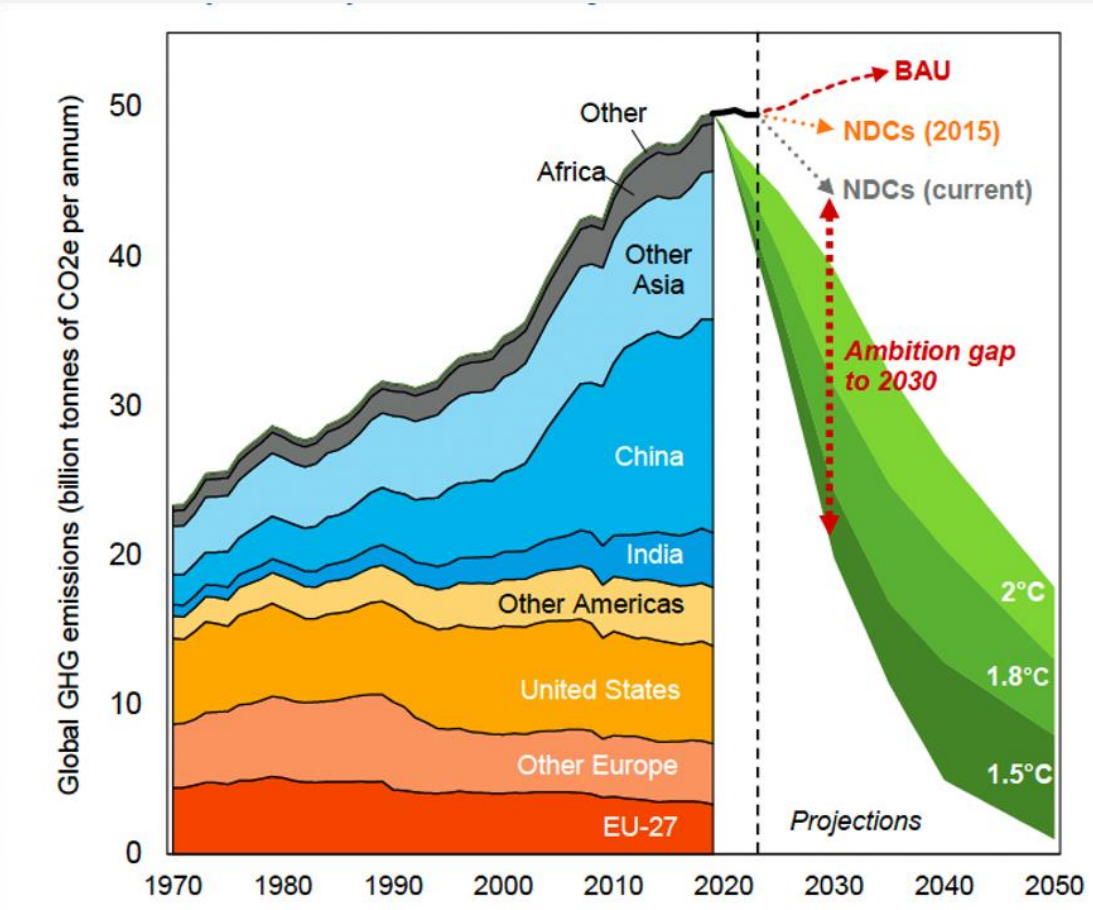
Francisco Amsler (EFICT)

17/07/2024

Contents

Financing needs for the low-carbon transition

THERE IS STILL A HUGE GAP TO REACH NET ZERO EMISSIONS



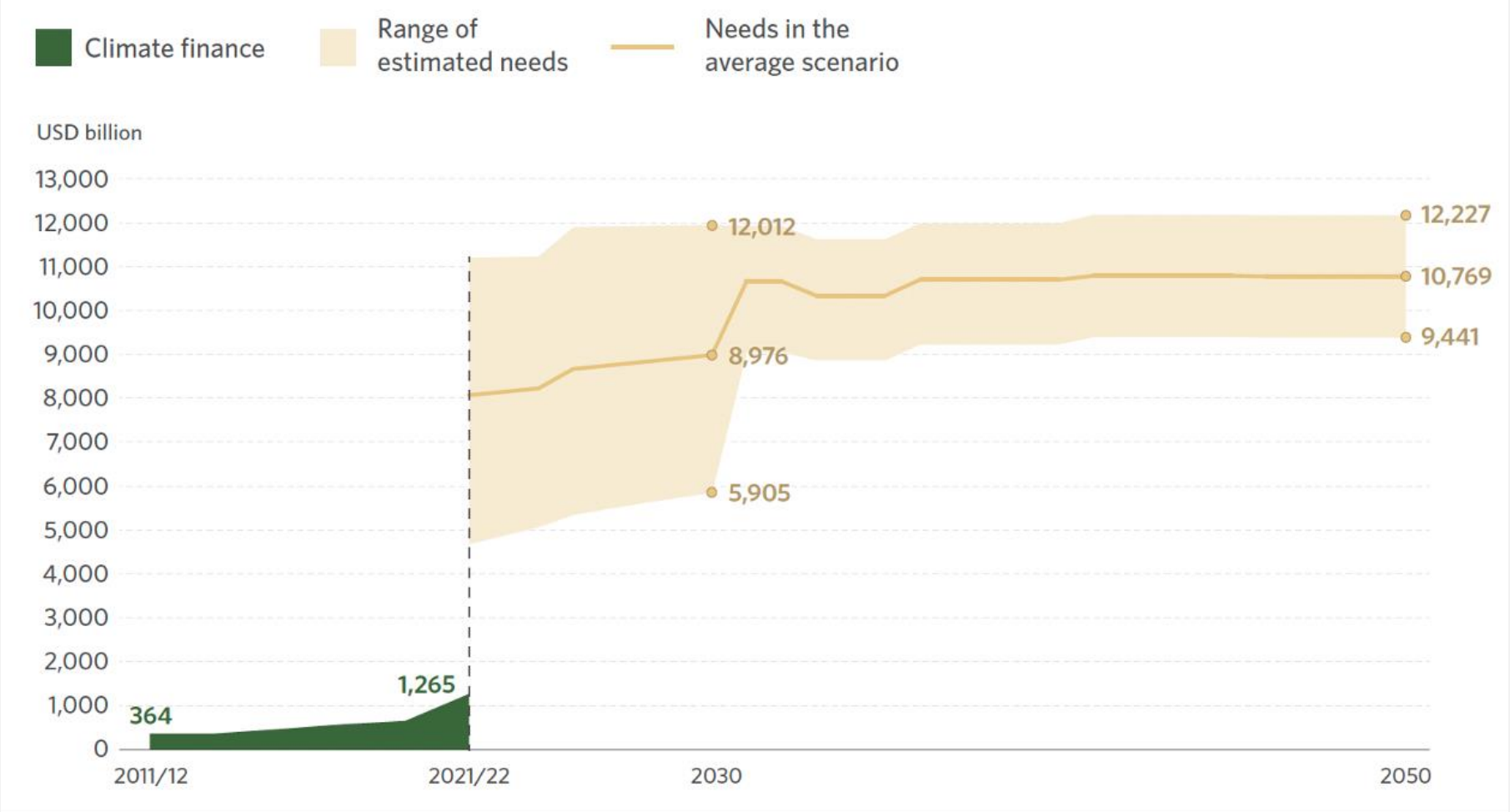
Ambition gap: Though countries have increased their mitigation ambition since the signing of the Paris Agreement in 2015, current NDCs would reduce global GHG emissions by just 11%.

Policy gap: In a business-as-usual scenario with no new mitigation policies, global GHG emissions are projected to increase by 4% to 51.5 billion tons in 2030—a rate that would exhaust the carbon budget for 1.5°C by 2035.

THE URGENT NEED TO RAMP UP CLIMATE FINANCE

- **Financing gap**: despite the recent progress in climate finance, we are still falling short of 6.5 trillion USD yearly to make all the required investments consistent with NZE.

- Closing the climate finance gap will involve developing a complete battery of financial sector initiatives.



Source: Climate Policy Initiative (2023). Global Landscape of Climate Finance 2023.

C3A Coalition for Capacity on Climate Action

Green Financial Sector Interventions (GFSI)

Some examples of Green Financial Sector Interventions (GFSIs)

Green regulatory policies (GRP)

- Green supporting factor
- Dirty penalizing factor

Green monetary policies (GMP)

- Green collateral framework
- Green QE

Public co-funding of green investments

- Soft loans
- Credit guarantees

Labelling

- Blue and Green Bonds and Loans

Debt for climate/nature swaps

Climate-resilient debt clauses

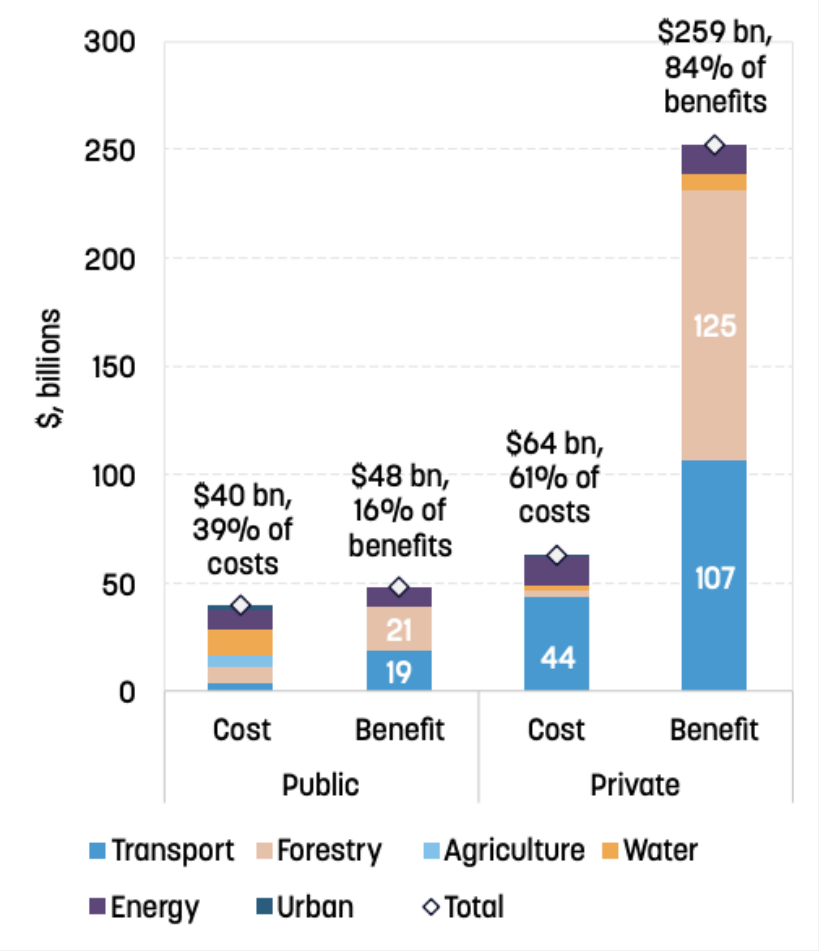
Ecuador's 'Galapagos Bond' (debt-for-nature swap)

PBoC's green monetary policies

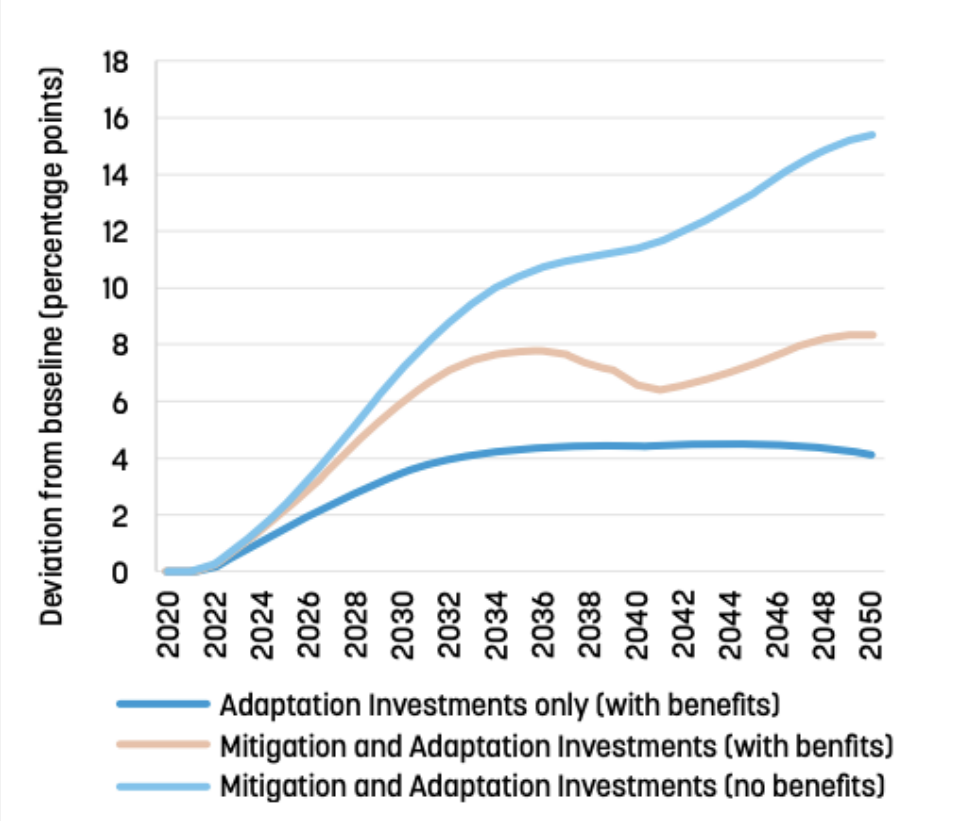
The low-carbon transition entails challenges for EMDEs

- Green investments will bring benefits and costs.
- Even when the net benefits are positive, the costs can generate specific vulnerabilities (i.e., an increase in debt).
- To prevent these vulnerabilities, policy makers could be tempted to delay the transition.

