Cross-Border Financial Flows and Global Warming

In a Two-Area Ecological SFC Model

BY EMILIO CARNEVALI, MATTEO DELEIDI, RICCARDO PARIBONI AND MARCO VERONESE PASSARELLA

1. Introduction

Aim: To test cross-area interactions among productive sectors, financial markets, social groups and the ecosystem

Method/tool: Ecological Open-Economy SFC model

Key findings:

- Financial investments can bring about unwanted ecological implications
- The unequal diffusion of green technologies and assets can lead the governments of less ecologically efficient areas to move further away from low-carbon policies
- Lacking a cross-area policy coordination plan, currency fluctuations may well counteract green behaviours and policies

Structure

2. Literature review
3. Theory and method
4. Findings
5. Conclusions

2. Literature review

a) Against growth imperative (Jackson & Victor 2015, 2016; Richters & Siemoneit 2017)

b) Energy sector (Naqvic 2015, Berg et al. 2015)

c) Dynamics of environmental, macro and financial variables (Dafermos et al. 2017, 2018)

d) Interaction between climate change and financial stability (Dafermos et al. 2018)

e) State-led innovation policies and the ecosystem (e.g. Mazzucato 2015; Mazzucato & Semieniuk 2018; Deleidi et al. 2019)

f) Impact of green fiscal policies and green bonds (Monasterolo & Raberto 2018; Bovari et al. 2018)

g) Financing the transition towards a green economy (Campiglio 2016; Ameli et al. 2017; Rademaekers et al. 2017) and tackle climate risks (Aglietta & Espagne 2016; Bardoscia et al. 2017; Battiston et al. 2017; Bovari et al. 2018; Dafermos et al. 2018)

3. Theory and method

Literature gap: Ecological models usually focus on a single area or the world economy. We focus on (side) effects of cross-border financial flows

Method/tool: Ecological Open-Economy SFC model

Model features: 228 difference equations, 2 redundant equations, coefficients > 100. Dynamic equations are 89, of which 28 are the driving stochastic equations.

Assumptions:

a) We divide the world economy in two main areas: Greenland and Brownland
b) Two social groups (households): workers and capitalists
c) Capitalists can diversify their portfolios by purchasing domestic and foreign government bills and/or firms' shares
d) Initial values of economic and financial stocks, and the related parameter values, are identical across areas (e.g. GDPs, wealth stocks, propensities to consume, interest rates, etc.)

3. Theory and method (cont'd)

Assumptions (cont'd):

e. Demand-led also in the long-run. No supply side constraint, except for the availability of natural reserves and the impact of global warming. All variables are expressed at constant prices

f. Productive firms can undertake both conventional investment and low-carbon investment. Green capital entails CO_2-, energy and matter-intensity ratios, relative to conventional capital

g. Current accounts are balanced in the baseline scenario, while government deficits are in line with world data (i.e. 4.5% of GDP ca)

h. There is a floating exchange rate regime (but we consider also a fixed exchange rate)

i. Natural resources' endowments (matter and energy stocks) are identical across areas. Each area can only access its own reserves

j. The techniques of production are different in terms of ecological efficiency. Greenland output is marked by lower CO_2-, energy- and matter-intensity ratios, and a higher share of renewable energy to total energy

3. Theory and method (cont'd)

Seventeenth blocks of equations:

i. Disposable, income wealth and taxes, e.g. $YD_r^B = Y_r^B \cdot (1 - \theta_B)$
ii. Consumption and income shares, e.g. $C_r^B = \left(\alpha_{1r}^B \cdot YD_r^B + \alpha_{2r}^B \cdot V_{r,-1}^B\right) \cdot \left(1 - d_{T,-1}^B\right)$
iii. Firms' investment plans, e.g. $INV_B = (\gamma_0^B + \gamma_1^B \cdot INV_{B,-1}) \cdot \left(1 - d_{T,-1}^B\right)$
iv. international trade, e.g. $X_B = \exp\left[\varepsilon_0 - \varepsilon_1 \cdot log\left(xr_{B,-1}\right) + \varepsilon_2 \cdot log(Y_G)\right] \cdot \left(1 - ad_X \cdot d_{T,-1}^B\right)$
v. Demand for financial assets, e.g. $B_d^{BB} = (\lambda_{10} + \lambda_{11} \cdot r_B - \lambda_{12} \cdot r_G - \lambda_{13} \cdot r_e^B - \lambda_{14} \cdot r_e^G) \cdot V_r^B$
vi. Supplies and prices of financial assets, e.g. $B_s^{BB} = B_d^{BB}$
vii. The banking sector, e.g. $F_b^B = r_{B,-1} \cdot B_{b,-1}^B + r_l^B \cdot L_{s,-1}^B$
viii. The central bank and the government sector, e.g. $B_{cb}^{BB} = B_s^B - B_s^{BB} - B_s^{GB} - B_b^B$
ix. The exchange rates, e.g. $xr_B = 1/xr_G$
x. The ecosystem: material resources and reserves, e.g. $y_{mat}^B = \mu_B \cdot Y_B$
xi. The ecosystem: energy resources and reserves, e.g. $e_B = \epsilon_B \cdot Y_B$

3. Theory and method (cont'd)

Seventeenth blocks of equations (cont'd):

xii. The ecosystem: emissions and climate change, e.g. $emis_B = \beta_0^B + \beta_1^B \cdot en_B$

xiii. The ecosystem: ecological efficiency, e.g. $\mu_B = \mu_{gr}^B \cdot \left(k_{gr}^B / k_B\right) + \mu_{con}^B \cdot \left(k_{con}^B / k_B\right)$

xiv. The ecosystem: damages and feedbacks, e.g. $d_T^B = 1 - \left(1 + d_1^B \cdot T_{AT} + d_2^B \cdot T_{AT}^2 + d_3^B \cdot T_{AT}^{x_B}\right)^{-1}$

xv. Auxiliary equations for domestic and foreign balances, e.g. $DEF_B = GOV_{tot}^B + r_{B,-1} \cdot B_{s,-1}^B - T_B - F_{cb,-1}^B$

xvi. Inequality indices, e.g. $gini_{YD}^B = YD_{hs,r}^B / YD_{tot}^B$

xvii. Financial indices, e.g. $q_G = \left(e_{s,-1}^G \cdot p_{e,-1}^G + L_f^G\right) / K_G$

Data and model calibration:

a. Economic/financial: global data (World Bank)

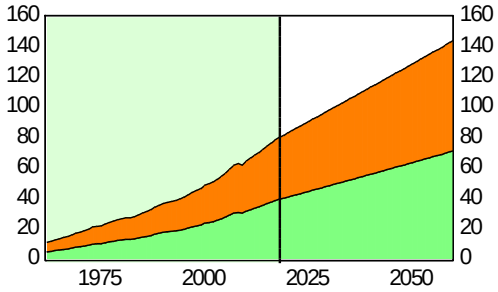
b. Temperature/emissions: GISTEMP (2019), Lenssen et al. (2019), Ritchie & Roser (2019)

c. Equation-by-equation OLS estimations and use of AR(1) to drive the whole economy

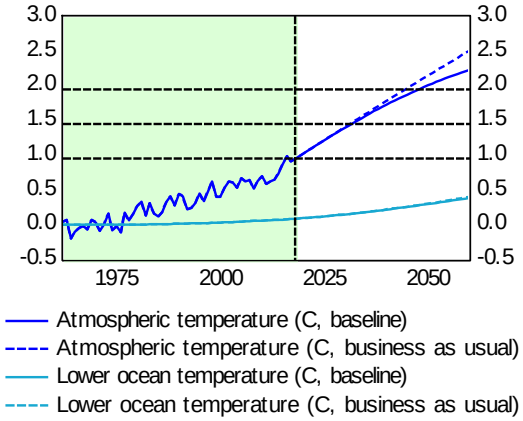
Baseline scenario and model validation: model run from 1960 to 2060 on annual basis. Validated through auto- and cross-correlation analysis.

