Climate Change,Inequality, and Migration Towards OECD Countries

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Outline

Objectives and focus

- Estimate internal and international mobility responses to long-term, slow-onset Climate Change (CLC)
  - Under current law and enforcement policies 'validated' by backtracking simulations for the year 2010
- Simplifying assumptions on CLC
  - Exogenous CLC (no feedback from growth and urban. on CLC)
  - Long-term direct CLC = Rise in temperature + Sea level rise
  - Indirect effects via reduced utility and conflicts
- Focus on migration decisions via mechanisms recognized in theoretical and empirical literature
  - Role of migration costs
  - Fertility and education response
  - Distribution implications between two types of labor; no capital

Why link migration to CLC

- Heading soon into uncharted territory
- Surface temperature of the world has increased since 19th Cent. with process accelerating since 1980
- Sea Level Rise (SLR) has also accelerated sharply (due to loss of ice sheet in Western Antarctica)

- Many economic implications documented (Dell et al. (2014)
  - Redistribution of TFP
  - Health/drudgery of work
  - Conflicts

- Heterogeneous effects across areas/sectors within countries and across countries
  - Exposition to SLR
  - Nonlinear effects of temp on TFP and utility (initial conditions matter)
  - Different adaptation capacities, etc.

Literature review

- Mix of case studies + cross-country empirical studies (see paper)
- Contrasted findings with small migration responses on slow-onset CLC small (except historical (Faigan (2008)).
- Strong, but usually temporary, migration, for fast-onset events (storm surges, floods)
- Beine-Jeusette (2018) meta-analysis unravels components resulting in contrasted findings
- Limitations of econometric studies based on past data
  - Slow-onset CLC in early stages
  - Distinguishing between climate and other factors difficult
  - Mobility responses are context-specific (geography, development, network, cultural, socio-economic)

- **Our response: Simulate likely effects on migration over the 21st Cent. in a world model**

Contribution

- Granularity in CLC (temp and SLR) and in economic structure
- Disentangle contributing factors: displacements from flooded areas vs. economic migration
- TFP and forced displacement vs. 'less firmly grounded' effects (utility loss and conflict)
- Two-sector (agriculture/nonagriculture) two-class (skill/unskill) OLG model simulated over 21st Cent.

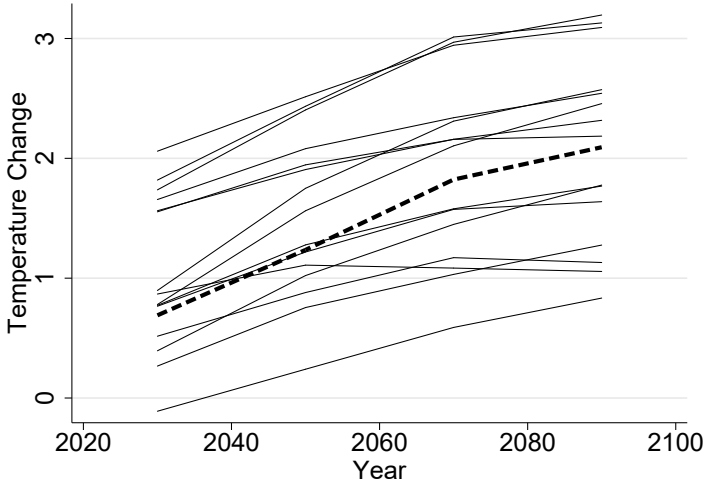
- **Contribution: reasonably suggestive predictions about likely internal and international migration responses to CLC for 145 developing countries to OECD countries**

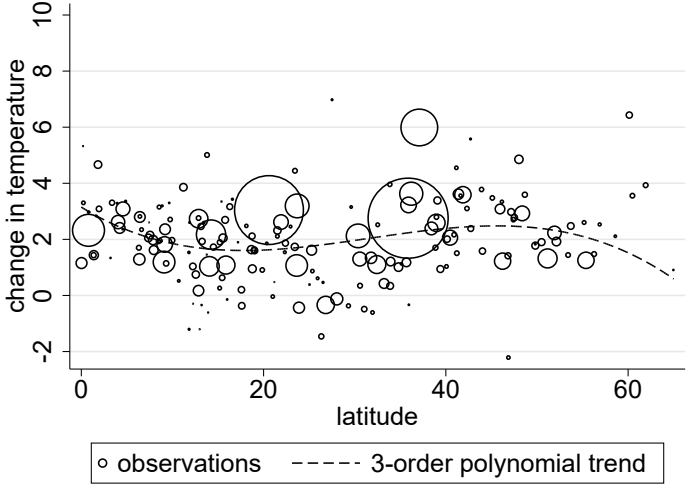
Modelling Climate Change (CLC)

- CLC is restricted to temperature increase and sea level rise (SLR)
  - Temperature: raw data + projections of monthly temp levels
  - Decreasing temperature btw. mean temperature and mean latitude
  - Median CCKP scenario w.r.t. emissions (RCP 4.5)
  - Median RCP variant w.r.t. to temperature +2.09°C after 2010
  - Link CCKP climatological 20 year windows to 2040, 2070, 2100
- Correction for population density
  - Dell et al. (2012) population-weighted temperature over 1995-2005