Benefits and costs of the low-carbon transition in Peru



Impact on the Public Debt-to-GDP ratio



Source: "World Bank Group. 2022. Peru Country Climate and Development Report. CCDR Series; World Bank, Washington, DC.

What is FSMAT aiming to?

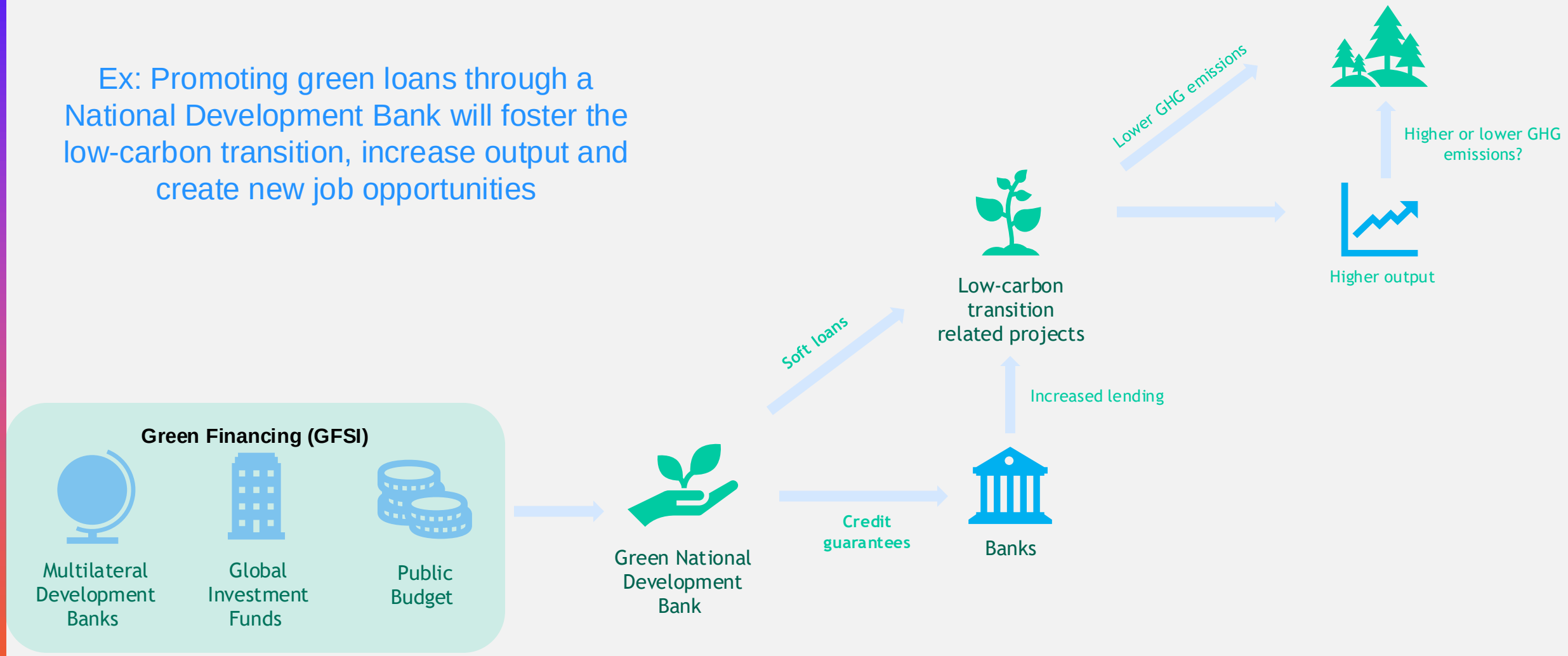
FSMAT is a tool to evaluate Green Financial Sector Interventions.

What are the dynamic macro-financial implications of GFSI?

How effective GFSI are to help reduce GHG emissions and cushion the effects of climate-related shocks?

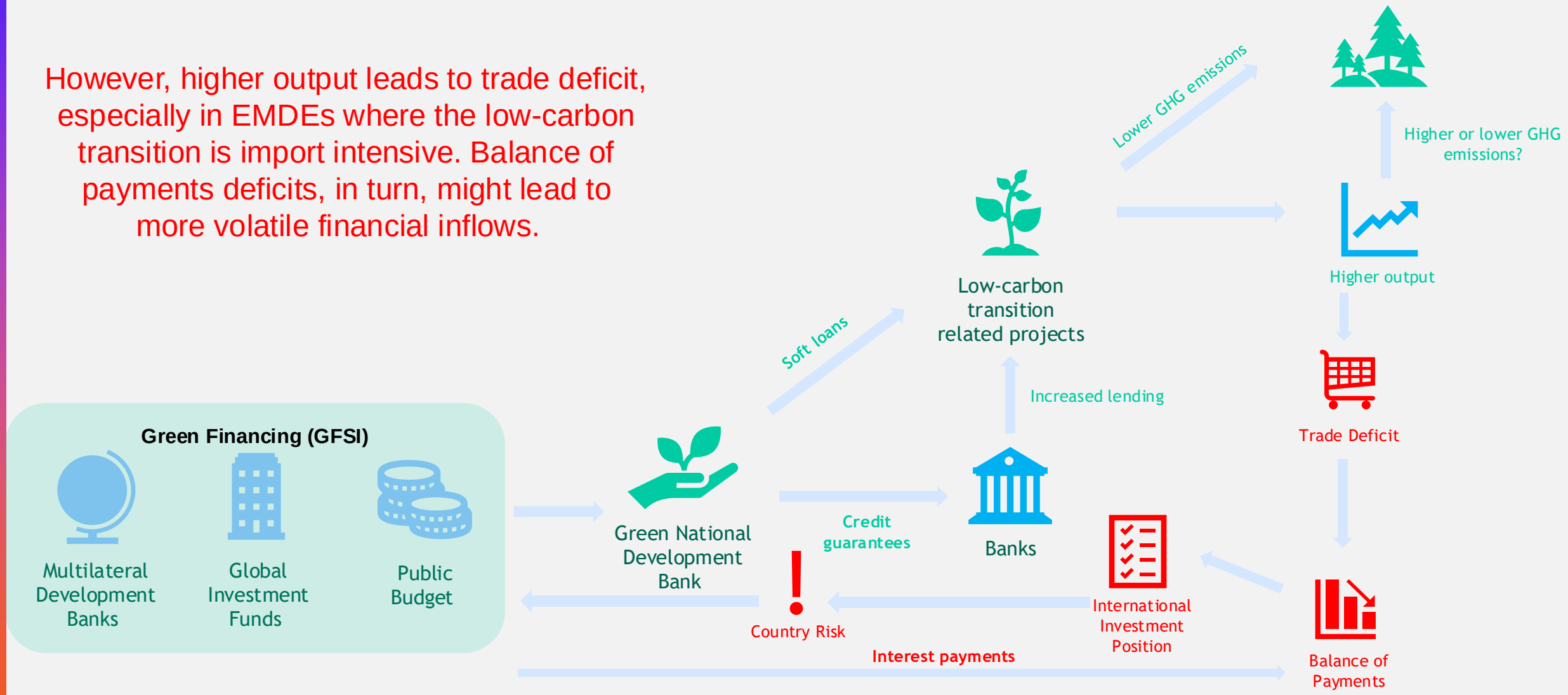
GFSI as enablers of the low-carbon transition

Ex: Promoting green loans through a National Development Bank will foster the low-carbon transition, increase output and create new job opportunities