Figure 1a. Selected variables under baseline scenario

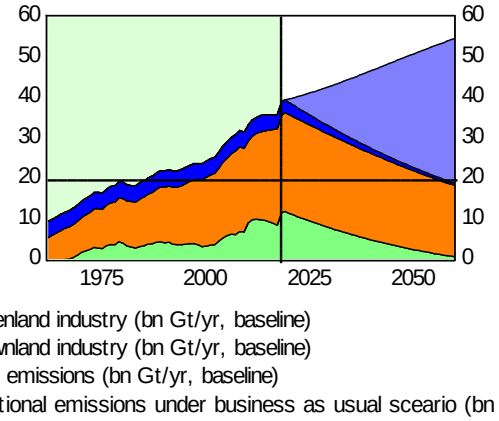
(a) Total output: predicted value after 2018



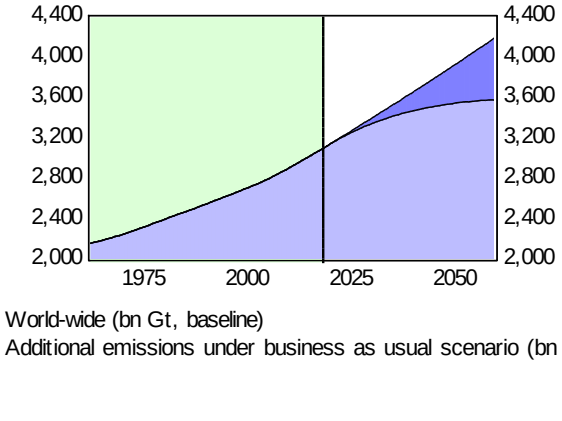
(b) Change in temperature (anomaly): predicted value after 2018



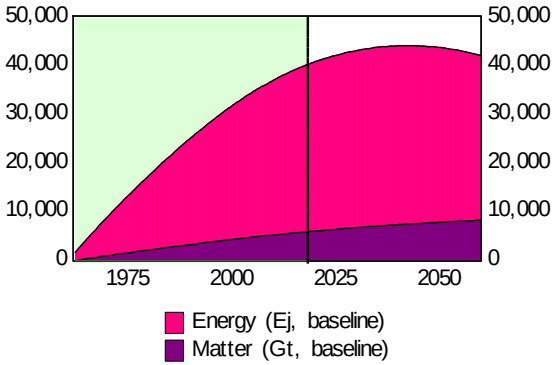
(c) CO2 emissions per year: predicted value after 2018



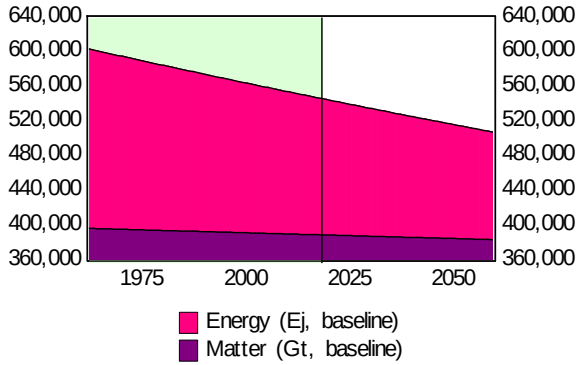
(d) CO2 concentration in atmosphere: predicted value



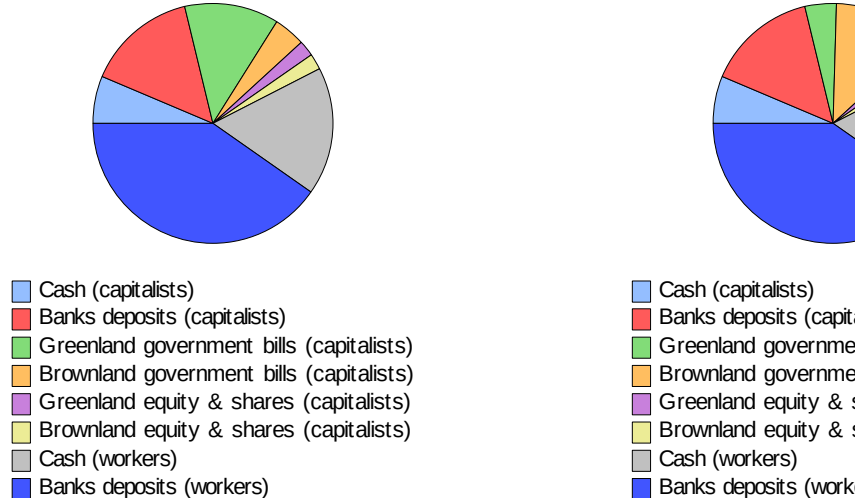
(e) World-wide reserves of matter and n.r. energy: predicted value