Temperature paths under RCP4.5

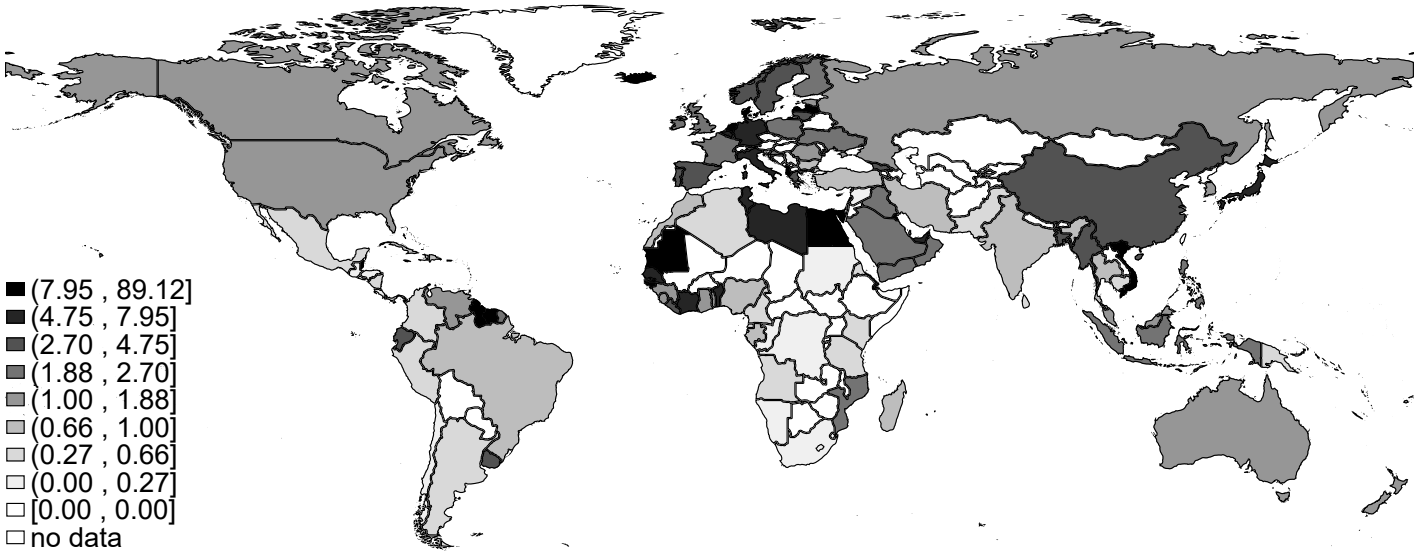
Distribution of changes in temperature by country and latitude in 2100





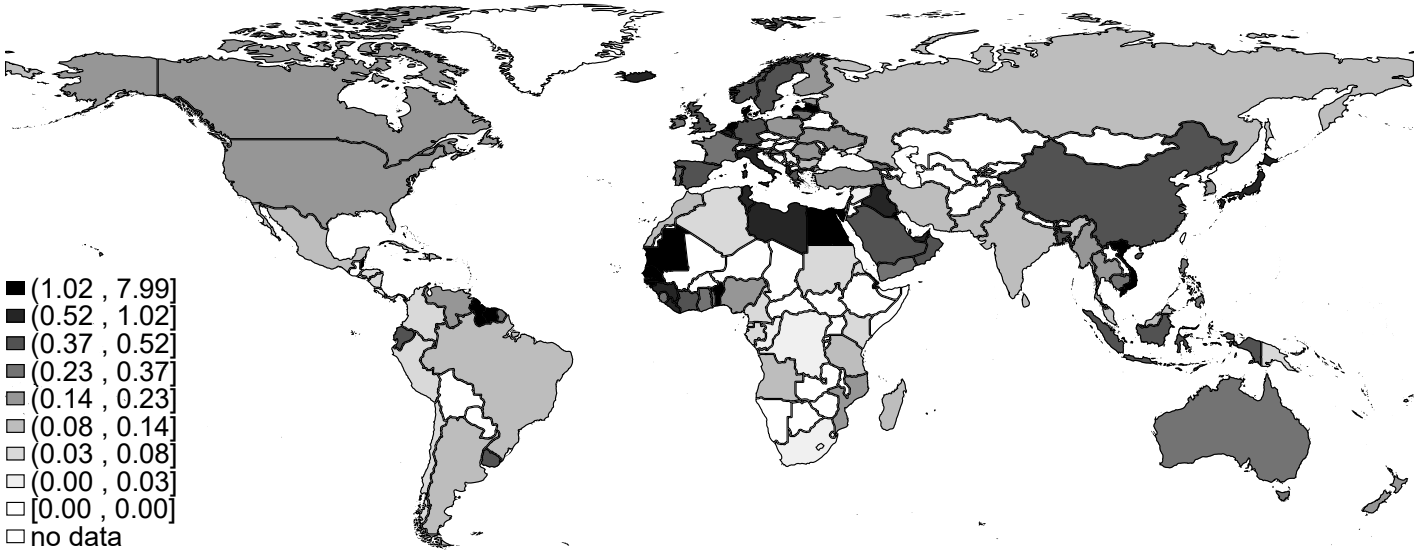
Modelling Climate Change (CLC)

Population shares living below 1.1m in 2010 (10bins)



Modelling Climate Change (CLC)

Populaton shares living between 1.1m and 1.3m in 2010 (10bins)



Channels of Transmission

- Temperature and productivity as in Desmet and Rossi-Hansberg (2015) and Shayegh (2017):
  - $G_r(T) = \max\{g_{0r} + g_{1r}T + g_{2r}T^2; 0\}$
  - Agr: agronomic studies, envelope of crop-specific relationships
  - Nonagr: relationship between population density and latitude
  - TFP scale factor: $G_{r,t} = \frac{1}{12}\sum_{m=1}^{12} G_r(T_{m,r,t})$
  - Productivity responses are country-specific: initial temp. matters
- And more...

