Global inequality, migration... and the weather

Frédéric Docquier

Canezei, January 16, 2020

Objectives

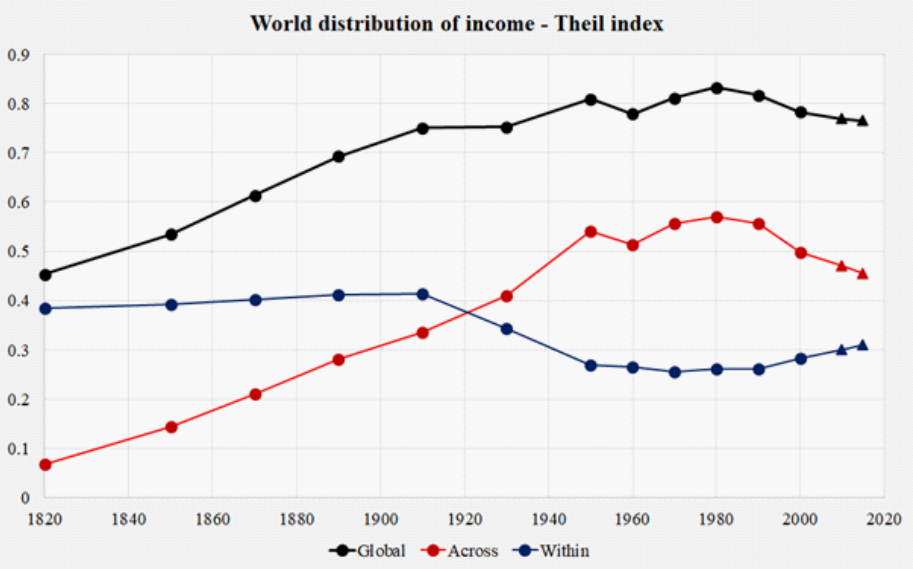
Global inequality, migration and climate change

- How will climate change affect global inequality trends, extreme poverty, and future migration pressures?
- Role of migration barriers? Role of climate scenarios?

- Use of "quantitative theory"

Global inequality trends...

It is not who you are, but where you are!



One indiv. = one vote

Theil index 1820-2015

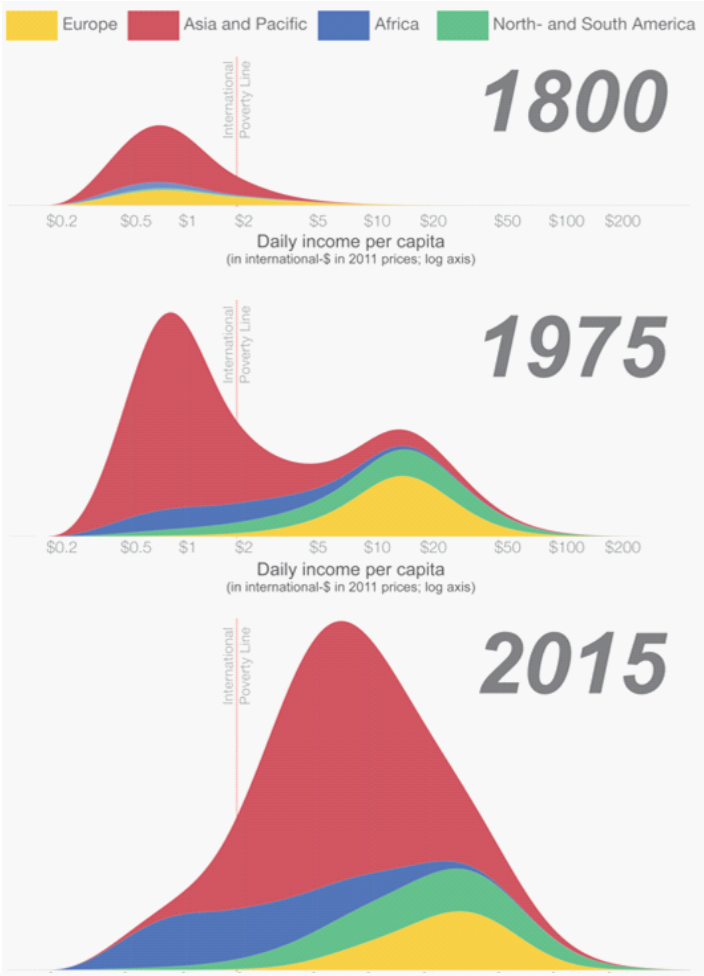
Major component = "across"

Decreasing trend since 1980

Decline in "across"

Increase in "within"

Global inequality trends...