(f) World-wide resources of matter and n.r. energy: predicted value

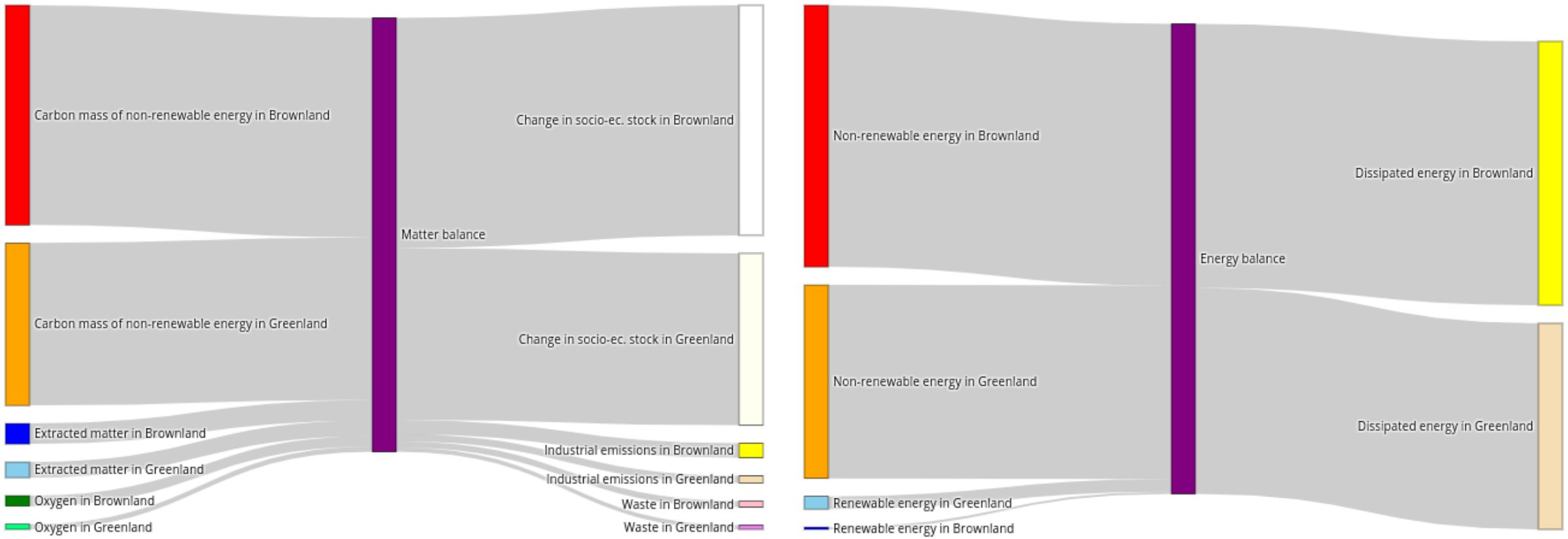


(g) Portfolio composition of Greenland households (2020)



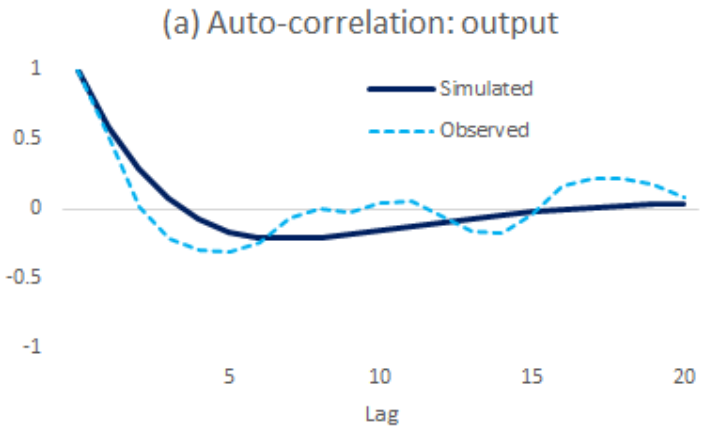
(h) Portfolio composition of Brownland households (2020)

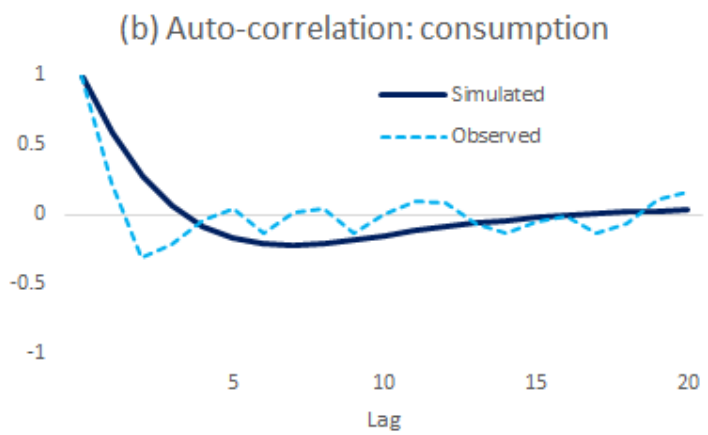
Figure 1b. Global matter and energy balances under the baseline scenario in 2018 (physical flows)

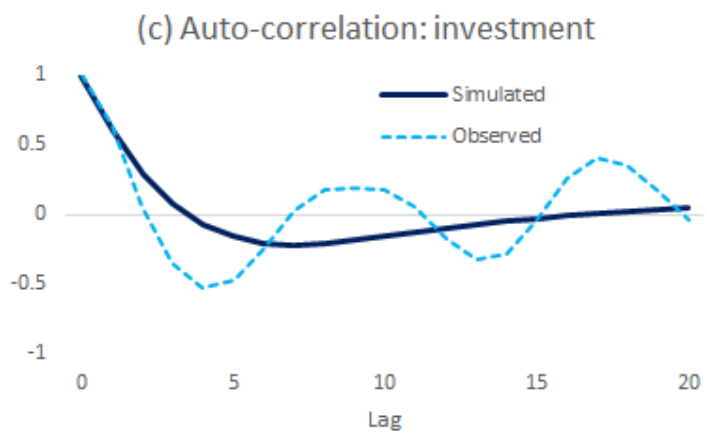


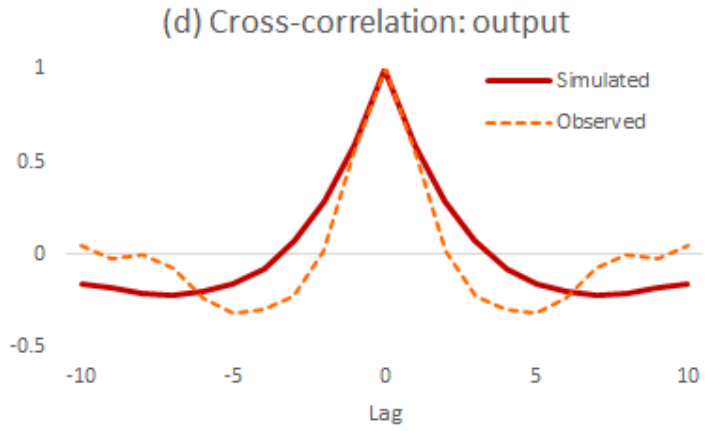
Note: Matter is measured in Gt while energy is measure in EJ

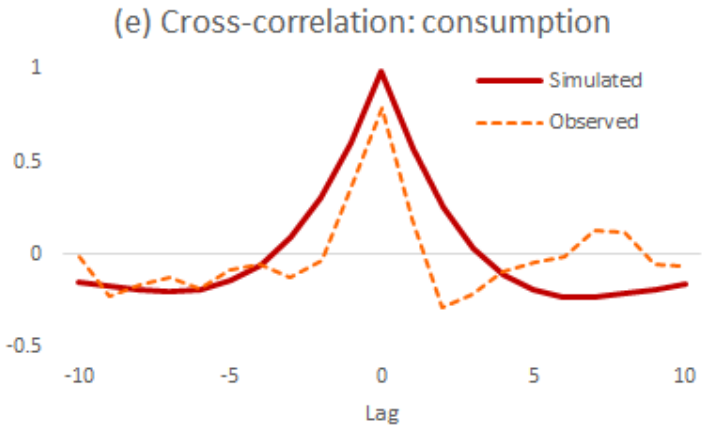
Figure 1c. Auto- and cross- correlations: simulated vs. observed series