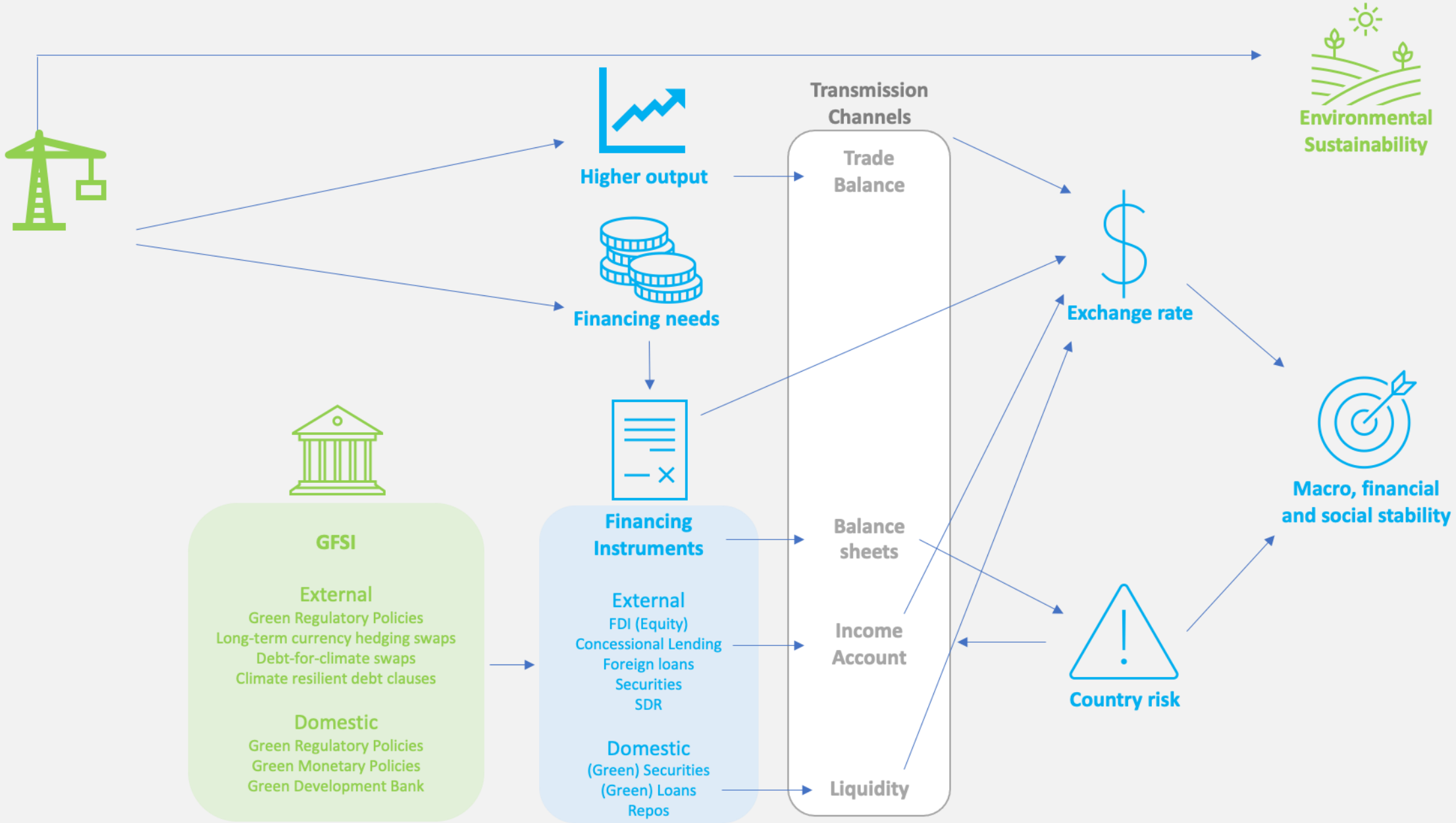


But GFSI can be self-defeating if not adequately designed and implemented

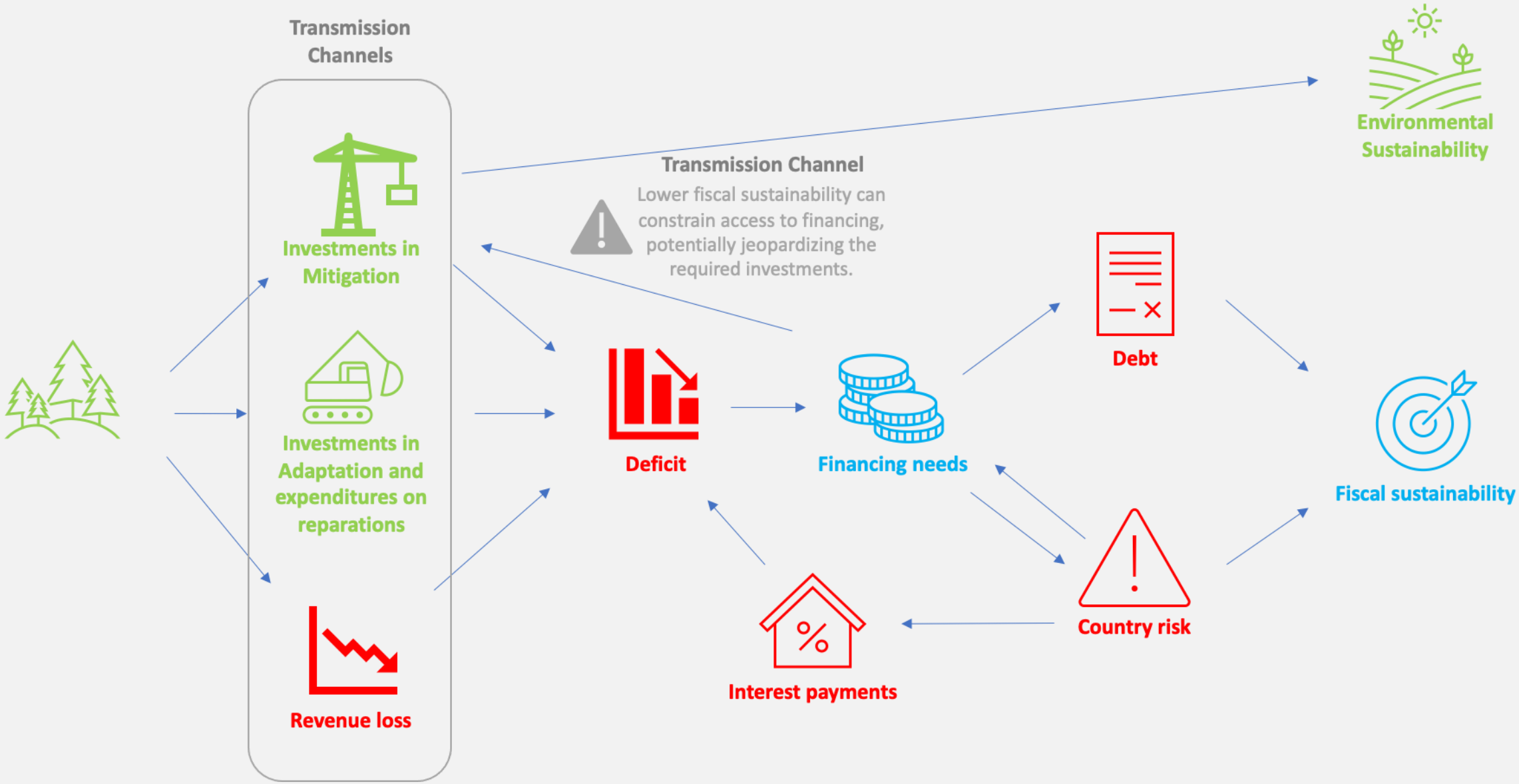
However, higher output leads to trade deficit, especially in EMDEs where the low-carbon transition is import intensive. Balance of payments deficits, in turn, might lead to more volatile financial inflows.



Key vulnerabilities and transmission channels captured by FSMAT



Key vulnerabilities and transmission channels captured by FSMAT (fiscal and debt side)



FSMAT can help identify transition risks to public finances

- FSMAT can provide insight into some of the dimensions defined in Cosefin's MIF, by offering:
- Macro-financial trajectories derived from alternative financing strategies, including the issuance of labelled bonds
- Risks and opportunities to fiscal revenues and expenditures emerging from the low-carbon transition
- The basis for a systemic approach to debt sustainability assessment

Matriz de Interés Fiscal (MIF)

del Consejo de Ministros de Hacienda o Finanzas de Centroamérica, Panamá y República Dominicana

COSEFIN
Secretaría Ejecutiva

Modelling pillars of FSMAT

Stock-Flow Consistency

- Flows affect stocks, which dynamically feed back into the flows.
- Quadruple entry bookkeeping
- Fulfilment of budget constraints.

Real and Financial spheres interdependencies

- The monetary and financial spheres are not just a mirror of the real side of the economy.
- The financial sector is autonomous and produces direct effects on the real side.

Disequilibrium approach

- Disequilibria in real and financial markets.
- Simultaneous price and quantity adjustment, but at different speeds.
- Continuous time modeling

Structuralism

- A country's economic structure conditions its macroeconomic performance.
- Need to account for these structural features.
- Alternative closures.

FSMAT builds upon a series of preexisting modeling approaches quickly gaining momentum.

Empirical SFC Models
US, Greece, Denmark, France, Argentina, England, Italy, Vietnam

GEMMES Approach
Tunisia, Morocco, Brazil, Colombia, Vietnam, Mexico, India

FSMT 1
Excel static tool for >100 countries

Model Features

- **Disequilibrium approach**
  - Markets, real and financial, simultaneously adjust via price and quantities, but at different speeds.
- **Full integration of the System of National Accounts**
  - The whole sequence from generation of income to the financial account are explicitly incorporated in the model's accounting structure.
  - This allows for the fulfilment of institutional agents' budget constraints.
- **Fully empirical models**
  - Country models are anchored on data, allowing for country-specific structural and institutional parameters, as well as vulnerability measures.
  - Dynamic calibration methods (CMA-ES).
- **Detailed financial sphere**
  - Broad range of financial instruments (at an aggregate level), representing the complexity of contemporary economies' financial dimension.
- **Pragmatic approach to behavioral equation specification**
  - Prioritize the model's capacity to replicate actual economic dynamics.
  - Importance of equations providing accurate descriptions of agents' decision-making processes.
- **Initially, single-sector economy** (with some sectoral flavor in the different blocks)

FSMAT – End-user experience

Data inputs

Required low-carbon transition investments

Import propensities

Total financing needs

User defines

Speed and intensity of the low-carbon transition

Combination of financing instruments

Dynamic Macroeconomic stock-flow Consistent Model

Output

GHG emissions reduction

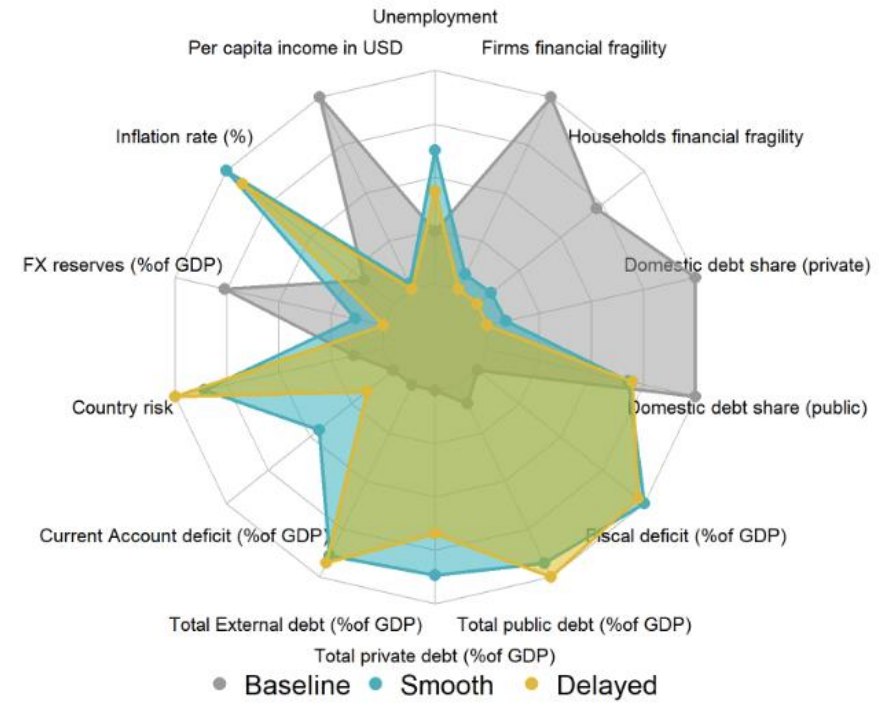
Macro-financial performance

Policy decision

FSMAT - Output

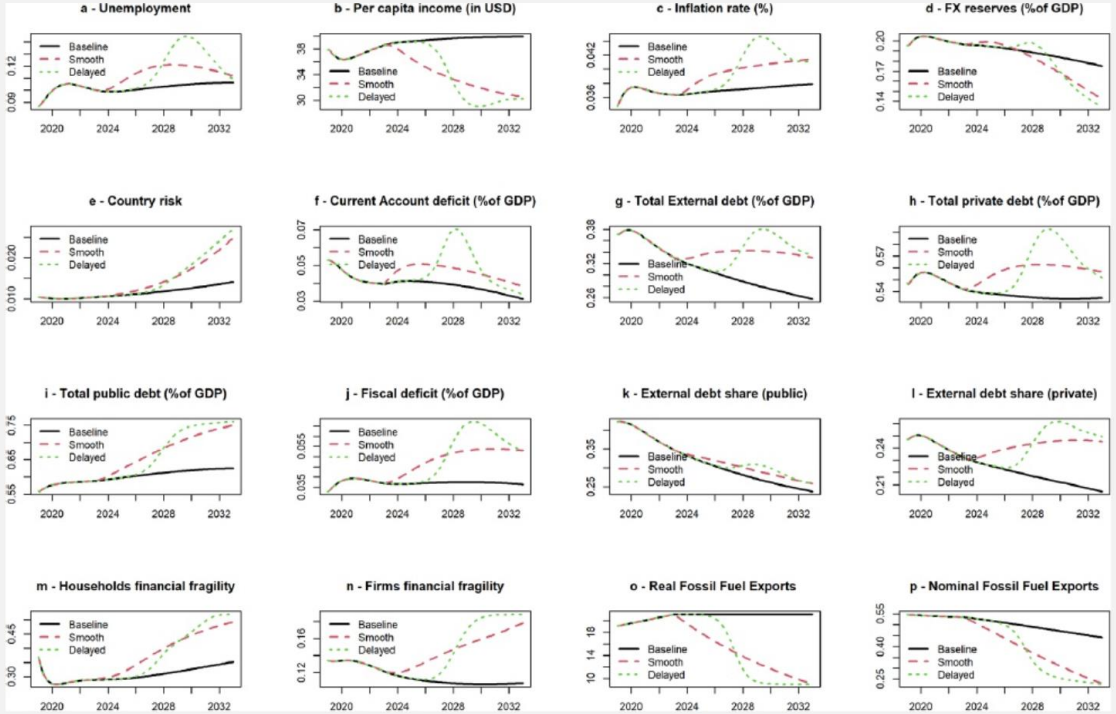
Radar charts

Summarize the impact on all variables for a specific point in time



Line plots

Describe the dynamic trajectory of each variable



Source: Moreno, A., Guevara, D., Andrade, J., Pierros, C., Valdecantos, S., Godin, A. & Yilmaz, D. (2023). Low-carbon Transition and Macroeconomic Vulnerabilities: A Multidimensional Approach in Tracing Vulnerabilities and its Application in the Case of Colombia. *AFD Research Papers.*

Global coverage and stock-flow consistent

(Quasi) global coverage: FSMAT 1.0 will cover around 100 EMDEs

Integrated assessment approach with stock-flow consistency

User friendly: easily usable interface to design, analyze and compare different GFSIs

Pilot countries







C3A Coalition for Capacity on Climate Action

FSMAT Databank

FSMAT Data Sources

The multidimensional nature of FSMAT requires compiling macroeconomic data from several international databases.