It is not who you are, but where you are!

Extreme poverty

Huge decline since 1980

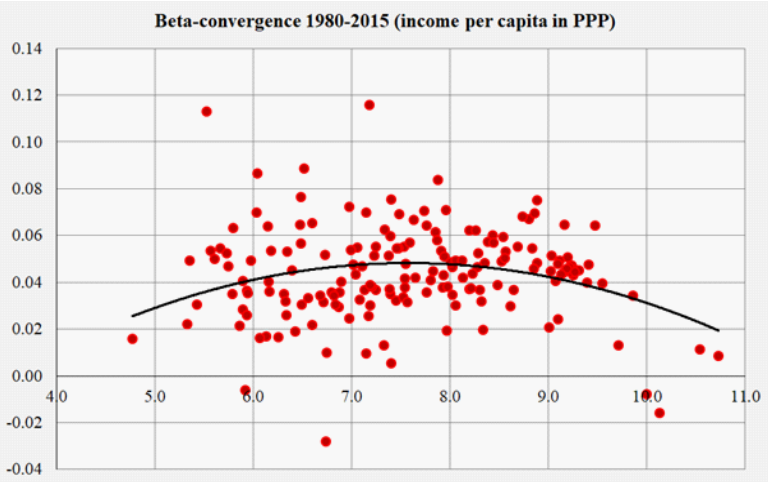
Africa is lagging behing...

will see its pop share x3

Poverty could increase!

Global inequality trends...

It is not who you are, but where you are!



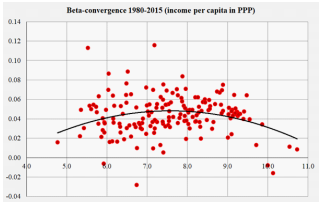
One ctry = one vote

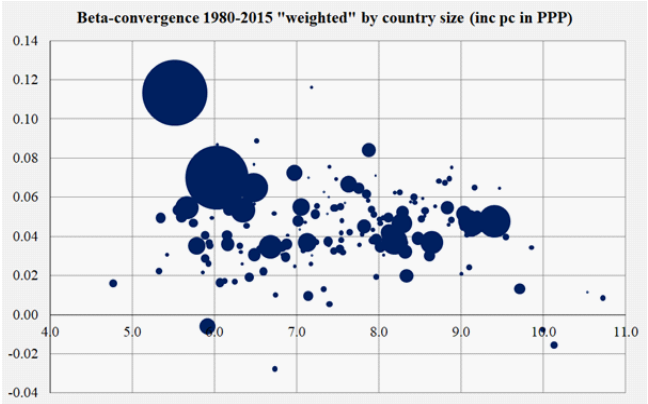
Persistent inequality

No conv. btw countries

Global inequality trends...

It is not who you are, but where you are!





One ctry = one vote

Persistent inequality

No conv. btw countries

"Across" $<$ large states...

Inequality could increase!

One individual, one vote

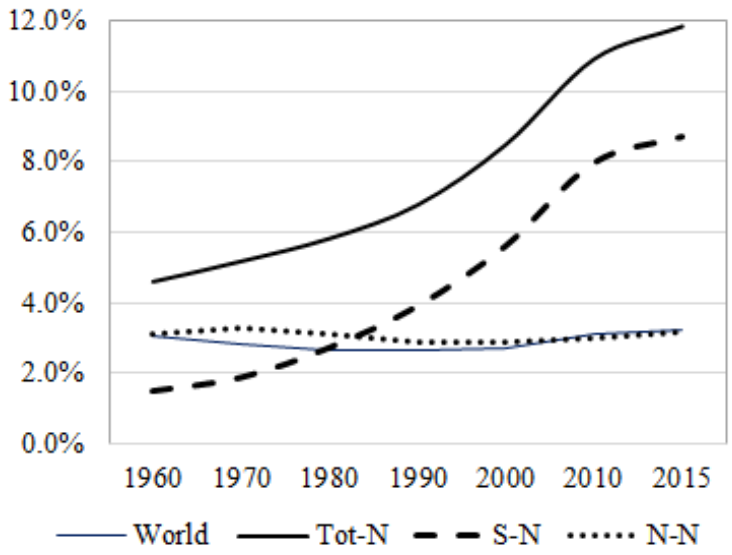
Population projections 2000-2100

Continent	P2000	As %	P2050	As %	P2100	As %
Asia	3.719	60,8	5.142	55,3	4.596	45,4
Africa	811	13,3	2.192	23,6	3.574	35,3
Europe	727	11,9	719	7,8	675	6,7
LAC	521	8,5	751	8,1	688	6,8
North Am	313	5,1	447	4,8	526	5,2
Pacific	31	0,5	55	0,6	66	0,7
World	6.122	100	9.306	100	10.125	100