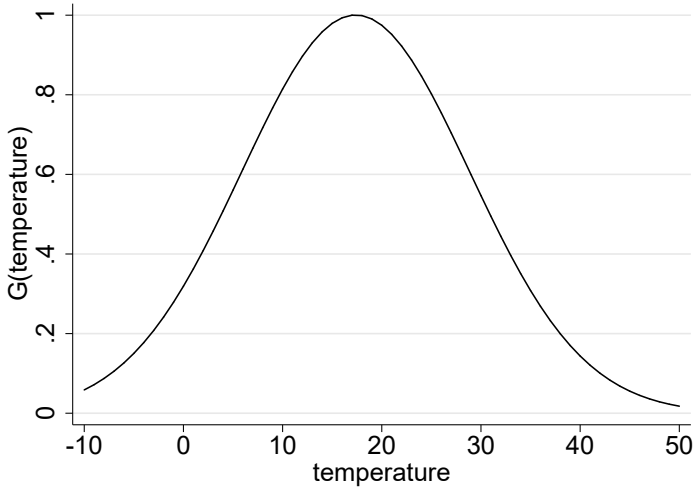
Channels of Transmission

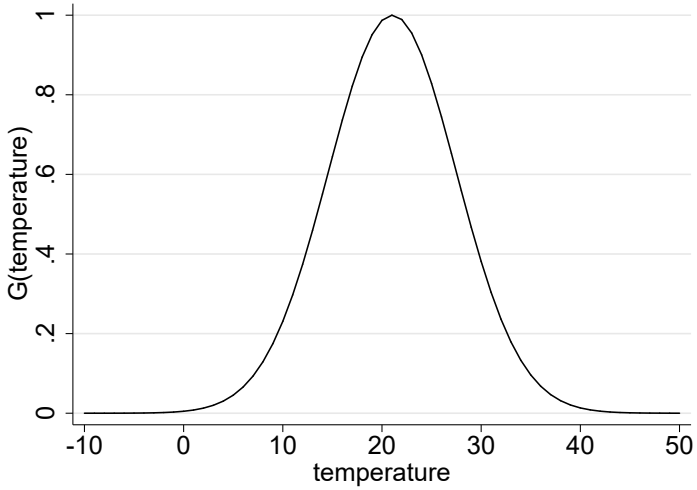
- Temperature and utility
  - Output per worker falls by 2 % per 1° when temp is above 22°
  - Assume it is due to disutility of work ($\Delta d \rightarrow \Delta \ell^*$)
  - Quasi-lin. U(c,l;d): $\frac{\Delta U^*}{U^*} = (1+\vartheta)\frac{\Delta \ell^*}{\ell^*} = -.02(1+\vartheta)\Delta T \equiv \tau$
- Rising sea level
  - Use of NASA data to identify share of population by elevation ($\Theta_{r,t}$)
- Acceleration of fast-onset events (storms, floods, fires: impact of CLC through conflicts)
  - CLC $\Rightarrow$ frequency of extreme events ($\Rightarrow$ temp & short-dist mig.)
  - High frequency of fast-onset events may induce tensions over resources and conflicts

Channels of Transmission

Productivity and temperature

Non-agriculture and Agriculture





Scenarios

Moderate Scenarios

Damages with strong empirical support

- Minimalist-no CLC [+0.09°C;+0m]. Reference only (unattainable?)
- Intermediate [+2.09°C;+1m]. Highly successful mitigation as described in Rintoul et al. (2018)
- Maximalist [+4.09°C;+1.3m].Likely outcome if continued delays at mitigation

Scenarios

Extreme Scenarios

Captures other damages with empirical support:
(much the same effects as TFP losses)

- Extreme-no SLR [+2.09°C;+0m]. This scenario neutralizes forced displacements
- Extreme-Greater SLR [+2.09°C;+2.7m]. Captures the SLR associated with the effect of storm surges analyzed in Rigaud et al.(2018) who project a SLR of 2m by 2040
- Extreme-Utility [+4.09°C;+1.3m;+ utility losses]. Maximalist + direct utility loss of 8% per 1°C increase where temp¿20°C
- Extreme-Conflict [Extreme-Utility+conflict in poorest countries]. Conflict arises in the 10 countries with the highest HC

Model Structure

- World economy with 145 countries and OECD as one recipient of migrants
  - emigrants to the OECD aggregate entity are allocated across countries on the basis of the dyadic shares of 2010
- 2 age groups: adults (decision-makers) and children
- 2 skill groups (s=h,l) college grads & less-educated
- 2 regions (r=a,na) produce the same good
- 2 areas (b=f,d). Flooded and unflooded
- The Model endogenizes
  - Mobility: local ag-nonag and to the OECD
  - Self-selection of migrants subject to mobility costs
  - Population dynamics: net migration, fertility and education
  - World distribution of income; human capital;TFP and Poverty