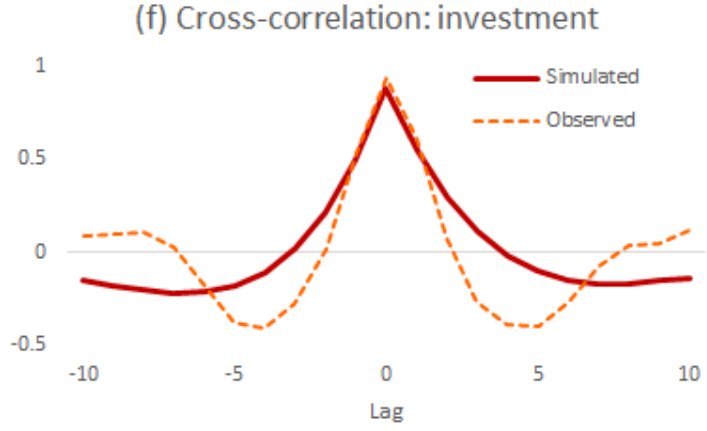












Note: Series are all expressed in logarithms. A Hodrick-Prescott filter was used to separate the cyclical component of each series from its trend. Only the former is considered. Observed data refer to the period 1960-2017. Simulated series refer to the period 2018-2060 (out-of-sample predictions)

4. Findings

We considered the following experiments:

1. Preference for safer financial assets
2. Preference for greener financial assets
3. Preference for greener products
4. Brownland austerity (and autarchy)
5. Higher government green spending
6. Coordinated government spending plan

We found that:

a) the effectiveness of green individual behaviours and low-carbon policies depends crucially on cross-border financial flows and their impacts on the exchange rates
b) Currency fluctuations bring about unintended implications from uncoordinated green actions
c) A fixed ER can help counter those implications, but it does not eliminate the perverse incentives for financially-distressed governments to cut green spending and import
d) A strong macroeconomic and monetary coordination across countries is paramount

Figure 2. Increase in risk aversion (preference for safer financial assets)