WBG World Development Indicators

- GDP and components
- Price indexes

IMF Government Finance Statistics

- Taxes on income, profits and capital gains

UN Data

- Inst. sector data

ILOSTAT

- Employment
- Income distribution

IMF International Financial Statistics

- Domestic financial assets and liabilities
- Interest rates

IMF Balance of Payments

- External assets and liabilities
- External transactions

IMF Investment and Capital Stock Statistics

- Capital stock by institutional sector

UNCTAD World of Debt Report

- Public debt interest payments

FSMAT data coverage: an in-depth analysis

Variable	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Repos and advances	7	7	7	7	7	7	7	7	7	7	7	139	140	143	143	141	144	145	146	146	147	147	149	153	155	154	153	152	151	150	146	141	113
FX deposits and cash (banks)	35	37	38	42	46	54	63	67	72	79	82	90	97	101	106	119	123	128	131	133	137	142	144	155	154	152	154	153	152	151	146	142	97
Domestic public securities and loans (banks)	11	11	11	12	12	12	12	12	12	12	12	156	158	158	161	162	166	167	168	167	170	170	172	176	178	177	175	174	173	172	168	162	115
Domestic public securities and loans (CB)	11	11	11	11	11	11	11	11	11	11	11	156	158	158	161	163	166	167	167	167	170	170	171	174	174	173	173	174	174	172	169	161	113
Domestic public securities and loans (HH)	167	163	162	158	150	141	133	130	126	123	120	38	36	35	34	31	30	28	26	25	166	166	160	156	156	162	169	155	165	159	152	165	181
External securities and loans (liab., CB)	30	31	32	37	42	50	60	62	67	75	76	83	90	93	98	110	113	117	119	120	127	131	133	141	141	140	141	140	139	137	136	131	90
External securities and loans (assets, gov.)	31	32	33	37	41	47	56	58	62	67	69	72	77	79	84	97	100	104	106	106	110	116	117	128	125	123	125	124	123	122	121	119	80
External securities and loans (liab., gov.)	36	38	39	43	47	56	66	69	75	80	83	91	98	101	106	119	123	127	131	133	137	142	144	155	154	152	154	153	152	150	145	141	96
Depreciation	173	168	172	175	179	187	187	187	187	188	192	194	195	195	195	195	195	195	196	196	197	199	198	199	199	198	197	196	196	193	187	0	0
Gov. Deposits	6	6	6	6	6	6	6	6	6	6	6	150	152	152	155	156	160	161	162	161	164	164	166	170	172	171	169	170	170	169	165	159	113
Government deposits at CB	11	11	11	11	11	11	11	11	11	11	11	156	158	158	161	163	166	167	167	167	170	170	171	174	174	173	173	174	173	171	168	160	112
HH Deposits	10	10	10	11	11	11	11	11	11	11	11	155	157	157	160	161	165	166	167	166	169	169	171	175	177	176	174	173	172	172	168	162	115
Investment	136	137	139	143	144	151	152	152	153	153	159	160	160	161	162	163	165	166	167	168	169	169	168	169	171	172	171	171	168	168	166	155	123
Changes in inventories	134	135	136	138	141	148	154	151	152	153	161	163	164	163	165	167	168	172	171	172	169	166	167	160	162	161	161	162	156	154	150	142	109
FDI	28	30	31	34	40	47	59	63	70	77	82	90	97	103	108	121	125	131	135	139	143	148	151	162	161	159	161	160	159	155	149	145	92
Financial VA	51	57	72	75	82	100	106	109	114	114	120	121	123	124	125	128	129	130	131	131	133	131	131	131	129	127	127	126	125	114	108	80	0
Foreign reserves	135	139	143	154	158	164	166	168	167	170	169	169	170	169	169	170	171	172	173	172	171	171	172	173	173	173	173	172	170	167	164	155	132
Government spending	137	139	141	145	148	156	155	155	157	157	162	163	163	165	166	167	169	171	171	171	172	173	172	174	176	178	177	177	173	172	168	157	124
FX deposits and cash (gov.)	3	3	5	7	6	9	16	16	17	22	30	32	37	41	46	55	57	58	63	66	72	76	82	96	99	102	106	113	113	110	112	109	80
GDP	176	177	178	179	181	189	189	190	191	191	197	198	199	199	200	200	200	200	200	201	202	202	201	202	202	201	200	200	200	199	199	196	183
Gross operating surplus	27	32	39	45	50	72	79	83	90	94	99	103	106	106	106	109	108	107	110	110	109	106	104	103	102	98	97	92	88	81	65	21	0
Consumption	136	137	138	143	147	154	153	154	156	156	161	163	163	165	166	167	169	171	171	171	172	173	172	173	175	177	176	176	173	172	168	157	123
FX deposits and cash (HH)	0	0	0	0	1	3	3	3	4	9	13	15	18	23	26	35	40	41	47	52	63	76	87	104	111	112	117	121	123	123	121	118	80
Cash	12	12	12	12	12	12	12	12	12	12	12	143	145	145	146	146	149	150	150	149	149	149	151	155	155	154	154	155	154	152	149	141	108
Interest rate deposits	76	79	86	89	95	101	105	108	110	111	112	116	119	121	126	136	137	137	138	136	138	136	138	143	141	139	138	137	120	118	113	109	86
Interest on deposits (Gov.)	5	4	6	6	6	6	6	5	6	6	6	102	104	105	110	120	123	124	125	123	125	123	128	135	136	134	132	132	117	114	110	105	76
Interest on deposits (HH)	6	5	7	8	8	8	8	7	8	7	7	103	105	107	112	122	125	126	128	126	128	126	131	138	139	137	135	133	117	115	111	106	77
Interest rate external	22	19	22	28	33	40	48	54	60	65	67	74	81	83	89	100	101	103	106	108	112	117	117	125	124	126	128	127	125	125	125	119	85
Interest rate external assets	20	19	24	27	32	36	43	47	52	54	56	61	68	70	75	85	84	85	89	90	94	99	95	110	105	105	109	107	104	101	100	97	73
Interest rate lending	69	73	79	82	86	93	96	101	105	110	110	114	115	116	121	131	134	133	134	133	134	133	136	141	138	134	133	132	120	117	112	108	84
Interest rate monetary policy	44	47	51	51	66	72	73	76	78	81	88	93	106	108	109	110	115	120	124	124	124	125	126	128	128	127	127	122	106	105	101	89	61
Interest paid on external securities and loans	22	19	21	27	33	40	48	54	59	64	65	72	79	81	86	96	97	100	103	106	110	114	115	123	122	124	126	126	125	125	125	119	85
Interest received on external securities and loans	20	19	24	27	32	36	43	47	52	54	56	61	68	70	75	85	84	85	89	90	94	99	95	110	105	105	109	107	104	101	100	97	73
Interest on domestic private securities and loans	8	9	9	9	9	9	9	8	8	9	9	100	101	102	108	118	123	123	125	123	124	123	128	135	135	132	130	128	117	114	110	105	73
Interest on domestic public securities and loans (Banks)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	146	143	150	150	154	152	148	148	149	144	138	101
Interest on domestic public securities and loans (CB)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	149	151	148	155	153	156	154	152	154	154	149	141	102
Interest on domestic public securities and loans (HH)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	135	140	130	132	130	139	144	127	136	131	125	132	140
Interest on repos and advances	4	5	5	5	5	5	5	5	5	6	6	82	94	97	98	99	105	109	114	113	114	115	118	121	123	121	120	117	102	101	96	85	55
Interest on domestic reserves	11	11	11	11	11	11	11	11	11	11	11	143	144	147	147	145	148	149	150	149	150	150	152	156	158	157	155	154	154	153	149	143	114
Interest rate US	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	0
Employment private	1	2	1	2	2	3	5	6	6	10	13	19	17	24	23	30	38	38	39	49	53	57	59	61	68	59	61	75	70	82	63	64	37
Employment private banks	0	1	0	1	1	2	3	5	3	6	11	14	14	20	20	25	33	32	35	43	49	51	54	55	61	55	55	72	68	77	59	59	34
Employment private firms	0	1	0	1	1	2	3	5	3	6	11	14	14	20	20	25	33	32	35	43	49	51	54	55	61	55	55	72	68	77	59	59	34
Employment public	1	2	1	2	2	3	5	6	6	10	13	19	17	24	23	30	38	38	39	49	53	57	59	61	68	59	61	75	70	82	63	64	37
Employment total	1	2	1	2	2	3	5	6	6	10	13	19	17	24	23	30	38	38	39	49	53	57	59	61	68	59	61	75	70	82	63	64	37
Domestic private securities and loans	12	12	12	12	12	12	12	12	12	12	12	156	158	158	161	162	166	167	168	167	170	170	172	176	178	177	175	174	172	172	168	162	115
Imports	143	146	148	152	157	165	165	166	167	167	170	170	171	172	172	173	174	175	177	177	179	180	179	181	182	183	182	182	179	176	172	165	133
Mixed income	14	18	19	23	28	47	48	49	51	53	56	56	58	58	58	61	64	67	69	71	70	68	70	68	67	67	67	65	62	59	52	16	0
Population	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204
Productivity	1	2	1	2	2	3	5	6	6	10	13	19	17	24	23	30	38	38	39	49	53	57	59	61	68	59	60	74	70	82	63	64	36
Productivity	0	0	0	0	0	0	0	0	0	0	0	0	0	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204
Domestic reserves	11	11	11	11	11	11	11	11	11	11	11	143	144	147	147	145	148	149	150	149	150	150	152	156	158	157	155	154	154	153	149	143	114
Remittances	109	111	119	124	129	134	140	139	145	146	150	151	156	159	161	179	179	179	180	180	180	183	183	184	184	184	184	183	180	179	181	177	165
Real exchange rate	80	83	84	88	92	92	92	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	92	92	92	92	92	92	92
External securities and loans (assets, banks)	35	36	37	41	46	54	64	68	74	78	81	87	95	98	103	115	118	122	127	129	133	138	140	150	150	148	150	149	148	147	143	139	96
External securities and loans (liab., banks)	35	36	37	41	46	53	63	66	73	77	81	87	94	97	102	113	118	122	125	127	131	136	139	149	149	146	148	146	145	145	140	136	92
External securities and loans (assets, firms)	33	34	35	39	44	53	62	65	70	75	76	82	90	92	96	109	112	116	118	118	121	128	130	141	140	140	142	140	138	137	136	132	91
External securities and loans (liab., firms)	34	35	36	40	44	52	62	66	73	78	81	88	94	97	103	115	118	120	124	126	129	136	139	150	149	148	150	149	148	147	144	140	95
Taxes on income, profits and capital gains (Firms)	75	76	78	79	84	67	65	64	70	70	65	75	74	82	85	87	92	90	93	96	102	106	107	104	112	112	108	113	106	104	97	75	3
Taxes on income, profits and capital gains (HH)	75	76	78	79	83	66	65	64	70	70	65	75	74	82	85	87	92	90	93	96	102	106	107	104	112	112	108	113	106	104	97	75	3
Taxes on products and imports net of subsidies	27	32	39	45	50	72	79	83	90	94	99	104	107	107	107	110	109	108	111	111	109	107	105	104	103	99	98	93	88	81	63	21	0
Wages	1	1	1	1	1	3	5	5	5	7	10	12	13	18	23	30	38	38	39	49	53	57	59	60	67	58	59	73	69	80	61	8	0
Wage bill	27	32	39	45	50	72	79	83	90	94	100	104	107	107	173	173	173	171	172	172	171	171	170	170	169	168	166	164	161	159	156	21	0
Wage bill	17	20	25	29	32	53	53	56	58	61	64	67	71	71	71	70	71	76	78	79	79	81	78	77	77	77	76	72	69	61	48	12	0
Welfare spending	17	19	22	26	30	52	55	57	59	61	64	67	67	69	69	73	73	78	78	79	78	76	78	75	74	73	71	67	64	61	50	13	0
WSC	20	23	28	32	36	54	56	59	60	61	64	65	65	67	67	72	73	77	78	79	78	75	77	74	73	72	70	66	62	59	49	10	0
Exports	143	146	148	152	157	165	165	166	167	167	170	170	171	172	172	173	174	175	177	177	179	180	179	181	182	183	182	182	179	176	172	165	133
Exchange Rate	165	167	175	181	185	187	189	191	191	192	193	192	191	190	190	192	192	192	192	192	192	195	195	196	196	196	196	194	191	191	192	188	177

C3A Coalition for Capacity on Climate Action

FSMAT in Cosefin Countries

Our questions for you

- What are the special (unique) features of the economies belonging to Cosefin that must be incorporated into a macroeconomic model to adequately capture the behavior of the key variables?