Source: UNPOP

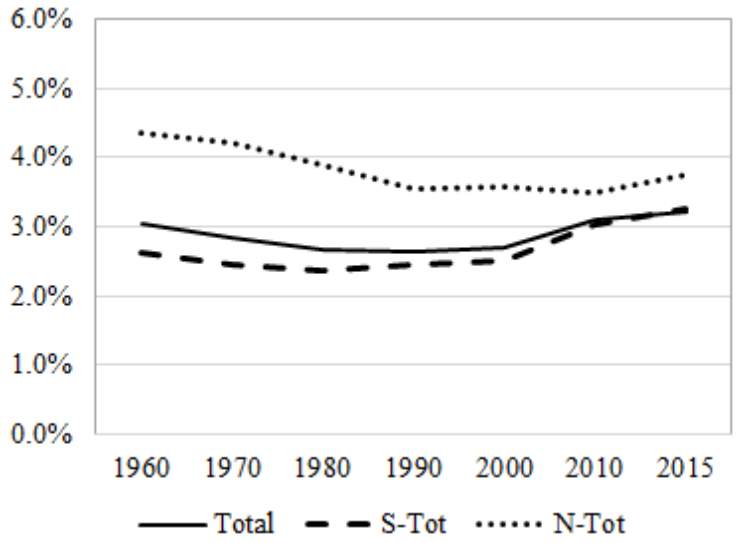
Global migration trends...

Immig rates: I/P



Increasing in N

Emig rates: E/(E+P-I)



Stable from S

Global migration trends...

Int'l migration ambiguously affects global inequality

- Displace people from low- to high-productivity countries but...
- Less than 3% of the developing world
- And affects average level of schooling in most countries
  - Emigrants are more educated than those left behind (pos. sel.)
  - Immigrants are less educated than host populations
  - Emigration prospects and immigration affect returns to education
- Uncertain effects on TFP conv & within-country inequality

On climate change...

Climate change will impact inequality & migration

- Mean surface temp of the world and sea level have increased since 19th, and the process has accelerated since 1980
- 21^{st} C: $+1$ to $+4°C$ in temp, $+1$ to $+2m$ in sea level
- Many economic implications (Dell et al. 2014)
- Heterogeneous effects across countries/regions!
  - Exposition to sea-level rise
  - Different adaptation capacities
  - Nonlinear effects of temp: initial levels matter
  - Larger effects on agricultural productivity

$\Rightarrow$ **Favorable conditions for increasing inequality and mobility**

Climate change...

Climate migration frightens !

Climate change...

Is the world ready for climate migrants?

By GULREZ SHAH AZHAR

Climate change

Climate change 'will create world's biggest refugee crisis'

CLIMATE

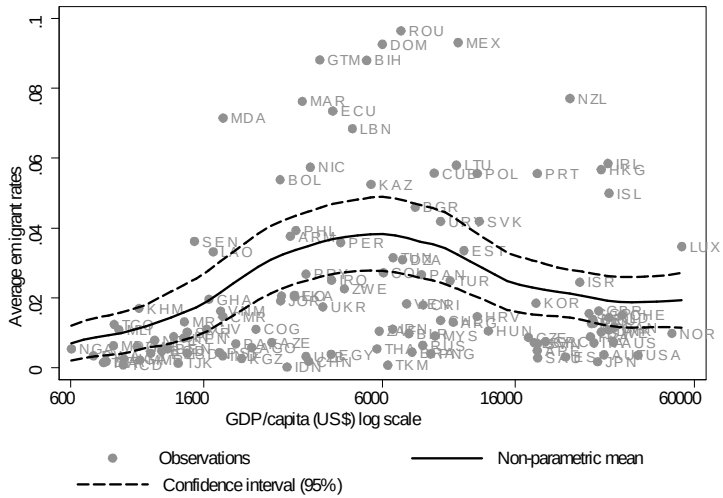
Climate Change Is Driving People From Home. So Why Don't They Count as Refugees?