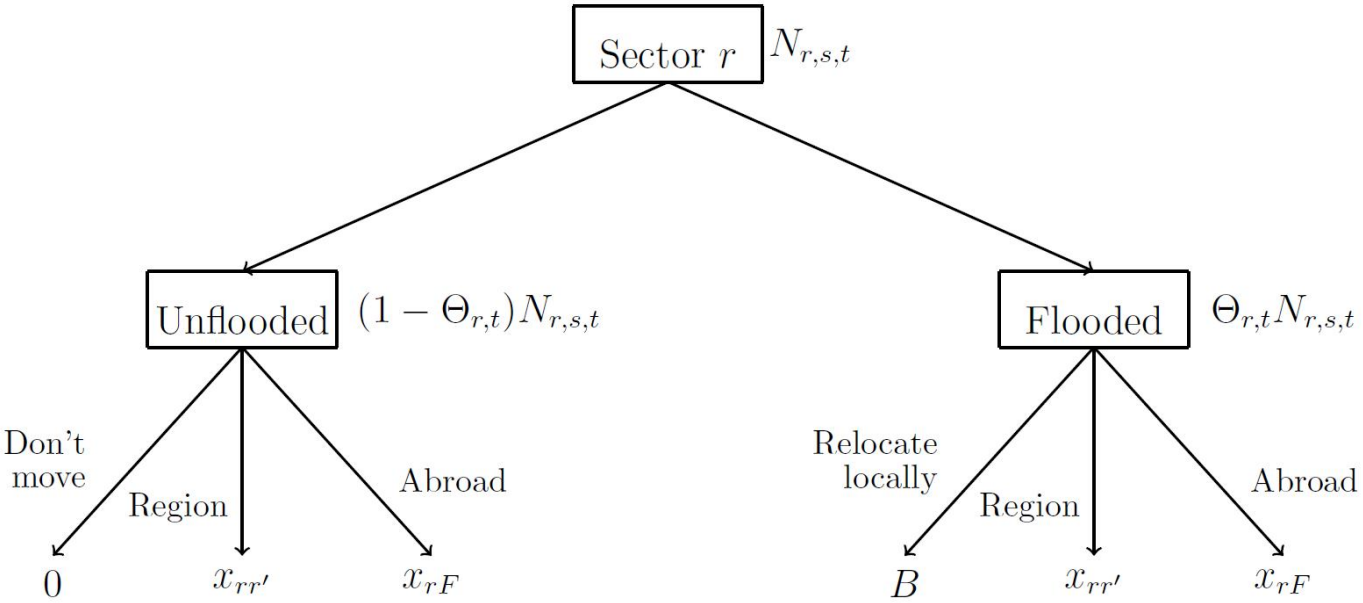
Technology

Output is feasible in unflooded areas only

- CES technology: $Y_{r,t} = A_{r,t}\left(\sum_s \eta_{r,s,t}\ell_{r,s,t}^{\frac{\sigma_r-1}{\sigma_r}}\right)^{\frac{\sigma_r}{\sigma_r-1}}$
  - With $s = (h, l)$ = College grads vs. Less educated
  - And $r = (a, n)$ = Agr vs. Nonagr
- Technological externalities:
  - Aggregate: $A_{r,t} = \gamma^t \overline{A}_r G_{r,t}\left(\frac{\ell_{r,h,t}}{\ell_{r,l,t}}\right)^{\epsilon_r}$
  - Skill-bias: $\Gamma^{\eta}_{r,t} \equiv \frac{\eta_{r,h,t}}{\eta_{r,l,t}} = \overline{\Gamma}^{\eta}_{r}\left(\frac{\ell_{r,h,t}}{\ell_{r,l,t}}\right)^{\kappa_r}$
- These eqs. govern income and productivity disparities

Preferences

- Skilled and unskilled Adults in Ag and non.ag sectors
- Area is flooded or unflooded



Preferences

Adults raised in unflooded areas: $N^d_{r,s,t} = (1 - \Theta_{r,t})N_{r,s,t}$

- Two-stage random utility model:
  - Outer utility function, $r^* \to r = (a, n, F)$:

$$U^d_{r^*r,s,t} = \ln v^d_{r,s,t} + \ln(1 - x_{r^*r,s,t}) + \xi^d_{r^*r,s,t}$$

  - Inner utility function (warm glow):

$$\ln v^d_{r,s,t} = \ln(1 - \tau_{r,t}) + \ln c^d_{r,s,t} + \theta \ln \left(n^d_{r,s,t} p^d_{r,s,t}\right)$$

- Budget constraint: $c^d_{r,s,t} = w_{r,s,t}(1 - \phi n^d_{r,s,t}) - n^d_{r,s,t} q^d_{r,s,t} E_{r,t}$
- Training technology: $p^d_{r,s,t} = \left(\pi_r + q^d_{r,s,t}\right)^{\lambda}$

Preferences

- Education and fertility (interior):

$$\begin{cases} q^d_{r,s,t} = \frac{\lambda\phi w_{r,s,t} - \pi_r E_{r,t}}{(1-\lambda)E_{r,t}} \\ n^d_{r,s,t} = \frac{\theta(1-\lambda)}{1+\theta} \cdot \frac{w_{r,s,t}}{\phi w_{r,s,t} - \pi_r E_{r,t}} \end{cases} \quad \Rightarrow \quad v^d_{r,s,t}(.)$$

- Migration (taste shocks $\xi^d_{r^*r,s,t}$ are EVD(0,μ)):

$$m^d_{r^*r,s,t} \equiv \frac{M^d_{r^*r,s,t}}{M^d_{r^*r^*,s,t}} = \left(\frac{v^d_{r,s,t}}{v^d_{r^*,s,t}} \right)^{1/\mu} (1 - x_{r^*r,s,t})^{1/\mu}$$

- Eqs. govern consumption, fertility, educ. & mobility

Preferences

Adults raised in flooded areas: $N^f_{r,s,t} = \Theta_{r,t} N_{r,s,t}$

- One difference: they lose a fraction B of their labor earnings if they relocate within the region of birth (no compensation):

$$w_{r,s,t}(1 - \phi n^d_{r,s,t}) \rightarrow (1 - B) w_{r,s,t}(1 - \phi n^f_{r,s,t})$$

- Decrease in local utility: $v^f_{r^*,s,t}(.) < v^d_{r^*,s,t}(.)$
- Different migration responses:

$$m^f_{r^* r,s,t} \equiv \frac{M^f_{r^* r,s,t}}{M^f_{r^* r^*,s,t}} = \left(\frac{v^d_{r,s,t}}{v^f_{r^*,s,t}} \right)^{1/\mu} (1 - x_{r^* r,s,t})^{1/\mu}$$

Intertemporal equilibrium

Definition

For a set $\{\gamma, \theta, \lambda, \phi, \mu, B\}$ of common parameters, a set of sector-specific elasticities $\{\sigma_r, \epsilon_r, \kappa_r\}$, a set of region-specific exogenous characteristics $\left\{\overline{A}_r, \overline{R}_r^{\eta}, \overline{x}_{r^*r,s,t}, \tau_{r,t}, \Theta_{r,t}, \psi_{r,t}, \pi_r\right\}$, and a set $\{N_{r,s,0}\}$ of predetermined variables, an intertemporal equilibrium is a set of endogenous variables $\left\{A_{r,t}, \eta_{r,s,t}, w_{r,s,t}, E_{r,t}, \ell_{r,s,t}, N^b_{r,s,t+1}, n^b_{r,s,t}, q^b_{r,s,t}, v^b_{r,s,t}, m^b_{r^*r,s,t}\right\}$ satisfying technological constraints, profit & utility max conditions, and population dynamics in all countries of the world.