  - Structural features
  - Institutional arrangements
  - Behavioral aspects

- What are the key transmission channels linking investment and its financing with the rest of the economy? (Are we missing anything relevant in the description made before?)

- What are Cosefin economies' risks and opportunities facing the low-carbon transition?

  - Import propensities
  - Import substitution potential
  - Exports of green products?

- How vulnerable are government revenues and expenditures to the low-carbon transition?

C3A / COSEFIN / ECLAC model session (2)

Financial Sector Mitigation and Adaptation Tool (FSMAT)

Sebastian Valdecantos

and Francisco Amsler (EFICT)

18/07/2024

Contents

C3A Coalition for Capacity on Climate Action

Accounting Structure

MONETARY ECONOMY

- **It is essential to distinguish between the resource constraint (e.g. current account) and the financing (e.g. how lending for consumption and investment are financed).**

- **While trade flows involve the actual exchanges of real resources (goods, services, labor, energy) payments are monetary flows by nature, and in most cases require financing.**

  - **Payments can be made either by reducing financial assets or increasing financial liabilities**
  - **Financial liabilities can be denominated in domestic or foreign currency**
  - **Financial liabilities bear dynamic implications (debt service)**
  - **Financial stability and systemic risk**

- **Although the current and the financial accounts mirror each other ex post (accounting identity) they are the result of decisions made by different agents with varying behaviors.**

- **The stock-flow consistent approach (Godley & Lavoie, 2006) allows for a separated but integrated treatment of current and financial accounts, thereby allowing for a realistic description of macro-financial dynamics.**

  - **This allows to overcome the problem of canonical open economy models where real resources are borrowed, leading to the overlapping of the real and the financial constraints (Borio & Disyatat, 2015).**

TRANSACTIONS-FLOW MATRIX (CURRENT ACCOUNTS)

	Households	**Nonfinancial Corportations**		**Financial Corp**	**Government**	**Central Bank**	**Rest of the World**	**Total**
		Current	Capital					
Private Consumption	$-C$	$+C$						0
Gov. Consumption		$+G$			$-G$			0
Investment	$-I^H$	I	$-I^{NFC}$	$-I^{FC}$	$-I^G$			0
Change in Inventories		$+\dot{V}$	$-\dot{V}$					0
Exports		$+X$					$-X$	0
Imports		$-IM$					$+IM$	0
Memo: [GDP]		$[GDP]$						$[GDP]$
Wage bill	$+WB$	$-WB^{NFC}$		$-WB^{FC}$	$-WB^G$			Y
Taxes on imports		$-T^{IM}$			$+T^{IM}$			0
VAT		$-VAT$			$+VAT$			0
Other indirect taxes		$-T^P$			$+T^P$			0
Mixed income & GOS	$+MIGOS^H$	$-GOS^{NFC}$		$+GOS^{FC}$	$+GOS^G$			0
Interest Deposits	$+i^D.D_H$	$+i^D.D_{NFC}$		$-i^D.D_{FC}$				0
Int. on FX Deposits	$+i^{D,FX}.D_H^{FX}.E$	$+i^{D,FX}.D_{NFC}^{FX}.E$		$-i^{D,FX}.D_{FC}^{FX}.E$				0
Interest Gov. Deposits				$-i_G^D.DG^{FC}$	$+i_G^D.DG^{FC}$			0
Int Dom. inst.	$-i^{DIBI}.DIBI_H$	$-i^{DIBI}.DIBI_{NFC}$		$+i^{DIBI}.DIBI_{FC}$				0
Int Dom. inst. in FX	$-i^{DIBI,FX}.DIBI_H^{FX}.E$	$-i^{DIBI,FX}.DIBI_{NFC}^{FX}.E$		$+i^{DIBI,FX}.DIBI_{FC}^{FX}.E$				0
Int. External Assets	$+i^{FXA}.EA_H.E$	$+i^{FXA}.EA_{NFC}.E$		$+i^{FXA}.EA_{FC}.E$	$+i^{FXA}.EA_G.E$	$+i^{FXA}.EA_{CB}.E$	$-i^{FXA}.EA_W.E$	0
Int. Ext. Liabilities		$-i^{FXL}.EL_{NFC}.E$		$-i^{FXL}.EL_{FC}.E$	$-i^{FXL}.EL_G.E$	$-i^{FXL}.EL_{CB}.E$	$+i^{FXL}.EL_W.E$	0
Int. Public Securities	$+i^B.B_H$			$+i^B.B_{FC}$	$-i^B.B_G$	$+i^B.B_{CB}$		0
FDI earnings		$-F_{NFC}^{FDI}$					$+F_{NFC}^{FDI}$	0
Interest on Reserves				$+i^R.R$		$-i^R.R$		0
Int. on net Advances				$-i.A$		$+i.A$		0
Remittances	$+Rem.E$						$-Rem.E$	0
Social contributions	$-SC_H$			$+SC_{FC}$	$+SC_G$			0
Social benefits	$+SB$			$-SB_{FC}$	$-SB_G$			0
Income taxes	$-T_H^I$	$-T_{NFC}I$		$-T_{FC}I$	$+T_GI$			0
Distributed Profits	$+DIV_{FC}$			$-DIV_{FC}$				0
Other inc. & exp.	$+OIE_H$	$+OIE_{NFC}$		$+OIE_{FC}$	$+OIE_G$	$+OIE_{CB}$	$+OIE_W$	0
Memo: Net lending	$[NL_H]$	$[-NL_{NFC}]$	$[+NL_{NFC}]$	$[NL_{FC}]$	$[NL_G]$	$[NL_{CB}]$	$[NL_W]$	0

TRANSACTIONS-FLOW MATRIX (FINANCIAL ACCOUNTS)

	Households	**Nonfinancial Corportations**		**Financial Corp.**	**Government**	**Central Bank**	**Rest of the World**	**Total**
		Current	Capital					
Memo: Net lending	$[NL_H]$	$[-NL_{NFC}]$	$[+NL_{NFC}]$	$[NL_{FC}]$	$[NL_G]$	$[NL_{CB}]$	$[NL_W]$	0
Cash and Deposits	$-\dot{D}_H$		$-\dot{D}_{NFC}$	$+\dot{D}_{FC}$		$+\dot{D}_{CB}$		0
Deposits in FX	$-\dot{D}_H^{FX}.E$		$-\dot{D}_{NFC}^{FX}.E$	$+\dot{D}_{FC}^{FX}.E$				0
Government Deposits				$+\dot{DG}_{FC}$	$-\dot{DG}$	$+\dot{DG}_{CB}$		0
Domestic Interest Bearing Instruments	$+\dot{DIBI}_H$		$+\dot{DIBI}_{NFC}$	$-\dot{DIBI}_{FC}$				0
Dom. Interest Bearing Instruments in FX	$+\dot{DIBI}_H^{FX}.E$		$+\dot{DIBI}_{NFC}^{FX}.E$	$-\dot{DIBI}_{FC}^{FX}.E$				0
External Assets	$-\dot{EA}_H.E$		$-\dot{EA}_{NFC}.E$	$-\dot{EA}_{FC}.E$	$-\dot{EA}_G.E$	$-\dot{EA}_{CB}.E$	$+\dot{EA}_W.E$	0
External Liabilities			$+\dot{EL}_{NFC}.E$	$+\dot{EL}_{FC}.E$	$+\dot{EL}_G.E$	$+\dot{EL}_{CB}.E$	$-\dot{EL}_W.E$	0
Public Securities	$-\dot{B}_H$			$-\dot{B}_{FC}$	$+\dot{B}_G$	$-\dot{B}_{CB}$		0
Foreign Direct Inv.			$+\dot{FDI}.E$				$-\dot{FDI}.E$	0
Reserves				$-\dot{R}$		$+\dot{R}$		0
Advances				$+\dot{A}$		$-\dot{A}$		0
Other sources and uses of funds	$+OSU_H$		$+OSU_{NFC}$	$+OSU_{FC}$	$+OSU_G$	$+OSU_{CB}$	$+OSU_W$	0
Change in Net Worth	$\dot{W}_H$	0	$\dot{W}_{NFC}$	$\dot{W}_{FC}$	$\dot{W}_G$	$\dot{W}_{CB}$	$\dot{W}_W$	0

- **Stock-flow consistency**
  - **Vertical consistency: the column for each sector (its budget constraint) is fulfilled at all time.**
  - **Horizontal consistency: all rows must add up to zero (no black holes in transactions).**
  - **Stock-to-flow consistency: accumulation of financial instruments (stocks) bear dynamic implications on flows.**
    - **Path-dependency**

C3A Coalition for Capacity on Climate Action

Disequilibrium Approach

EQUILIBRIUM

Pure price adjustment (Goods market)

$$\dot{p} = \beta_P.[AD(p) - AS(p)]$$

$$\lim_{B_P -> \infty} p = p^E,\ p^E |\ AD(p^E) = AS(p^E)$$

Pure quantity adjustment (Goods market)

$$Y^p = Y^e$$

$$\dot{Y}^e = \beta_y.[AD(p) - Y^e]$$

$$\lim_{B_y -> \infty} Y^e = Y^{eE},\ Y^{eE} |\ AD(p) = Y^p)$$

DISEQUILIBRIUM (GOODS MARKET)

- In the real world both prices and quantities adjust simultaneously and permanently, but at different speeds.

$$\dot{y}^e = \beta_y \cdot \left(y^D - y^e\right) + g_k \cdot y^e$$
$$v^d = \alpha_v \cdot y^e$$
$$i^{v,d} = \beta_{iv} \cdot \left(v^d - v\right)$$
$$y^P = y^e + i^{v,d}$$
$$\dot{v} = y^P - y^D$$

- Firms adjust their expected sales to their forecasting errors.
- Desired inventory accumulation (stock)
- Desired inventory accumulation (flow)
- Expected sales and desired inventory accumulation determines production
- Excess supply in the goods market is cleared with inventory accumulation

- Firms' desired price is based on mark-up pricing on historical unit costs
- The actual price converges to the desired price at a speed beta_p
- The mark-up is endogenous to the business cycle

$$p^d = (1 + \mu) \cdot HUC$$
$$\dot{p} = \beta_p \cdot \left(p^d - p\right)$$
$$\mu = \mu_0 - \mu_1 \cdot \left(\frac{v}{y^e} - \alpha_v\right)$$

- None of the speeds of adjustment tend to infinity. Hence the market is never cleared.