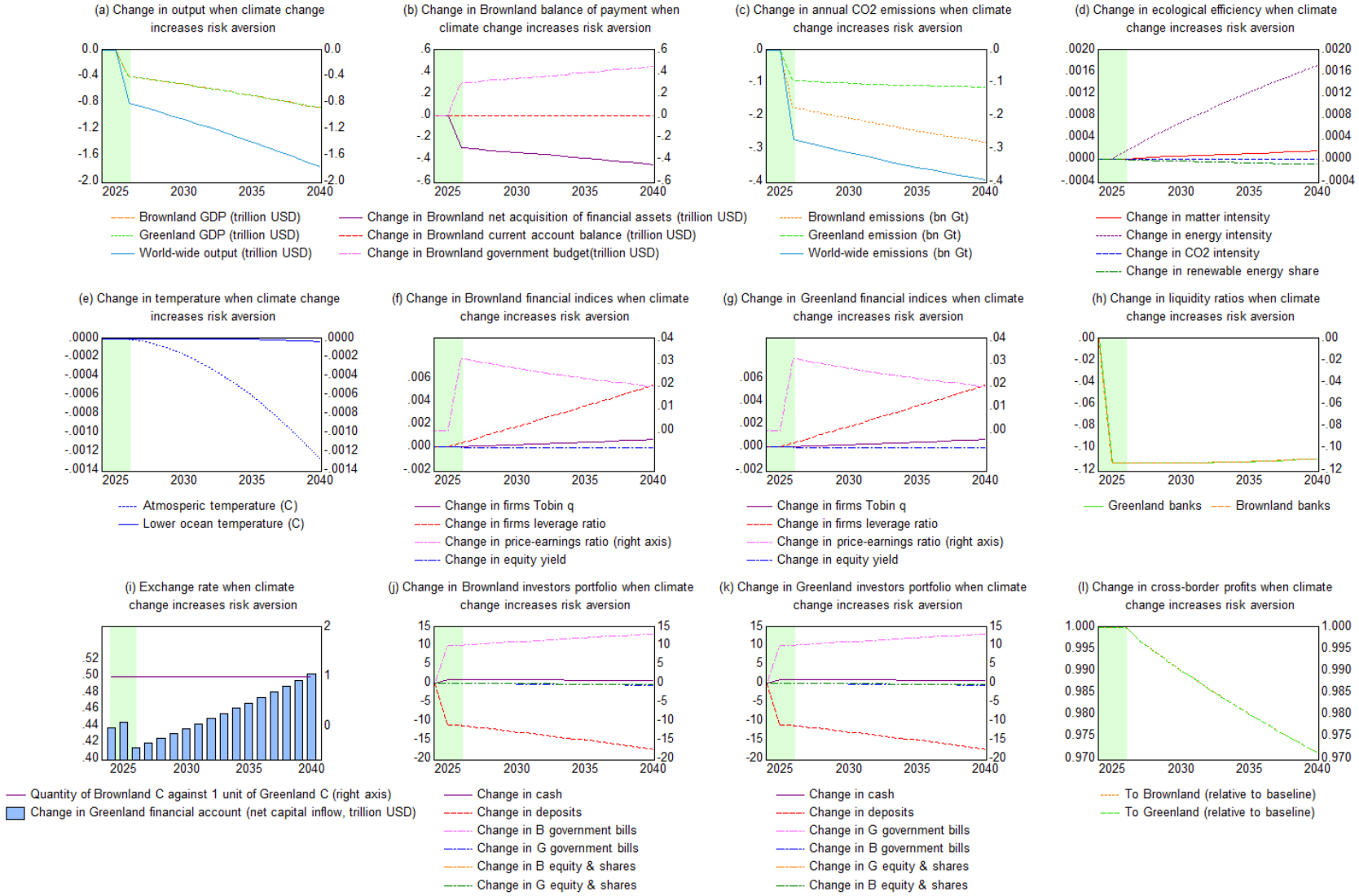


Figure 3. Preference for greener financial assets

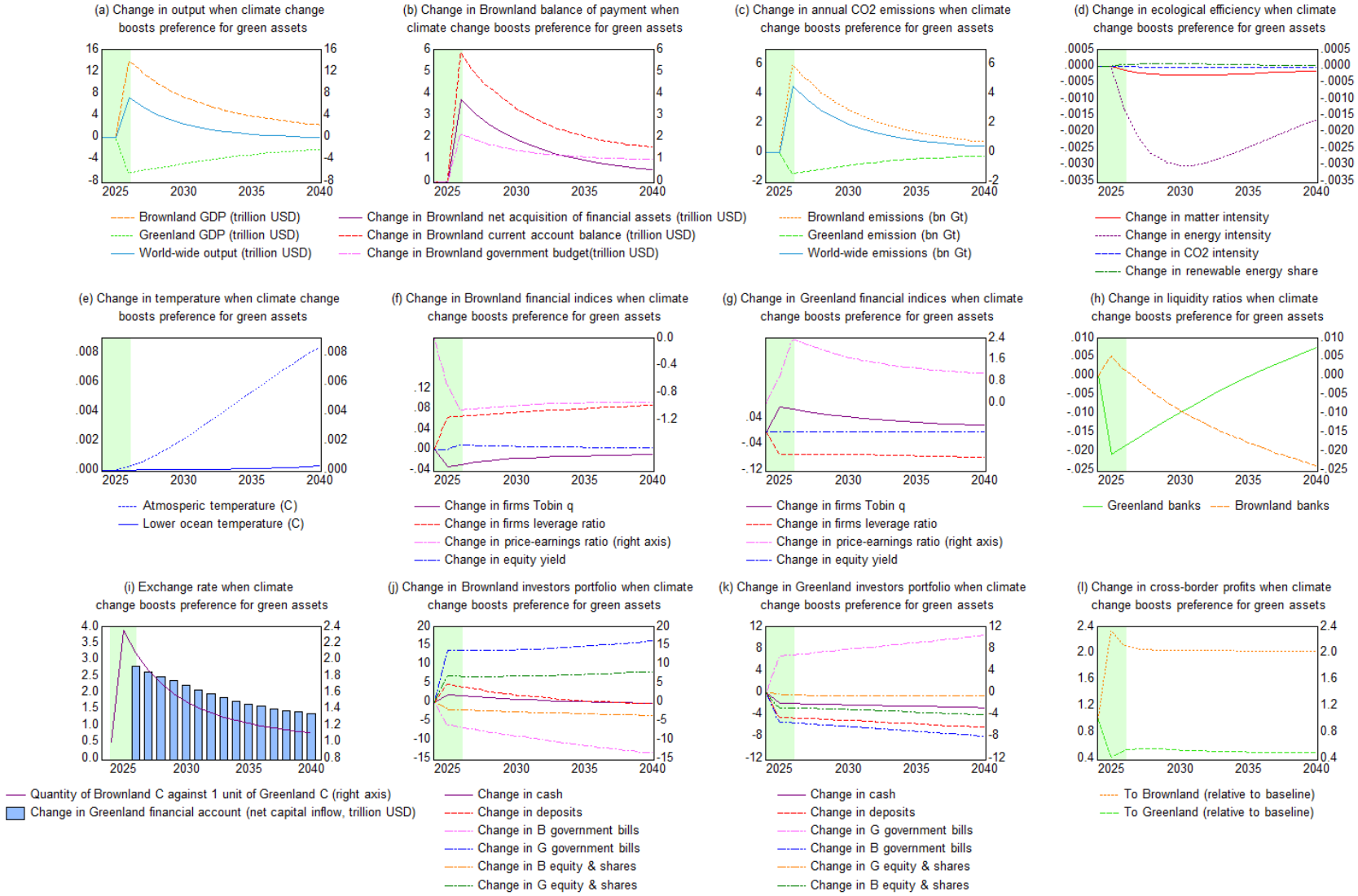


Figure 4. Preference for greener products

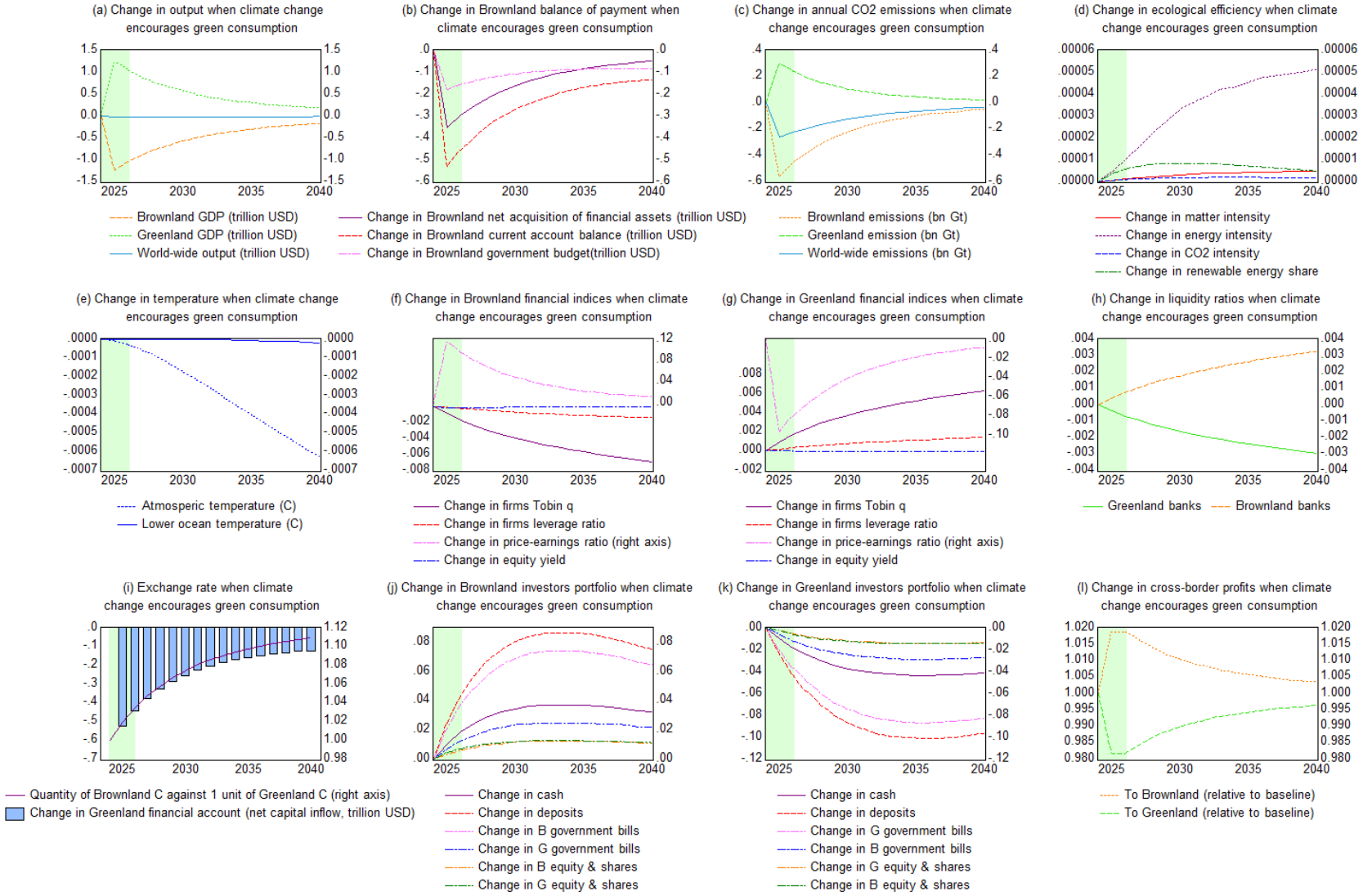


Figure 5. Austerity: cut to green icentives

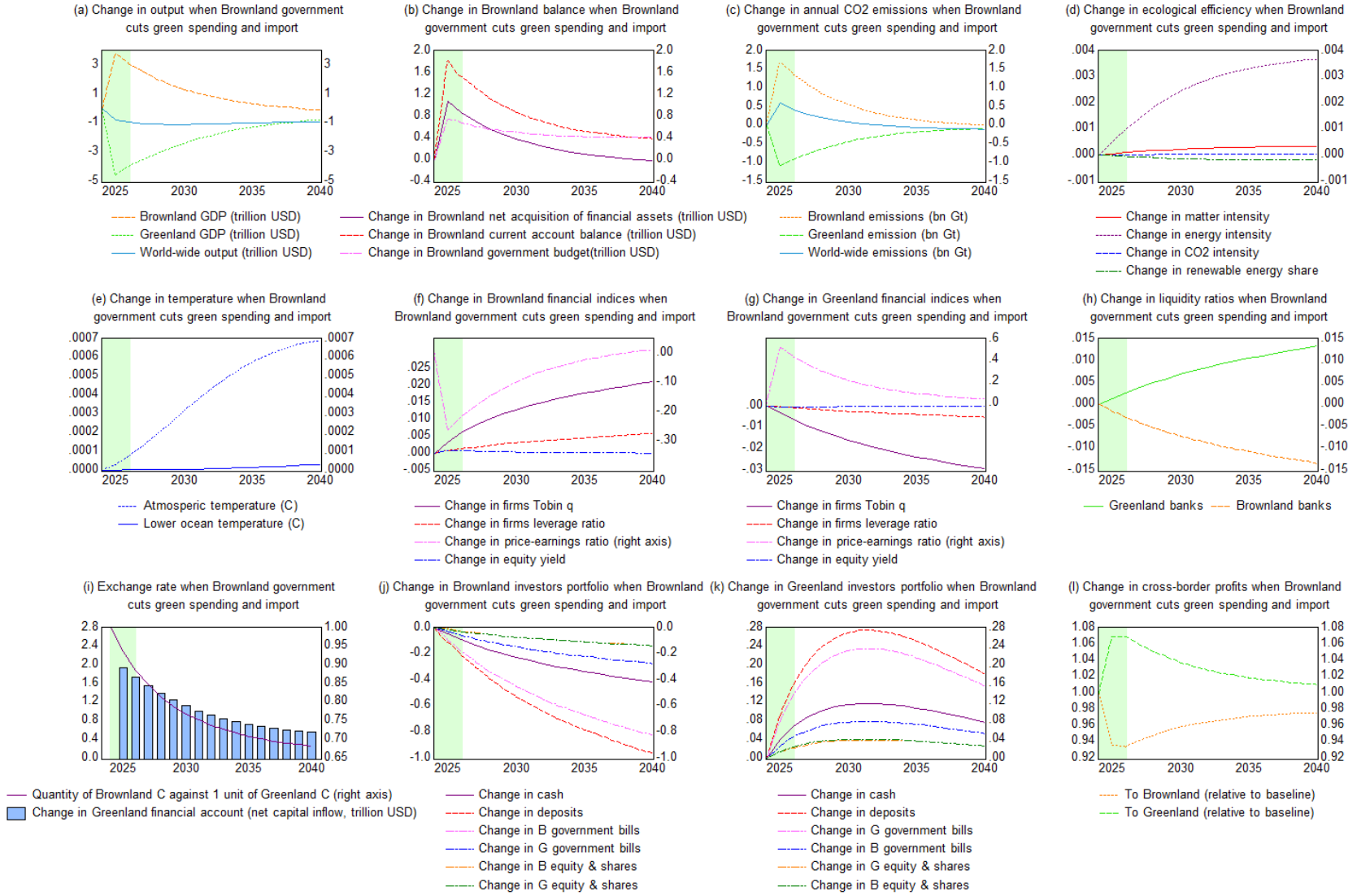


Figure 6. Green MOIS undertaken by Greenland government

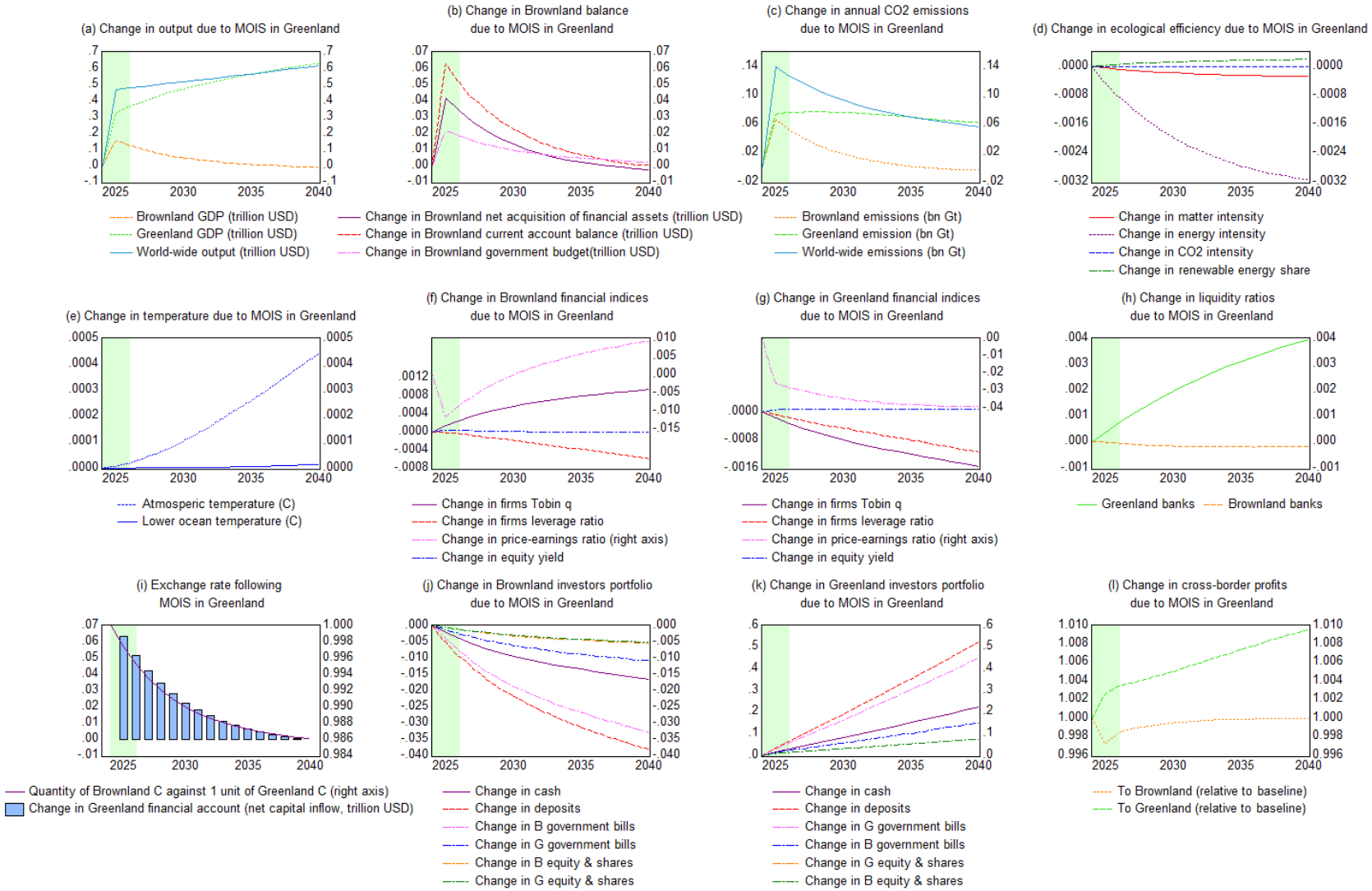


Figure 7. Coordinated green MOIS

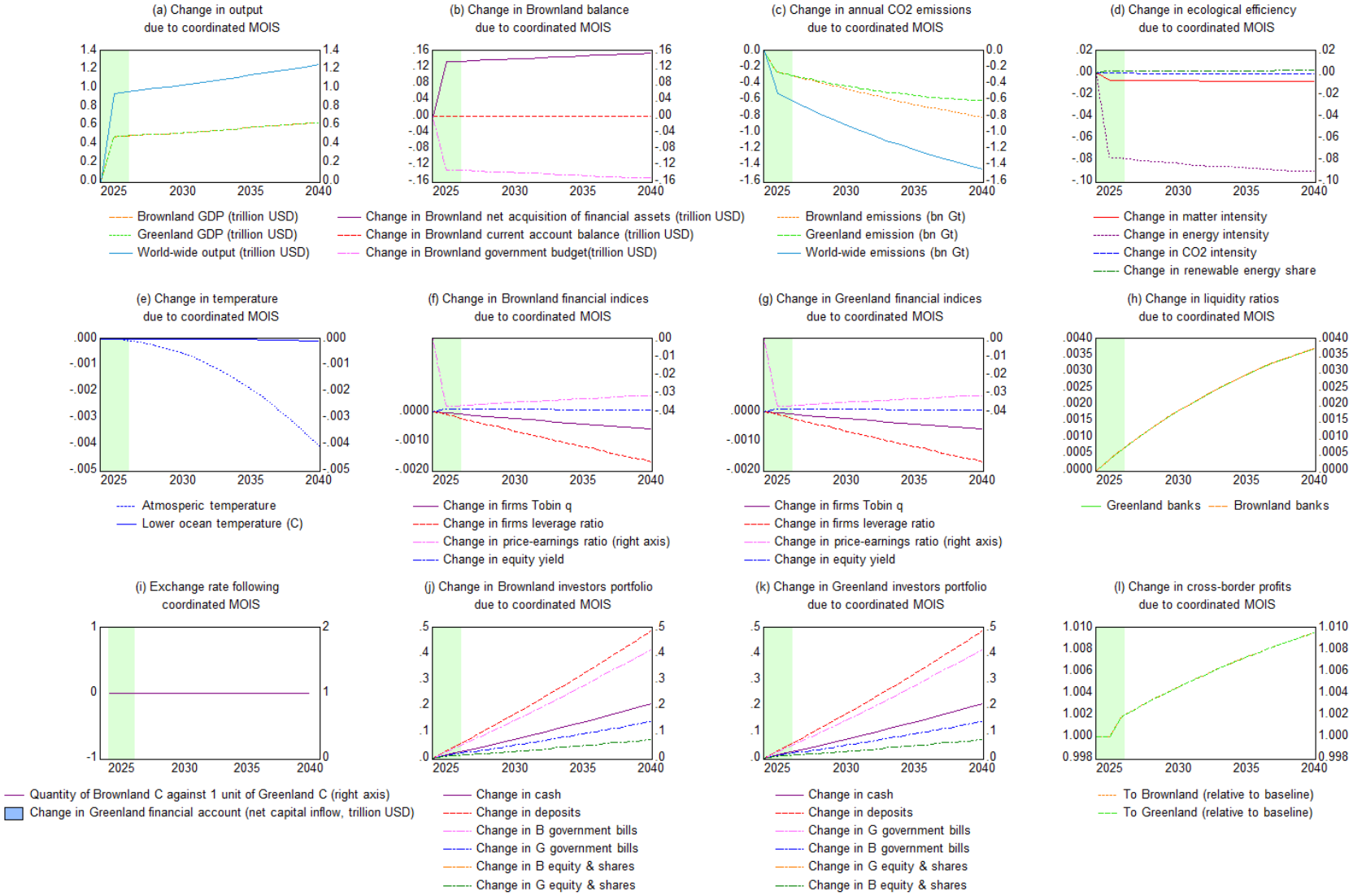
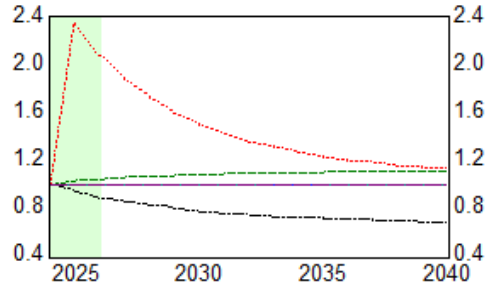


Table A. Changes in selected variables in 2050 relative to 2025

	Scenario 1. Safer financial assets			Scenario 2. Greener financial assets			Scenario 3. Greener consumption			Scenario 4. Austerity in Brownland			Scenario 5. MOIS in Greenland			Scenario 6. Coordinated MOIS		
	B	G	W	B	G	W	B	G	W	B	G	W	B	G	W	B	G	W
Economy																		
Total output*	-1.33003	-1.33003	-2.6601	0.91581	-1.28647	-1.1477	-0.09247	0.08459	-2.3929	-0.54237	-0.40141	10.5787	-0.02563	0.74698	1.056	0.76648	0.76648	1.5329
Exchange rate	0	0	NA	-0.034915	0.036178	NA	-0.106996	0.119815	NA	0.520033	-0.34212	NA	0.015008	-0.014786	NA	0	0	NA