Data

Calibration for 145 countries +OECD countries as one entity

- Macro data on VA population, HC by country for 1908-2010
- Bilateral migration matrices (DIOC), urbanization trends
- Microdata on fertility, income per HH member, migration intention plans by region, and education level (Gallup world polls)
- UN socio-demographic for 2040 (pop and HC)

Parameters

- Technology
  - Elasticity of substitution: $\sigma_n = 2$ and $\sigma_a = \infty$
  - $\eta_{r,s,t}$ matches $\frac{w_{r,h,t}}{w_{r,l,t}}$; $A_{r,s,t}$ matches $Y_{r,t}$ in 1980 and 2010
  - Skill biased extern. (correlation): $\overline{\kappa}_n = .26$ and $\overline{\kappa}_a = .00$
  - TFP extern. (correlation): $\overline{\epsilon}_n = .56$ and $\overline{\epsilon}_a = .64$
  - Externality = halved correlations ($\kappa_n = .13$, $\epsilon_n = .28$, $\epsilon_a = .32$)
- Preferences
  - Common parameters: $\theta = .2, \lambda = .6, \phi = .1, \mu = 1.4$
  - Mig costs $x_{rF,s}$: match DIOC + Gallup data
  - Others ($\pi_r, \psi_{r,t}, x_{an,s}$): match Δ pop, Δ educ, Δ urban in 1980-2010 (+ in 2010-2040)

Projections

- Estimation of a convergence eq. for access to education $\psi_{r,t}$
  - Identify $\psi_{r,t}$ in 1980 and 2010 (and predictions for 2040+)
  - $\ln\left(\psi_{r,t+1}/\psi_{r,t}\right) = \alpha_r + \beta_{1,r}\ln(\psi^{US}_{r,t}/\psi_{r,t}) + \beta_{2,r}\left[\ln(\psi^{US}_{r,t}/\psi_{r,t})\right]^2$
  - Convergence btw middle-income and rich countries
  - Constant migration costs and other parameters
- Socio-demographic outcomes in line with official projections over 1980-2010 and to 2040 (Burzynski et al. 2017)
- 'Proof of concept' that the stylized model is relevant

Climate parameters

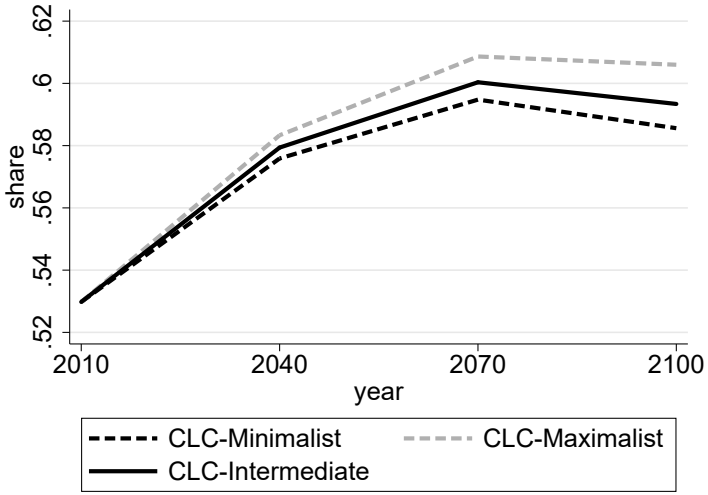
- Effect of temperature and rising sea level
  - $G_{r,t}$ and $\Theta_{r,t}$ identified above
- Utility loss from increasing temp. (health, drudgery of work):
  - Output per worker decreases by 2% per $1°C$ above $22°C$
  - Quasi-linear utility (with LS elasticity of 1/3): $\tau = -0.08\Delta T$
- Relocation costs for forcibly displaced people: $B = .5$
- Temperature and conflicts
  - Burke et al. (2015): One σ increase in temperature raises intergroup conflict by 11.3 percent
  - Long-term conflicts captured by a reduction in int'l emigration costs so as to raise stock of emigration stocks by a factor of 2.

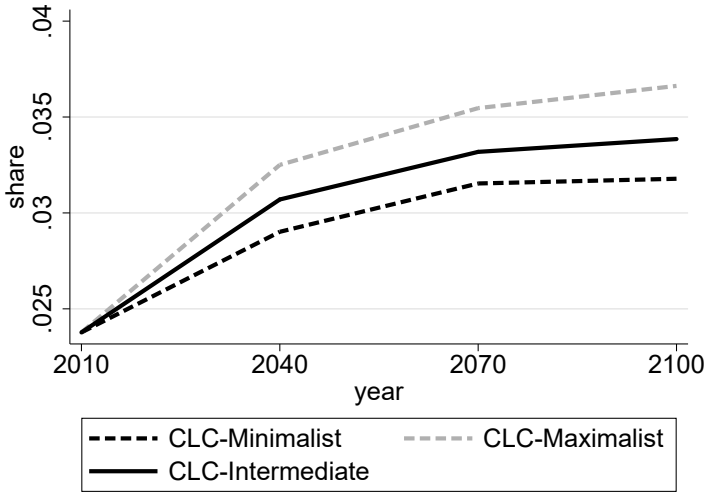
Results: Moderate scenarios

Worldwide responses

- Small effects on income per worker, population growth and education (see paper)
- large effects on urbanization and on share of international migrants to OECD (shown below)