INTERNATIONAL BUSINESS

A Migration Juggernaut Is Headed for Europe

Climate change...

Emig rates and income pc



Dispersion due to country size, geographic distance, etc.

Climate change...

Climate migration vs climate poverty:

Where is the real threat?

Quantitative theory...

- Empirical analysis of migration responses to climate change
  - Literature mostly focused on fast-onset variables (weather shocks)
  - Consensus on internal mobility responses but...
  - Highly uncertain effects on int'l mig (Beine-Jeusette 2018)
- Limitations of empirical studies:
  - Low granularity of cross-country mig data (time/spatial)
  - Distinguishing btw climate variables & other drivers is difficult
  - Mobility responses are context specific (development, geography, network, political, socio-demog, cultural)
  - CLC has not fully materialized yet: we are in uncharted territory!!!

Quantitative theory...

- Need for an alternative, micro-founded approach
  - How many movers? How many int'l migrants?
- Quantitative theory is appropriate to:
  - Model multiple mig. options at various spatial scales
  - Account for the context (calibration so as to match actual mig. data: very good predictive power when "backcasting")
  - Account for general eq. effects (direct/indirect effects of CLC)
  - Account for dynamic effects (pop growth, education, etc.)
- Incipient literature (DRH 2015, Desmet et al. 2018, Shayegh 2017)

Road map

1. Modelling inequality $\Rightarrow$ migration
   - Micro-foundations and interpretation
2. Modelling climate change $\Rightarrow$ inequality
   - Climate damage function
3. Extended dynamic framework
4. Projections of inequality and migration

I. Modelling migration

Preamble

Looking at migration matrices (200x200):

- Characteristics of dyadic migration flows:
  - Emig rates vary with gender, educ, country size, development
  - With some exceptions, emig rates are low
  - Emigrants from i do not choose the same destination
  - Many corridors are empty (60%)
  - Mig flows are bidirectional (from i to j, and from j to i)

Preamble

Looking at migration matrices (200x200):

- Characteristics of dyadic migration flows:
  - Emig rates vary with gender, educ, country size, development
  - With some exceptions, emig rates are low
  - Emigrants from i do not choose the same destination
  - Many corridors are empty (60%)
  - Mig flows are bidirectional (from i to j, and from j to i)
- **Is there a theory compatible with these facts?**
  - Yes: the Random Utility Model (RUM)

RUM basics

M_i heterogeneous agents in age to migrate from country i

- Individual λ from country i. Staying at home:

$$U_{ii}^{\lambda} = V_{ii} + \varepsilon_{ii}^{\lambda}, \quad \text{where}$$

  - Observable and unobservable determinants
  - V_{ii} = deterministic level of utility in i (wages, amenities, etc.)
  - $\varepsilon_{ii}^{\lambda}$ = random component (heterog. preferences/matching)

RUM basics

M_i heterogeneous agents in age to migrate from country i

- Individual λ from country i. Staying at home:

$$U_{ii}^{\lambda} = V_{ii} + \varepsilon_{ii}^{\lambda}, \quad \text{where}$$

  - Observable and unobservable determinants
  - V_{ii} = deterministic level of utility in i (wages, amenities, etc.)
  - $\varepsilon_{ii}^{\lambda}$ = random component (heterog. preferences/matching)

- **If the same individual λ emigrate to j $= 1 \ldots J$:**

$$U_{ij}^{\lambda} = V_{ij} + \varepsilon_{ij}^{\lambda}, \quad \text{where}$$

  - V_{ij} = deterministic level of utility country j (net of mig. costs)

RUM basics

Discrete choice of location (max utility)

- If $\varepsilon_{ik}^{\lambda} \rightsquigarrow$extreme-value distribution (McFadden, 1974)
  - Mean = 0; assume scale = 1
  - Probability to emigrate follows a logit expression:

$$\Pr[U_{ij} = \max_k U_{ik}] = \frac{M_{ij}}{M_i} = \frac{\exp(V_{ij})}{\sum_k \exp(V_{ik})}$$

RUM basics

Discrete choice of location (max utility)

- If $\varepsilon_{ik}^{\lambda}$ $\rightsquigarrow$extreme-value distribution (McFadden, 1974)
  - Mean = 0; assume scale = 1
  - Probability to emigrate follows a logit expression:

$$\Pr[U_{ij} = \max_k U_{ik}] = \frac{M_{ij}}{M_i} = \frac{\exp(V_{ij})}{\sum_k \exp(V_{ik})}$$

- **Proportion of migrants from i to j in pop**
  - Depends on obs. characteristics of all possible destinations
  - E.g. Crisis in Spain (denominator decreases) increases emigration from Romania to Germany!