Current account*	0	0	NA	1.289506	-1.238625	NA	-0.121874	0.108898	NA	0.326035	-0.49453	NA	-0.004751	0.004822	NA	0	0	NA
Government budget*	0.578545	0.578545	1.15709	1.119517	-1.090655	0.028862	-0.098938	0.090738	-0.0082	0.452714	-0.406542	0.046172	-0.000281	-0.174481	-0.174762	-0.167543	-0.167543	-0.335086
Society																		
Socio-economic stock (Gt)	-15.1	-11.484	-26.584	80.659	-45.319	35.34	-7.769	5.515	-2.254	12.219	-23.744	-11.525	0.305	8.257	8.562	3.951	3.249	7.2
Waste (Gt)	-0.1652	-0.11204	-0.27724	0.30206	-0.18459	0.11747	-0.01526	0.00987	-0.00539	-0.0286	-0.04559	-0.07419	-0.00048	0.04401	0.04353	-0.15942	-0.10318	-0.2626
Income inequality	-0.012224	-0.012224	NA	0.002012	-0.005532	NA	-0.00005	-0.0000231	NA	-0.002174	-0.000447	NA	-0.0000642	0.001822	NA	0.001748	0.001748	NA
Wealth inequality	-0.009	-0.009	NA	-0.002961	-0.00881	NA	0.001117	-0.001158	NA	-0.006066	0.00394	NA	-0.000216	0.001664	NA	0.001484	0.001484	NA
Finance																		
Tobin's q of firms	0.00144	0.00144	NA	-0.007669	0.010038	NA	-0.009141	0.008189	NA	0.027104	-0.039172	NA	0.001182	-0.002227	NA	-0.000915	-0.000915	NA