DISEQUILIBRIUM (FOREX MARKET)

- **In the real world both prices and quantities adjust simultaneously and permanently, but at different speeds.**
  - **Central Bank interventions in the FX market**

$$\dot{EA}_{CB} = \begin{cases} \beta_{EACB} \cdot (\theta_{FX,IM} \cdot im \cdot p_M^W - EA_{CB}), & \text{if } \theta_{FX,IM} \cdot im \cdot p_M^W - EA_{CB} > 0 \\ 0, & \text{otherwise} \end{cases}$$

  - **Price adjustment (nominal exchange rate dynamics)**

$$\dot{E} = \beta_E \cdot \left(\frac{D^{FX} - S^{FX}}{S^{FX}} \right) \cdot E$$

  - **Quantity adjustment**

$$\dot{EA}_{FC} = \dot{EA}_{RW} - \dot{EA}_H - \dot{EA}_{NFC} - \dot{EA}_G - \dot{EA}_{CB}$$

Banks' <u>actual</u> demand for external assets

$$\dot{EA}^d_{FC} = \dot{EL}_{FC} + \dot{D}^{FX}_{FC} - \dot{DIBI}^{FX}_{FC}$$

Banks' <u>desired</u> demand for external assets

PATH DEPENDENCY

- **In these models there is no predetermined long-run equilibrium. The long-run position of the economy results from the succession of multiple short-run positions, which are most likely disequilibrium positions.**
  - For instance, actual households consumption is represented as a dynamic adjustment towards a target level of consumption

$$C^T = m_1 \cdot YD_H + m_2 \cdot \left(D_H + D_H^{FX} \cdot E + B_H + EA_H \cdot E\right) + m_3 DI\dot{B}I_H$$
$$\dot{C} = \beta_C \cdot \left(C^T - C\right)$$

  - The propensities to consume are not fixed parameters - they are endogenously determined by the model's dynamics

$$m_1 = LB_H^{YD} + \frac{1}{1 + exp\left(-\epsilon_H^{YD} \cdot \left(\left(i_H^D - \frac{\dot{p}}{p}\right) - \chi_H^{YD}\right)\right)} \cdot \left(UB_H^{YD} - LB_H^{YD}\right)$$
$$m_2 = LB_H^{W} + \frac{1}{1 + exp\left(-\beta_H^{W} \cdot \left(\left(i_H^D - \frac{\dot{p}}{p}\right) - \chi_H^{W}\right)\right)} \cdot \left(UB_H^{W} - LB_H^{W}\right)$$

- **This setting enables for a continuous adjustment process, representing persistent disequilibria because:**
  - There is no reason why beta_C should be equal to infinity, implying that consumption may react slowly
  - Consumption propensities are always adjusting to the changes in the economy, thereby affecting target consumption

C3A Coalition for Capacity on Climate Action

Key Behavioral Assumptions

INFLATION DYNAMICS

Inflation dynamics are driven by several factors.

- **Labor market dynamics and institutions**
- **External sector dynamics (summarized in the exchange rate)**
- **Market structure and institutions (as reflected in the mark-up and its dynamics)**
- **Production structure (as reflected in the import propensities)**
- **Government policy (as reflected in the various tax rates)**

$$p^C = (1+\tau^V)\cdot(1+\tau^{PC})\cdot\left[(1-\sigma_{M,C})\cdot p \; + (1+\tau^M)\cdot\sigma_{M,C}\cdot p_m^W\cdot E\right]$$

$$\dot{HUC} = \beta_{HUC}\cdot(UC - HUC)$$

$$UC = \frac{WB_{NFC} + IC + \tau^Y\cdot y^P\cdot p}{y^P}$$

$$WB_{NFC} = (1+\tau^l)\cdot W_{NFC}\cdot L_{NFC}$$

$$\dot{W}_{NFC} = \left(\omega_0^{NCF}\cdot\alpha_D + \omega_1^{NFC}\cdot\left(\frac{L}{POP} - \omega_2^{NFC}\right) + \omega_3^{NFC}\cdot\frac{\dot{p}}{p}\right)W_{NFC}$$

- **Consumption goods prices (foreign and domestic components)**
- **Partial dynamic adjustment of labor costs**
- **Production costs**
- **Wage bill**
- **Phillips Curve**

INVESTMENT DYNAMICS

- **Investment dynamics are given by both endogenous factors and the exogenous low-carbon transition (LCT).**
  - Investment does not need to equal saving. It is defined by firms' (expected) real profitability
  - Partial dynamic of actual investment to the target level.
  - Green investment is taken from the CCDR and assumed exogenous.
  - The share of private investment on total green investment is also taken from the CCDR.
  - Part of capital accumulation is imported

$$i^T_{NFC} = \left[\kappa_0 + \kappa_1 \cdot e^{\left(\frac{-v}{\kappa_2 \cdot y^e}\right)} \cdot \left(r_{NFC} - \frac{\dot{p}}{p}\right)\right] \cdot k_{NFC}$$

$$\dot{i}_{NFC} = \beta_{IF} \cdot \left(i^T_{NFC} - i_{NFC}\right) + gi_{NFC}$$

$$gi_{NFC} = \frac{LCT \cdot INV_{LCT} \cdot sh_{NFC} \cdot E}{pk}$$

$$im = \sigma_{M,C} \cdot \left(\frac{C}{p^C}\right) + \sigma_{M,I} \cdot \left(\frac{I^K - LCT \cdot INV_{LCT,T} \cdot E}{p^K}\right) + \sigma_{M,X} \cdot \left(\frac{X}{p^X}\right) + \dots$$

$$\dots \sigma_{M,IC} \cdot \left(\frac{IC}{p^C}\right) + \sigma_{M,P} \cdot LCT \cdot \frac{INV_{LCT,P} \cdot E}{pk} + LCT \cdot \sigma_{M,T} \cdot \frac{INV_{LCT,T} \cdot E}{pk}$$

- **Firms' target investment**
- **Firms' actual investment (including green – LCT – investments)**
- **Green investment (defined by the intensity of the LCT)**
- **Impact of LCT investments on imports**
  - Specific import propensities for power and transport sectors

CENTRAL BANK INTERVENTIONS

In the real world both prices and quantities adjust simultaneously and permanently, but at different speeds.

- **Central Bank interventions in the FX market**

$$\dot{EA}_{CB} = \begin{cases} \beta_{EACB} \cdot (\theta_{FX,IM} \cdot im \cdot p_M^W - EA_{CB}), & \text{if } \theta_{FX,IM} \cdot im \cdot p_M^W - EA_{CB} > 0 \\ 0, & \text{otherwise} \end{cases}$$

- **Price adjustment (nominal exchange rate dynamics)**

$$\dot{E} = \beta_E \cdot \left(\frac{D^{FX} - S^{FX}}{S^{FX}} \right) \cdot E$$

- **Quantity adjustment**

$$\dot{EA}_{FC} = \dot{EA}_{RW} - \dot{EA}_H - \dot{EA}_{NFC} - \dot{EA}_G - \dot{EA}_{CB}$$

Banks' actual demand for external assets

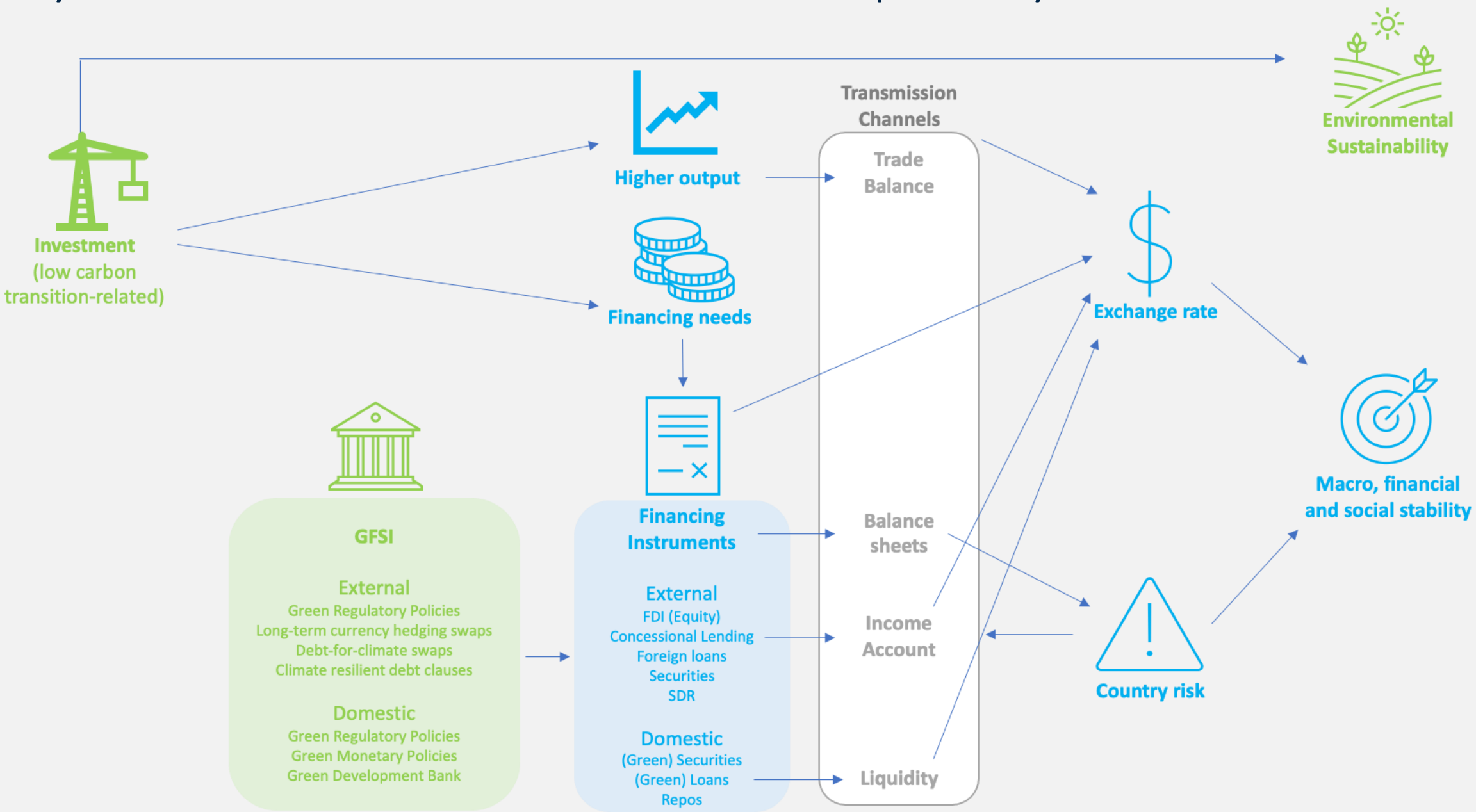
$$\dot{EA}^d_{FC} = \dot{EL}_{FC} + \dot{D}^{FX}_{FC} - \dot{DIBI}^{FX}_{FC}$$

Banks' desired demand for external assets

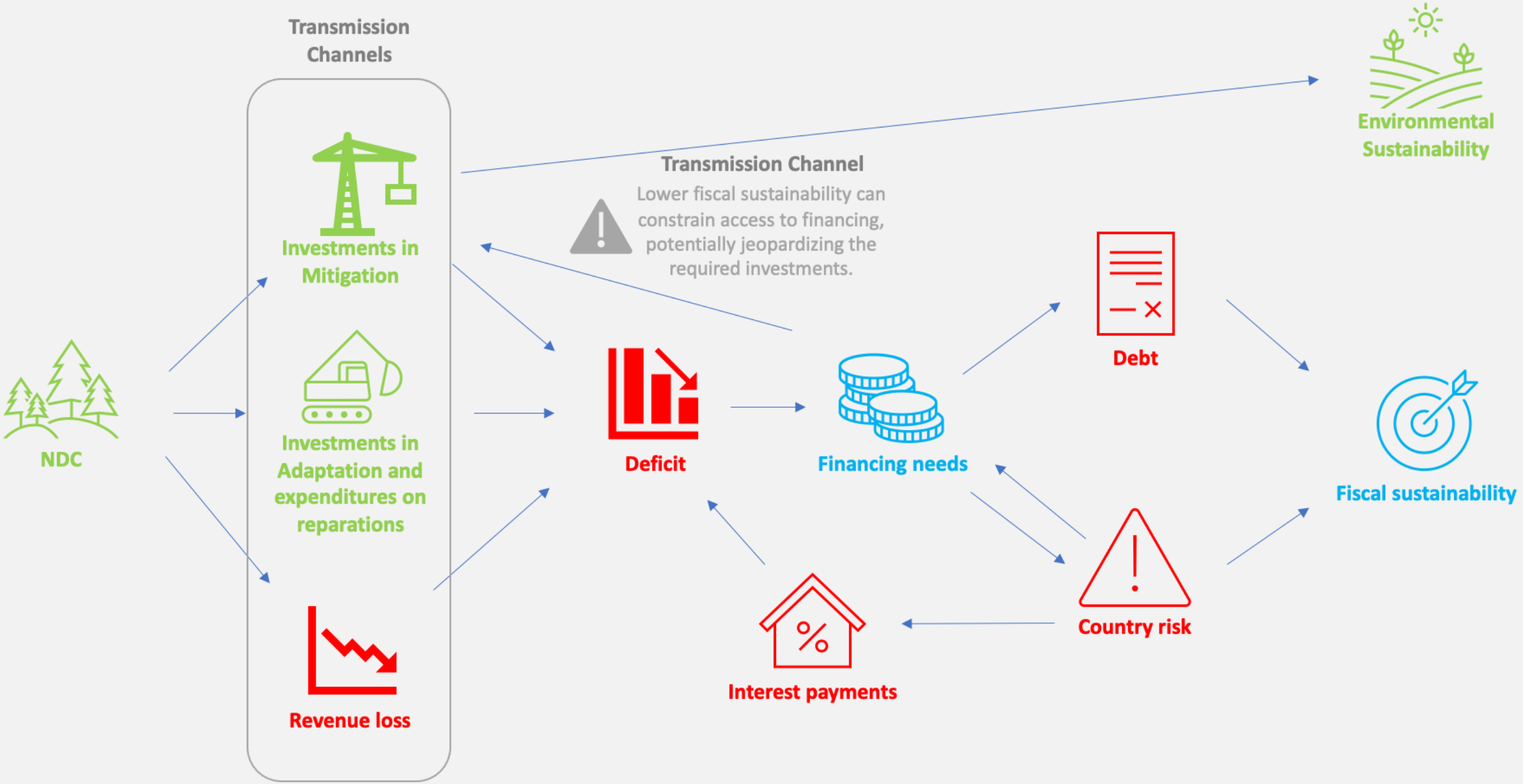
C3A Coalition for Capacity on Climate Action