RUM basics

- However, dividing by the (optimal) proportion of stayers:

$$\frac{M_{ij}}{M_{ii}} = \frac{\exp(V_{ij})}{\exp(V_{ii})} = \exp\left(V_{ij} - V_{ij}\right) \equiv m_{ij}$$

- The "migrant-to-stayer" ratio is a relevant variable of interest:
  - The ratio only depends on charact. of i and j (IIA)
  - E.g. a crisis in Spain proportionately increases the number of stayers in Romania and the number of emigrants to Germany

RUM basics

Need to specify a utility function:

- Grogger-Hanson: $V_{ij} = \alpha (w_j - C_{ij})$ with $C_{ii} = 0$

$$\ln \frac{M_{ij}}{M_{ii}} = \alpha (w_j - w_i) - C_{ij}$$

- Bertoli et al.: $V_{ij} = \alpha \ln w_j + \ln(1 - c_{ij})$ with $c_{ii} = 0$

$$\ln \frac{M_{ij}}{M_{ii}} = \alpha \ln \frac{w_j}{w_i} + \ln(1 - c_{ij})$$

- C_{ij} or c_{ij} depends on distance, network, income, visa cost, etc.

RUM in empirical studies

- RUM in logs: $\ln \frac{M_{ij}}{M_{ii}} = V_{ij} - V_{ii}$
- Micro-foundation of a gravity model of migration
  - Role of discounted present value of inc. $w_j = \frac{\text{annual wage}_j}{r}$
- Log or linear specification?
  - GH: $\ln \frac{M_{ij}}{M_{ii}} = \alpha(w_j - w_i) + \delta \ln D_{ij} + F_i + F_j + u_{ij}$
    - If all wages increase by $x\%$, $\frac{M_{ij}}{M_{ii}}$ increases (problem)
  - BB: $\ln \frac{M_{ij}}{M_{ii}} = \alpha \ln \frac{w_j}{w_i} + \delta \ln D_{ij} + F_i + F_j + u_{ij}$
    - If all wages increase by $x\%$, $\frac{M_{ij}}{M_{ii}}$ is cst (better w. panel data)

RUM in simulation studies

- Calibrate C_{ij} or c_{ij} + Simulate effects of Δw or Δc
- Equilibrium approach (allocation of M_{ii} across J destinations)
  - Migration-to-stayer ratios (system of $J-1$ eqs.):

$$m_{ij} = \frac{M_{ij}}{M_{ii}} = \exp\left(V_{ij} - V_{ij}\right) \quad (J-1 \text{ eqs } \forall j \neq i)$$

  - Aggregation constraint (J^{th} eq.):

$$M_{ii} + \sum_{j \neq i} M_{ij} = M_{ii}\left(1 + \sum_{j \neq i} m_{ij}\right) = M_i$$