Firms' leverage ratio	0.009579	0.009579	NA	0.103119	-0.098122	NA	-0.00233	0.002166	NA	0.008699	-0.008614	NA	-0.001009	-0.001907	NA	-0.002767	-0.002767	NA
Return on equity	-0.0000256	-0.0000256	NA	0.003281	-0.00108	NA	-0.0000007	0.0000018	NA	-0.0000612	0.0000229	NA	-0.0000221	0.0000683	NA	0.0000489	0.0000489	NA
Bank liquidity ratio	-0.101727	-0.101727	NA	-0.033434	0.021117	NA	0.004249	-0.003938	NA	-0.017305	0.017707	NA	-0.000118	0.004965	NA	0.004502	0.004502	NA
Ecosystem																		
CO_2 emissions (Gt)	-0.34204	-0.111831	-0.45387	0.20499	-0.102272	0.10272	-0.02131	0.006389	-0.01491	-0.11178	-0.030183	-0.14196	-0.00697	0.047948	0.04099	-1.09073	-0.67633	-1.76705
Atm. temperature (C)	NA	NA	-0.003214	NA	NA	0.012885	NA	NA	-0.000982	NA	NA	0.000503	NA	NA	0.000791	NA	NA	-0.010935
Matter intensity (Kg/USD)	0.000246	0.000246	0.000246	-0.000579	0.000436	-0.0000714	0.0000511	-0.0000391	0.000006	0.000484	0.000192	0.000338	-0.0000004	-0.000619	-0.00031	-0.010395	-0.007632	-0.009014
Energy intensity (Ej/trillion USD)	0.002743	0.002743	0.002743	-0.006449	0.004858	-0.000796	0.000568	-0.000436	0.000066	0.005389	0.002134	0.003761	-0.000005	-0.006893	-0.003449	-0.112214	-0.084587	-0.0984