Urbanization Share of int'l migrants (to OECD)

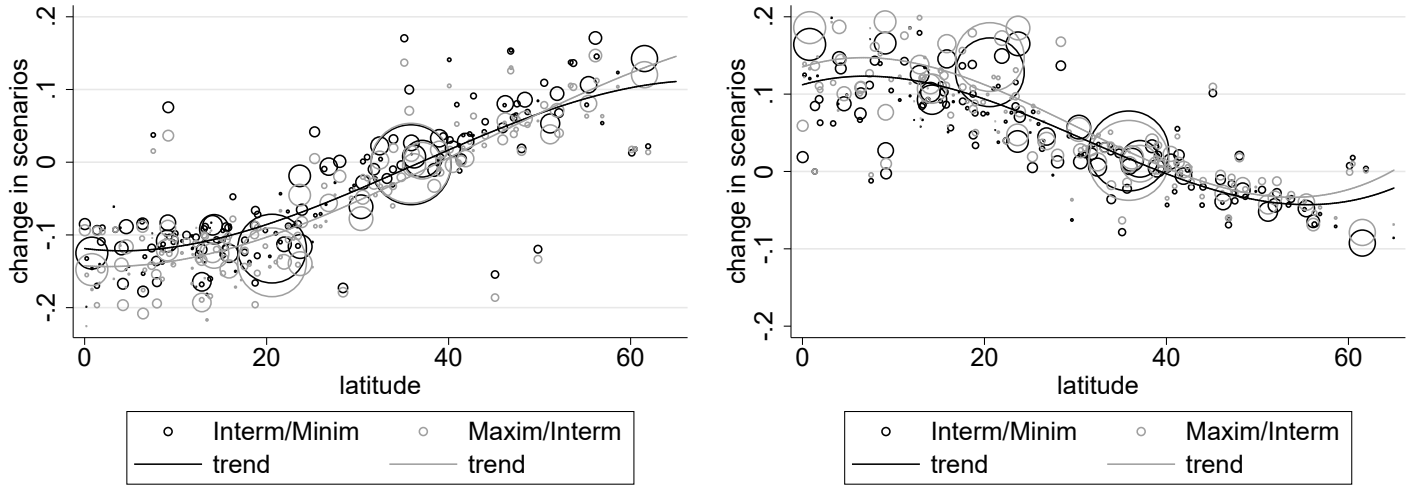




Results: Moderate scenarios

Country-specific effects by latitude

Income per capita and Emigration (Equator: -15% in mean inc)



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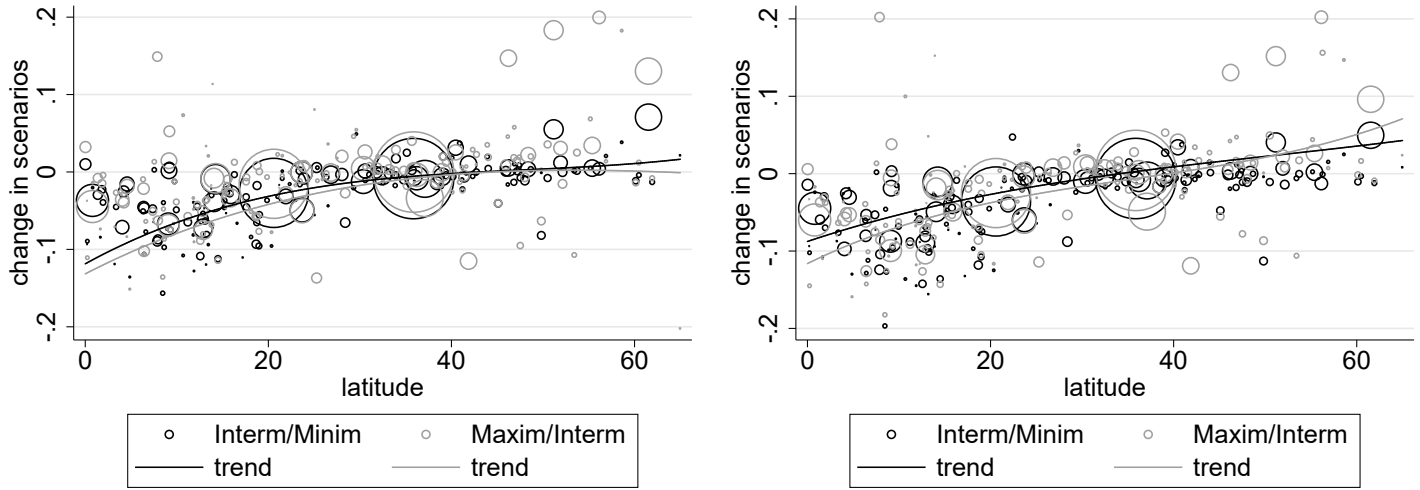
intm./minim.[+2.09°C;+1m]/[+0.09°C;+0m]

maxim./intm. [+4.09°C;+1.3m]/[+2.09°C;+1m]

Results: Moderate scenarios

Skill bias in emigration

Skill bias in internal migration in international migration



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maxim./intm. [+4.09°C;+1.3m]/[+2.09°C;+1m]

Results: Moderate scenarios

Mostly internal migration (as in Rigaud et al. (2018)

	Number (in million)			As % world pop		
	2040	2070	2100	2040	2070	2100
	Intermediate minus Minimalist					
Total	78.4	24.6	16.9	2.05	0.57	0.36
Ag-Nonag	13.1	4.1	1.1	0.34	0.10	0.02
International	6.4	6.9	9.2	0.17	0.16	0.20
Local	58.8	13.6	6.6	1.54	0.31	0.14
Flooded	69.4	15.5	7.5	1.82	0.36	0.16
	Maximalist minus Minimalist					
Total	109.7	42.6	33.2	2.58	1.01	0.69
Ag-Nonag	26.5	13.5	4.5	0.69	0.32	0.09
International	13.6	16.5	21.2	0.35	0.38	0.46
Local	69.8	12.7	7.5	1.83	0.29	0.16
Flooded	82.5	14.5	8.5	2.16	0.34	0.18