- In general equilibrium: V_{ij} is endogenous

Consistency with stylized facts: Reduced form vs. structural form

Fact #1: correlation with country size

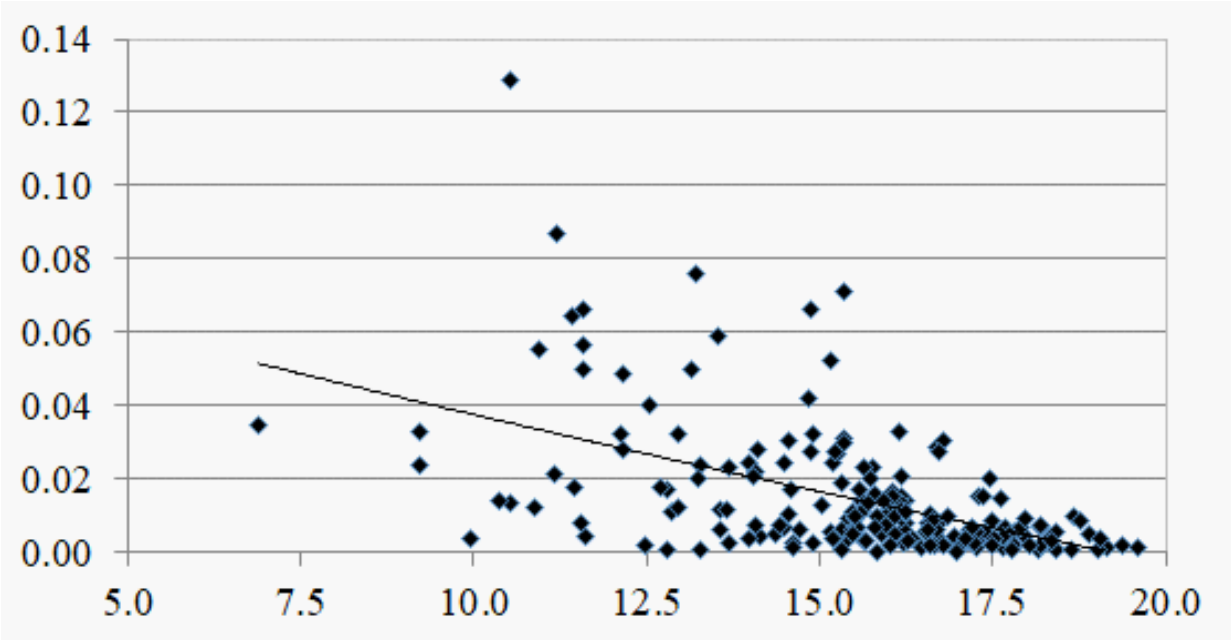
Fact #2: Positive selection

Fact #3: Positive sorting

Fact #4: Mobility transition curve

Fact #1: correlation with country size

Emig rate and log of pop at origin in 2010



Decreasing relationship between emig rate and country size (log)!

Fact #1: correlation with country size

Emigration stocks and rates (to OECD destinations)

(Data by education level and for the years 1990, 2000 and 2010)

	Rate low-skill (As %)			Rate high-skill (As %)		
Year	1990	2000	2010	1990	2000	2010
World	1.3	1.5	1.7	5.2	4.7	5.1
By country size						
High-pop (>25M)	0.9	1.1	1.2	4.0	3.8	4.2
Upper-mid (>10M)	2.9	3.6	4.3	10.2	8.8	9.4
Lower-mid (>2.5M)	4.7	5.5	6.2	12.1	10.5	10.4
Low-pop (<2.5M)	8.0	9.3	9.9	28.2	24.5	22.1

Country size

- Emigration rate decreases with country size: are people more migratory in small countries? No reason to think so!
- Disparities in emigration rates are due to differences in internal migration opportunities
  - Large countries include more (diversified) regions
  - More opportunities to self-select on unobervables internally
  - Internal mig. costs are smaller than international mig. costs

Country size

- How to formalize internal mig opportunities?
  - Consider the log-linear migration model
  - Individuals have possibility to migrate internally to $1 + R$ regions
  - For simplicity, regions share the same observables (same wage rates, same size, etc.)
  - Actual international and internal mig costs $= \widehat{c}_{ij}$ and $\widehat{c}_{ii}$

Country size

- In the standard RUM:

$$\frac{M_{ij}}{M_i} = \frac{w_j^{\alpha}(1 - c_{ij})}{w_i^{\alpha} + \sum_{k \neq i} w_k^{\alpha}(1 - c_{ik})}$$

- Extended RUM with internal mig. opportunities:

$$\frac{M_{i(r)j}}{M_{i(r)}} = \frac{w_j^{\alpha}(1 - \widehat{c}_{ij})}{w_i^{\alpha} + Rw_i^{\alpha}(1 - \widehat{c}_{ii}) + \sum_{k \neq i} w_k^{\alpha}(1 - \widehat{c}_{ik})} = \frac{M_{ij}}{M_i}$$

Country size

- Extended RUM can be rewritten as:

$$\frac{M_{ij}}{M_i} = \frac{w_j^{\alpha}\left(\frac{1-\widehat{c}_{ij}}{1+R(1-\widehat{c}_{ii})}\right)}{w_i^{\alpha} + \sum_{k\neq i} w_k^{\alpha}\left(\frac{1-\widehat{c}_{ik}}{1+R(1-\widehat{c}_{ii})}\right)}$$

- Calibration with dyadic data: we estimate "net" international migration costs $(1 - c_{ij})$

Country size

With dyadic data...