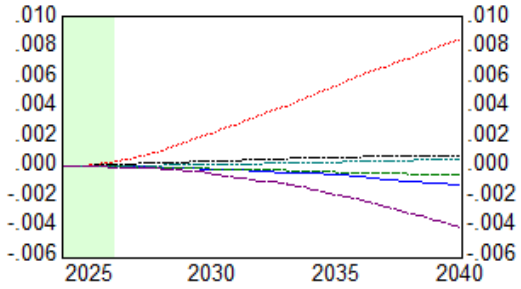
Figure 8. Additional charts (other trade-offs)

(a) Quantity of Brownland currency per unit of Greenland currency



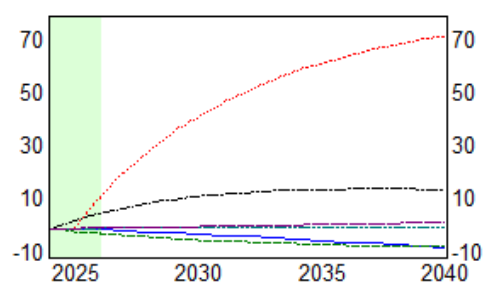
Higher risk aversion
Preference for greener financial assets
Preference for greener products
Brownland cuts green incentives
Greenland government MOIS
Greenland and Brownland government MOIS

(b) Atmospheric temperature: difference with baseline (C)



Higher risk aversion
Preference for greener financial assets
Preference for greener products
Brownland cuts green incentives
Greenland government MOIS
Greenland and Brownland government MOIS (right axis)

(c) Change in socio-economic stock of Brownland (Gt)



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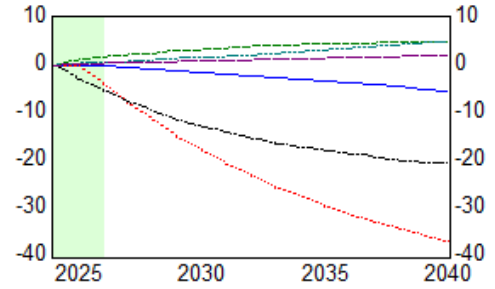
(d) Change in socio-economic stock of Greenland (Gt)



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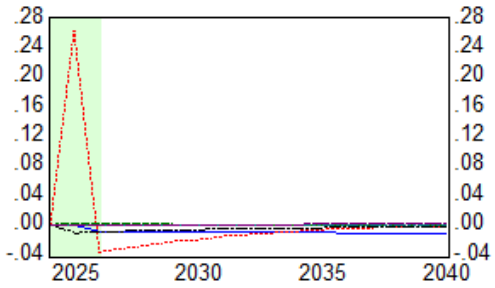
(e) Change in income inequality index (including CGs) of Brownland



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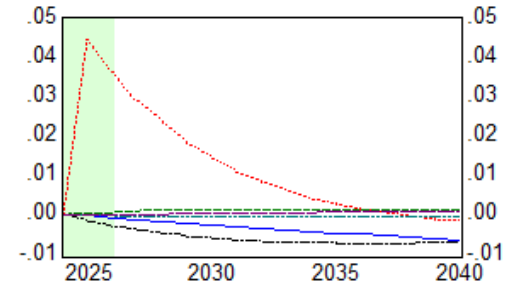
(f) Change in wealth inequality index of Brownland



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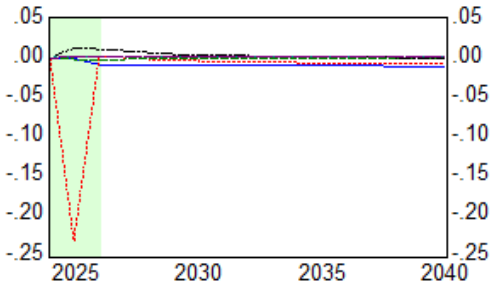

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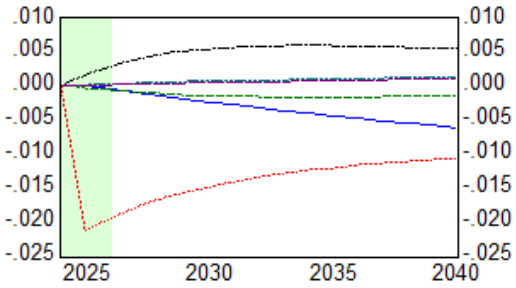
(h) Change in wealth inequality index of Greenland



Higher risk aversion
Preference for greener financial assets
Preference for greener products
Brownland cuts green incentives
Greenland government MOIS
Greenland and Brownland government MOIS (right axis)

4. Conclusions

We have developed an ecological open-economy SFC model to test the impact of cross-area financial flows on the economy, the financial sector, the society and the ecosystem.

Some well-known empirical facts are replicated by the model (e.g. the rebound effect). Additional counter-intuitive effects are found:

a) The search for safe financial assets (brought about by climate-related uncertainty) can affect economic growth and financial stability if the portion of idle balances increases
b) The search for green financial assets can exacerbate climate change if capitals are free to move and exchange rates are fully floating (reacting to cross-area financial flows)
c) Green consumption affects the current account and hence the government budget of less ecologically-efficient areas
d) If governments of 'brown' areas react by cutting (green) spending, the net effect on regional output depends on the sensitivity of imports to government (green) spending. Global output and financial stability are always affected instead
e) Lacking a strong coordination, green innovation-oriented government policies are likely to generate negative side effects for other areas. In addition, ecological efficiency gains are likely to be offset by the higher growth rate of the economy (rebound effect)

Thank you

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