Results: Moderate scenarios

Ranking in 2100 of top 20 adversely affected (% difference in income). Mostly Poor countries and close to Equator

	Country	Interm/Minim		Country	Maxim/Interm	
		2040	2100		2040	2100
1	Sao Tome and Principe	-17.8	-19.9	Sao Tome and Principe	-20.1	-22.5
2	Gambia	-11.7	-18.2	Gambia	-15.1	-21.7
3	Venezuela	-13.8	-17.8	Venezuela	-16.4	-20.8
4	Nepal	-15.9	-17.3	Malaysia	-16.8	-19.7
5	Grenada	-13.4	-17.1	Dominican Republic	-16.0	-19.6
6	Nicaragua	-15.3	-16.8	Ghana	-18.9	-19.4
7	Malaysia	-14.3	-16.7	Philippines	-18.1	-19.3
8	Dominican Republic	-13.5	-16.6	Nicaragua	-17.5	-18.9
9	Ghana	-15.9	-16.5	Cuba	-15.3	-18.6
10	Philippines	-15.3	-16.4	El Salvador	-16.1	-18.4
11	El Salvador	-13.9	-16.0	Nepal	-18.1	-17.9
12	Cuba	-12.6	-15.4	Liberia	-21.7	-17.6
13	Liberia	-18.6	-15.3	Gabon	-15.2	-17.5
14	Fiji	-11.9	-15.0	Brunei Darussalam	-17.0	-17.2
15	Brunei Darussalam	-14.4	-14.8	Fiji	-14.4	-17.2
16	Gabon	-12.5	-14.6	Guinea-Bissau	-15.0	-16.7
17	Guyana	-14.2	-14.3	Equatorial Guinea	-18.6	-16.6
18	Belize	-14.2	-14.1	Belize	-18.0	-16.2
19	Equatorial Guinea	-14.5	-14.0	Panama	-15.6	-16.1
20	Barbados	-12.5	-13.8	Maldives	-15.2	-16.0

Results: Moderate scenarios

International migration rates to OECD (percent)

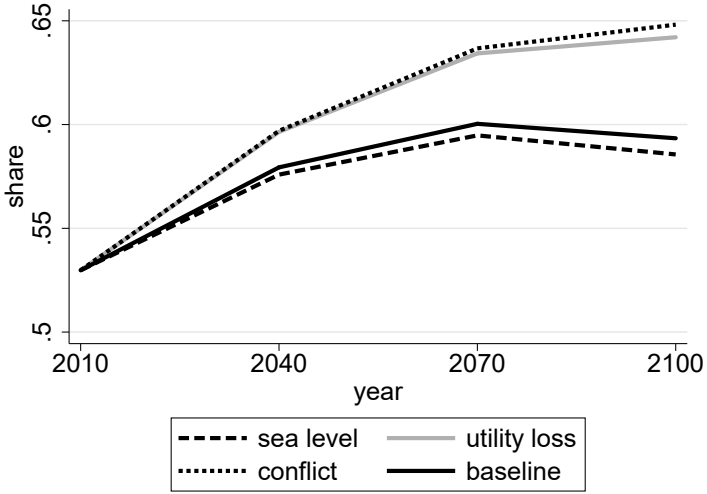
	Intermediate				Minim.	Maxim.
	2010	2040	2070	2100	2100	2100
Emigration rates						
Latin America	3.8	5.3	6.1	6.7	6.3	6.7
Sub-Saharan Africa	1.3	1.8	2.1	2.2	2.0	2.2
MENA	2.8	4.0	4.3	4.6	4.4	4.6
Asia	1.1	1.9	2.5	3.0	2.8	3.0
OECD	4.7	5.6	5.2	4.7	4.8	4.7
Immigration rates						
United States	16.0	21.4	23.0	23.1	22.7	23.6
Canada	18.7	26.5	28.5	28.4	28.2	28.6
Australia	24.9	29.4	29.2	28.1	27.8	28.5
European Union	12.1	18.6	21.9	23.6	23.2	24.1
EU15	13.6	20.3	23.3	24.6	24.2	25.1
Germany	15.0	22.5	25.4	26.4	26.1	26.8
France	12.2	18.8	20.5	22.1	21.6	22.6
United Kingdom	14.6	22.2	25.4	26.6	26.3	26.9
Italy	10.9	17.2	20.6	22.5	21.9	23.1
Spain	14.0	20.6	23.3	24.3	23.8	24.8

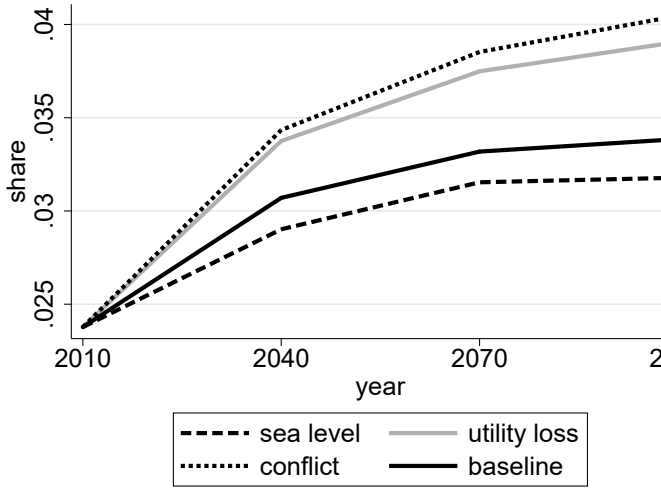
Results: Extreme scenarios

Worldwide responses

- Large effects of utility losses/conflicts on urbanization and on share of international migrants to OECD (shown below)