Key Transmission Mechanisms

Key vulnerabilities and transmission channels captured by FSMAT



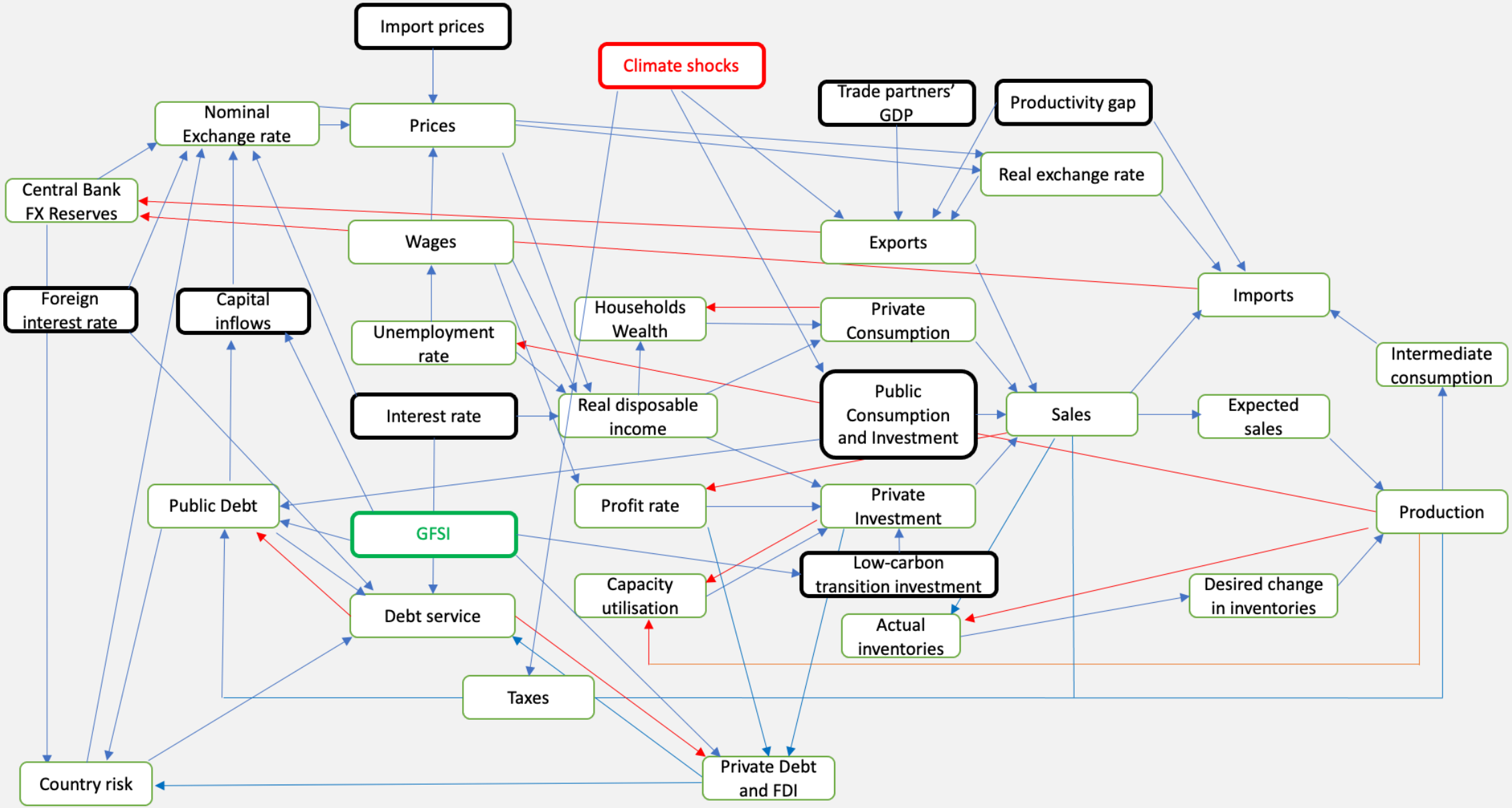
Key vulnerabilities and transmission channels captured by FSMAT (fiscal and debt side)



C3A Coalition for Capacity on Climate Action

Modelling Pillars of FSMAT

A Systemic Modelling Approach



C3A Coalition for Capacity on Climate Action

Calibration

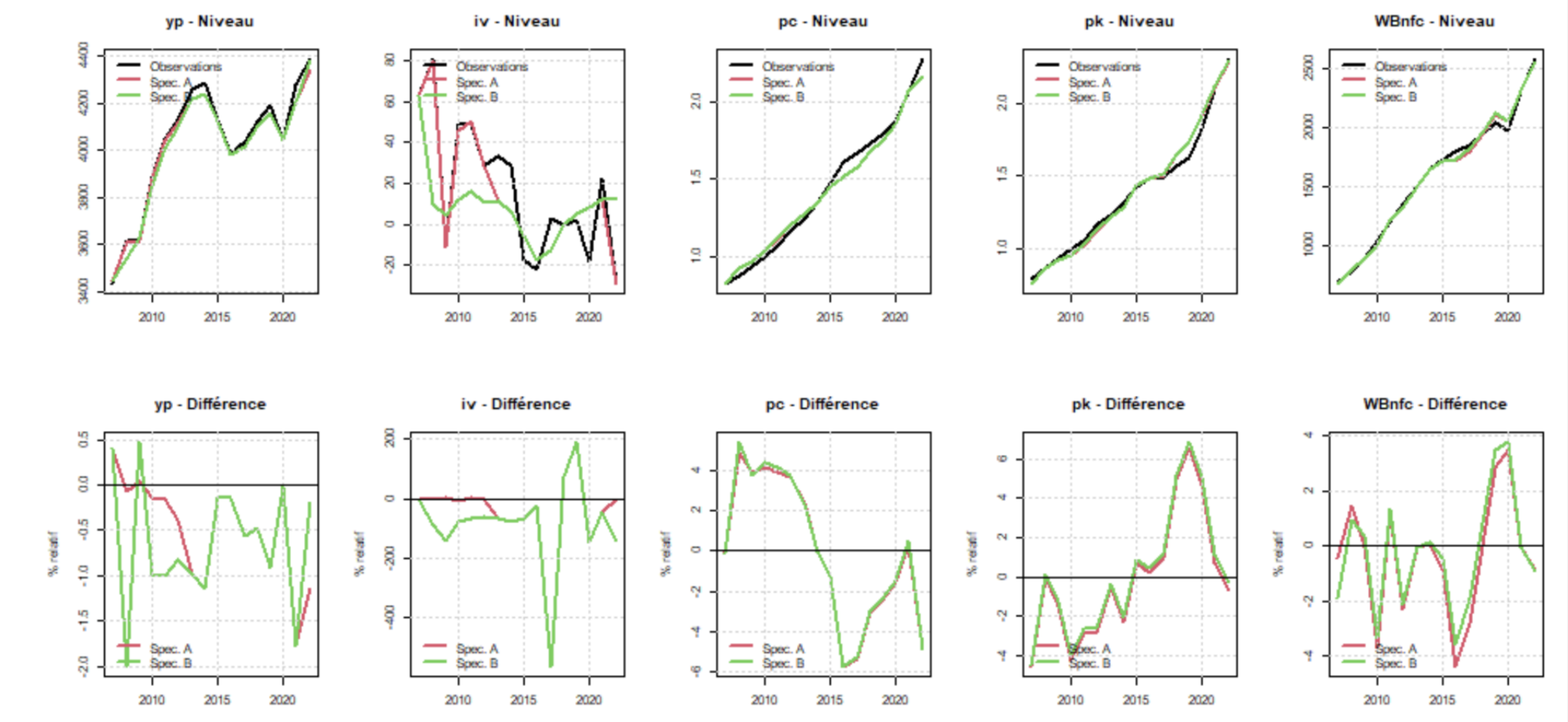
BLOCK-BY-BLOCK CALIBRATION

- **Six blocks of simultaneous equations.**
  - **Rest of the World**
  - **Production and Prices**
  - **Nonfinancial corporations**
  - **Households**
  - **Financial sector (inc. CB)**
  - **Government**

```
##intermediate variables
vd=alphav*ye # desired stock of inventories
ivd=betaiv*(vd-v) # desired investment in inventories
yp=(ye+ivd)*(1+iota1yp08*dummy08) # real output
iv=vDot # investment in inventories
pd=(1+mu)*HUC # desired price
mu=mu0-mu1*(v/ye-alphav) # markup
WBnfc=(1+t_l)*Wnfc*Lnfc # Wage bill paid by NFC
UC=(WBnfc+IC+t_y*yp*pp)/yp # Unit cost
pc=(1+t_v)*(1+t_pc)*((1-sigmaMC)*pp+(1+t_m)*sigmaMC*pm_W*E) # price index of private consumption
pk=(1+t_pk)*((1-sigmaMI)*pp+(1+t_m)*sigmaMI*pm_W*E) # price index of capital goods

##exogenous variables
@ADDEXOG

##sampling time
@ADDSAMPLE

##time derivatives
ye=betay*(yd-ye)+gk*ye # real expected sales
v=yp-yd # inventories
pp=betaP*(pd-pp) # production price
HUC=betaHUC*(UC-HUC) # Historical unit cost
Wnfc=(omegaF0*a_Dhat+omegaF1*(L/POP-omegaF2)+omegaF3*(ppDot/pp))*Wnfc # Nominal wage paid by NFC
```

BLOCK-BY-BLOCK CALIBRATION

Iterative approach (using CMA-ES – Covariance Matrix Adaptation Evolution System)



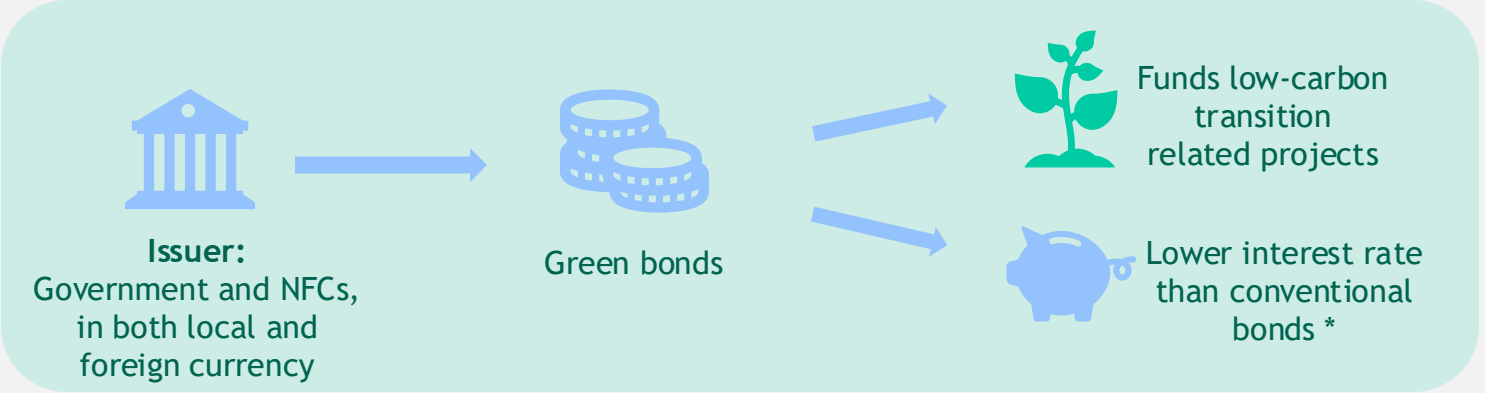
C3A Coalition for Capacity on Climate Action

Green Financial Sector Interventions

Green Bonds

Green Bonds

Fixed-income debt security to finance green (climate or nature-related) projects.