Worldwide shares of urban pop. and of int'l migrants (to OECD)





Results: Extreme scenarios

International migration rates to OECD (percent)

	Interm. 2100	No SLR 2100	Great SLR 2100	Utility 2100	Conflict 2100
Emigration rates					
Latin America	6.7	6.7	6.7	7.6	7.6
Sub-Saharan Africa	2.2	2.2	2.2	2.8	3.2
MENA	4.6	4.6	4.6	4.7	4.7
Asia	3.0	3.0	3.1	3.6	3.7
OECD	4.7	4.7	4.7	4.5	4.5
Immigration rates					
United States	23.1	23.2	23.1	24.0	24.4
Canada	28.4	28.4	28.3	28.8	29.0
Australia	28.1	28.2	28.1	28.8	29.1
European Union	23.6	23.6	23.6	24.5	24.9
EU15	24.6	24.6	24.6	25.4	25.9
Germany	26.4	26.4	26.4	27.0	27.5
France	22.1	22.1	22.0	23.0	23.4
United Kingdom	26.6	26.6	26.5	27.2	27.5
Italy	22.5	22.5	22.4	23.6	24.2
Spain	24.3	24.3	24.2	25.2	25.7

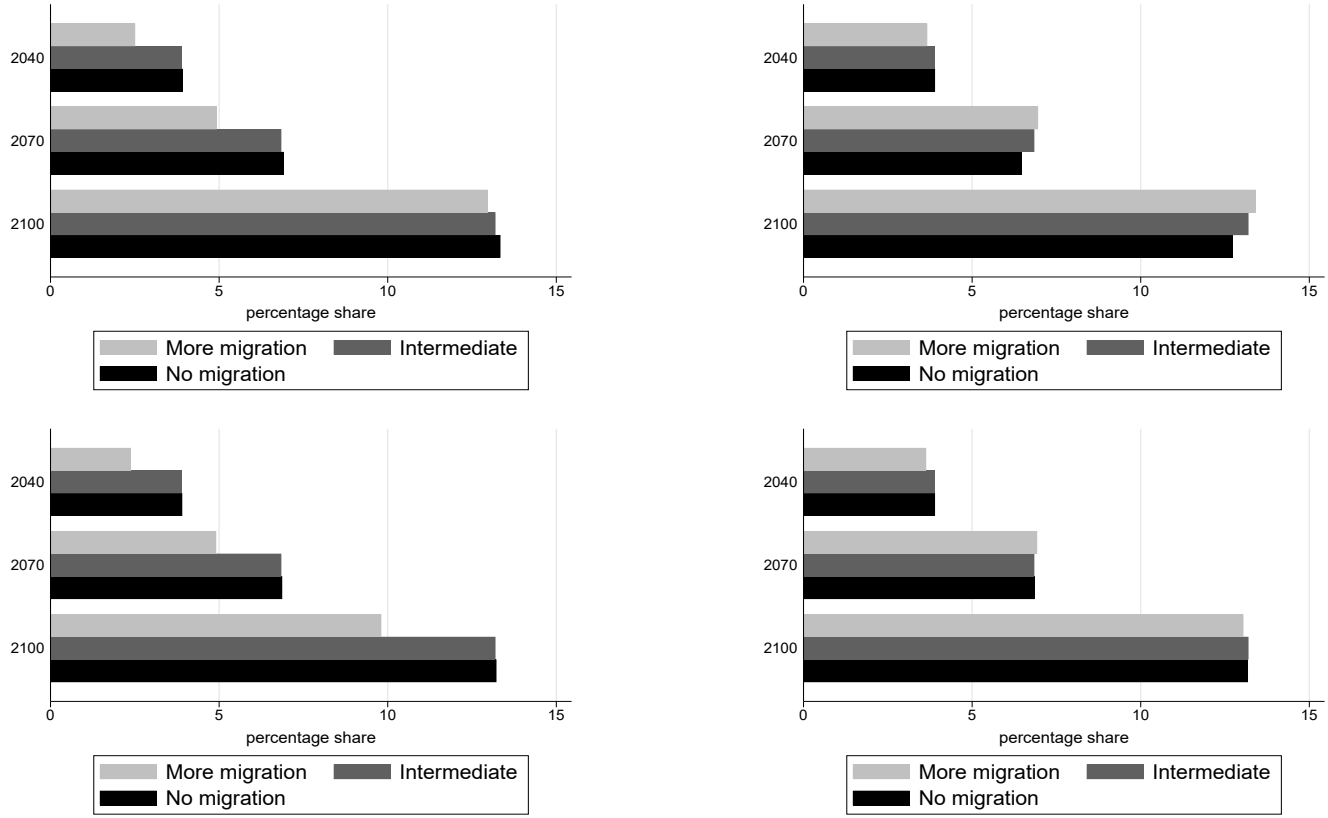
Migration Policy Scenarios

Should OECD countries adjust their migration policy to limit inequality and poverty effects of CLC?

- no mig and reduced mig costs vs. intermediate scenario
- 10 countries with highest poverty HC most heavily affected
- Policy applied to all workers vs. low-skill workers in agriculture
- Reinforcing restrictions has little effect: current costs are large
- Fall in poverty only if policy targets poorest group, not if targets countries with greatest temp rises!

Migration Policy Scenarios

Poverty headcounts



Conclusions. . .

- CLC increases inequality and extreme poverty.
- Mobility responses: Local >> Interregional > international.
- Concerns about international migration pressures.

  Current policies: small impacts on intĺ migration (+0.2pp).

  Small effects of reducing migration costs.
- What is a climate refugee?

  85 percent of forcibly displace people move locally.

  Half of non-local movements ....and 95 percent of international movements are voluntarty (indirect economic channel).

Thank you for your attention!

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