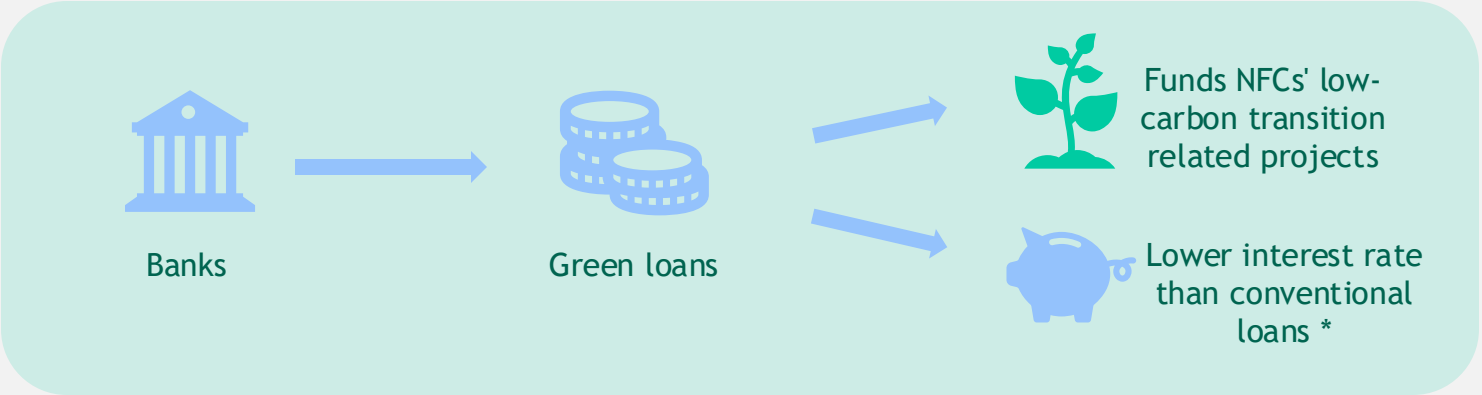
*The empirical literature estimates a ***negative*** **greenium** of green bonds, driven by lower perceived risk, regulatory incentives, and investor demand (e.g., MacAskill et al. (2021), Caramichael & Rapp (2024)).

- For bonds issued in local currency, we model the interest rate as a mark-down on the interest rate of conventional bonds:
  $i_{GB} = i_B + greenium$
- For bonds in foreign currency, we model the interest rate as a mark-down on the interest rate of external liabilities:
  $i_{GEL} = i_{EL} + greenium$
- The bonds issued in local currency are bought by FCs and the ones issued in foreign currency by the RoW.

Green Loans

Green loans

Form of financing that enables borrowers to use the proceeds to exclusively fund green projects.



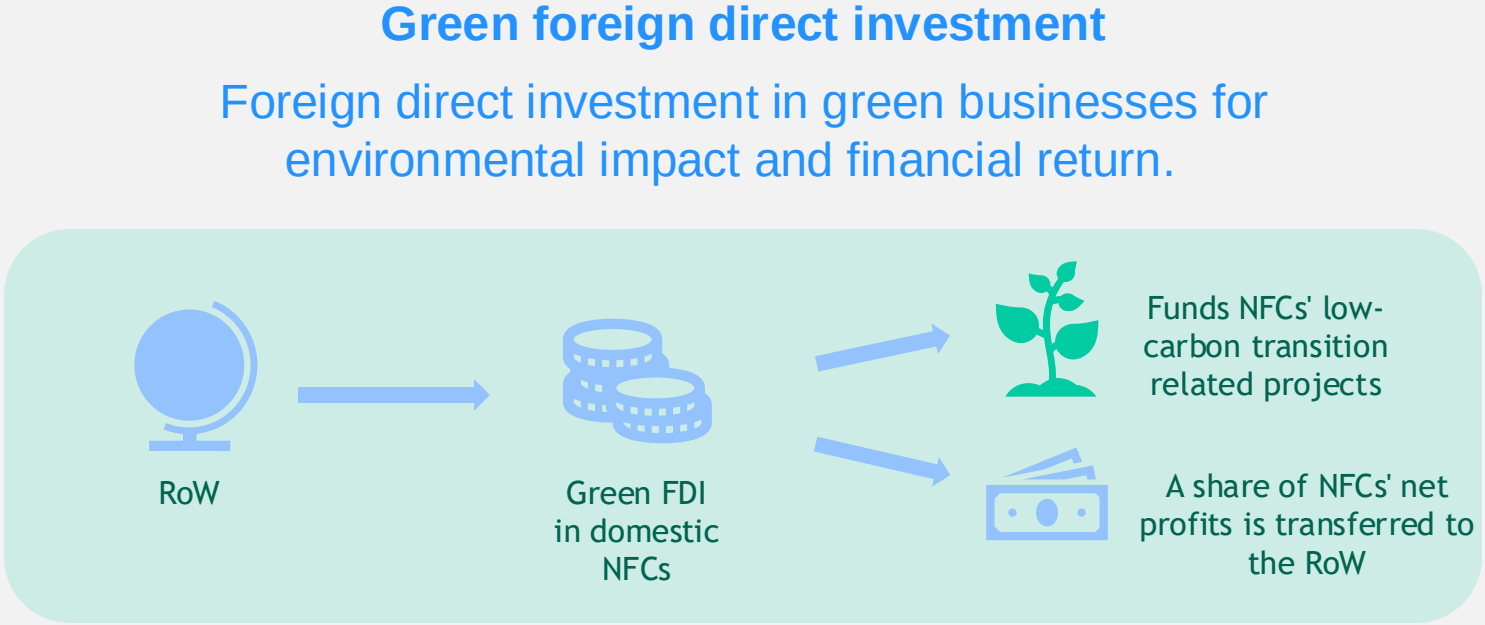
*The empirical literature estimates a ***negative*** **greenium** of green bonds, driven by lower perceived risk, regulatory incentives, and investor demand (e.g., MacAskill et al. (2021), Caramichael & Rapp (2024)).

- We model the interest rate on green loans as a mark-down on the interest rate of conventional loans:

$$i_{GL} = i_L + greenium$$

- In the model, green loans are extended by domestic banks to NFCs in local currency.

Green Foreign Direct Investment



- Green FDI operates as traditional FDI. Although it does not entail an outflow of interest payments, it may imply an outflow of profits repatriated.

Green Concessional Lending

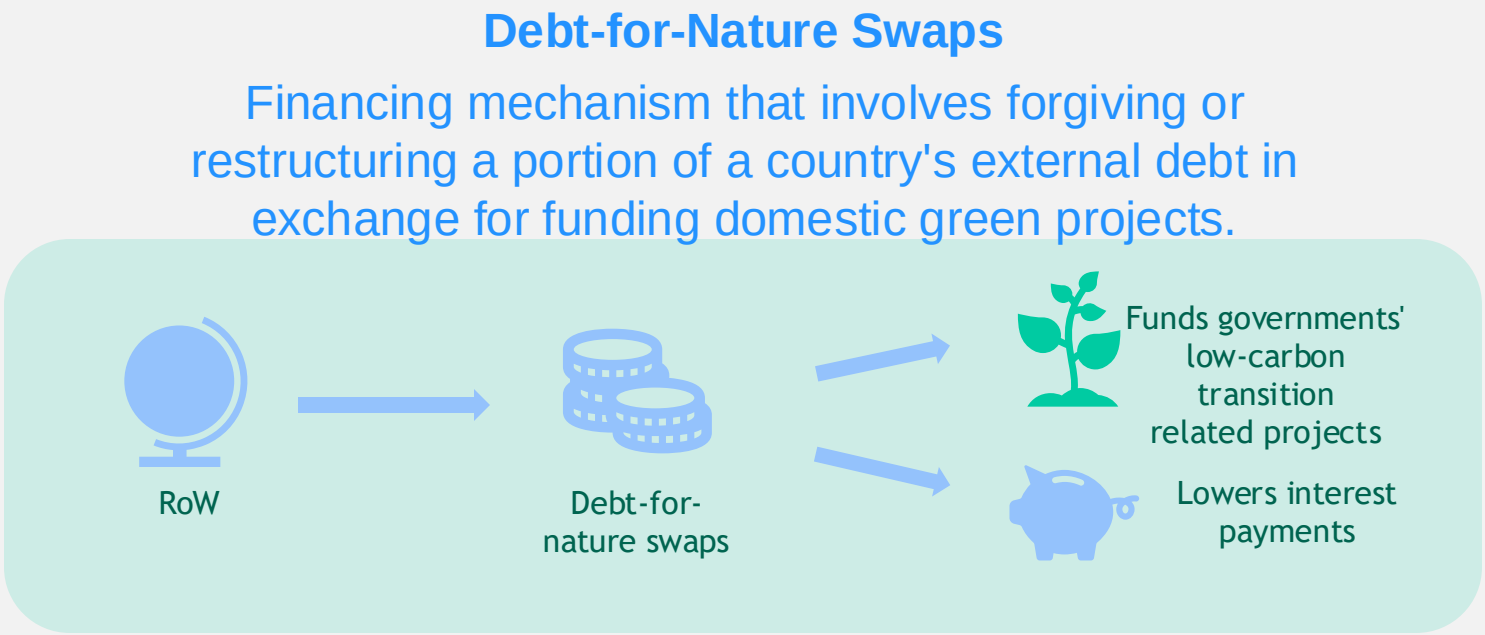
Green concessional loans

Below-market rate loan financing from development banks and lenders to lower costs of green projects.

- We model the interest rate on green concessional loans as a mark-down (md) on the interest rate of external liabilities:

$$i_{GCL} = (i_{EL} + greenium)*(1-md)$$

Debt-for-Nature Swaps



- In the model, debt-for-nature swaps are conceptualized as restructuring of existing external debt.
- A share of the government's external debt is changed into concessional loans, which carries a lower interest rate. This brings down the government's interest payments.

GFSI Scenarios

	Transition Intensity	Transition Speed	Private Sector Investment				Public Sector Investment			
			Green Loans in LCU	Green Bonds in LCU	Green Bonds in FX	Green FDI	Green Bonds in LCU	Green Bonds in FX	Green Concessional Lending	Debt-for-Nature swaps
Baseline	0%	-	-	-	-	-	-	-	-	-
Scenario 1	100%	Uniform	40%	40%	0%	20%	80%	0%	20%	0%
Scenario 2	100%	Uniform	0%	0%	80%	20%	0%	80%	20%	0%
Scenario 3	100%	Uniform	25%	25%	0%	50%	40%	20%	20%	20%
Scenario 4	66%	Uniform	40%	40%	0%	20%	80%	0%	20%	0%
Scenario 5	66%	Uniform	0%	0%	80%	20%	0%	80%	20%	0%
Scenario 6	66%	Uniform	25%	25%	0%	50%	40%	20%	20%	20%
Scenario 7	33%	Uniform	40%	40%	0%	20%	80%	0%	20%	0%
Scenario 8	33%	Uniform	0%	0%	80%	20%	0%	80%	20%	0%
Scenario 9	33%	Uniform	25%	25%	0%	50%	40%	20%	20%	20%

Transition intensity measures the percentage of the required investments until 2030 estimated by the CCDR. A 100% can be considered consistent with a net zero by 2050.
Transition speed measures how the given investment flow is distributed across time.
The shares of private and public investment are taken from the CCDR.
The percentages in the financial instruments columns represent the share of the sectoral low-carbon transition financing needs covered through each instrument for each sector.

Thank you!

Corresponding contacts on FSMAT
eespagne@worldbank.org
svaldecantoshalp@worldbank.org