- Extended RUM equivalent to "reduced form" with

$$1 - c_{ij} = \frac{1 - \widehat{c}_{ij}}{1 + R(1 - \widehat{c}_{ii})}$$

- Country size should not affect actual mig. costs ($\widehat{c}_{ij}$), but calibrated mig. costs are net of internal mig opportunities
- This implies that $1 - c_{ij}$ depends on country size

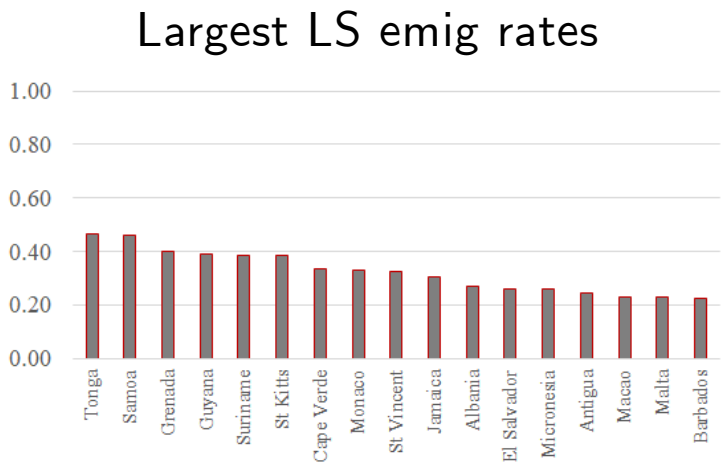
Fact #2: correlation with education

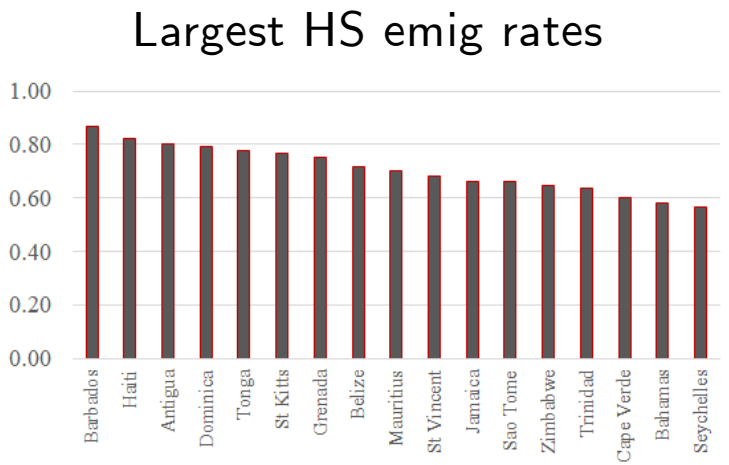
Emigration stocks and rates (to OECD destinations)

(Data by education level and for the years 1990, 2000 and 2010)

	Rate low-skill (As %)			Rate high-skill (As %)		
Year	1990	2000	2010	1990	2000	2010
World	1.3	1.5	1.7	5.2	4.7	5.1
By income group						
High-income	2.7	3.0	3.0	3.9	3.3	3.7
Upper-middle	0.9	1.3	1.6	6.4	5.5	5.1
Lower-middle	0.9	1.1	1.3	8.5	8.4	8.1
Low-income	0.5	0.8	1.1	16.5	16.2	18.0

Fact #2: correlation with education





How to explain positive selection?

- Two types of natives: low-sk and high-sk ($s = l, h$)
- Native pop & emigration rates: M_i^s, m_{ij}^s and $\overline{m}_i^s$
- Selection: who migrates more?
  - Positive selection: $\overline{m}_i^h > \overline{m}_i^l$ and $m_{ij}^h > m_{ij}^l$
  - Equivalently: $\ln \frac{M_{ij}^h}{M_{ii}^h} > \ln \frac{M_{ij}^l}{M_{ii}^l}$

How to explain positive selection?

- South-North migration example:
  - Poor ctry: $w_i^l = 7.5$, $w_i^h = 30$, $\%h = 0.05$, $\overline{w}_i \simeq 9$
  - Rich ctry: $w_j^l = 75$, $w_j^h = 150$, $\%h = 0.33$, $\overline{w}_i \simeq 100$
- When does $\ln \frac{M_{ij}^h}{M_{ii}^h} > \ln \frac{M_{ij}^l}{M_{ii}^l}$ hold?

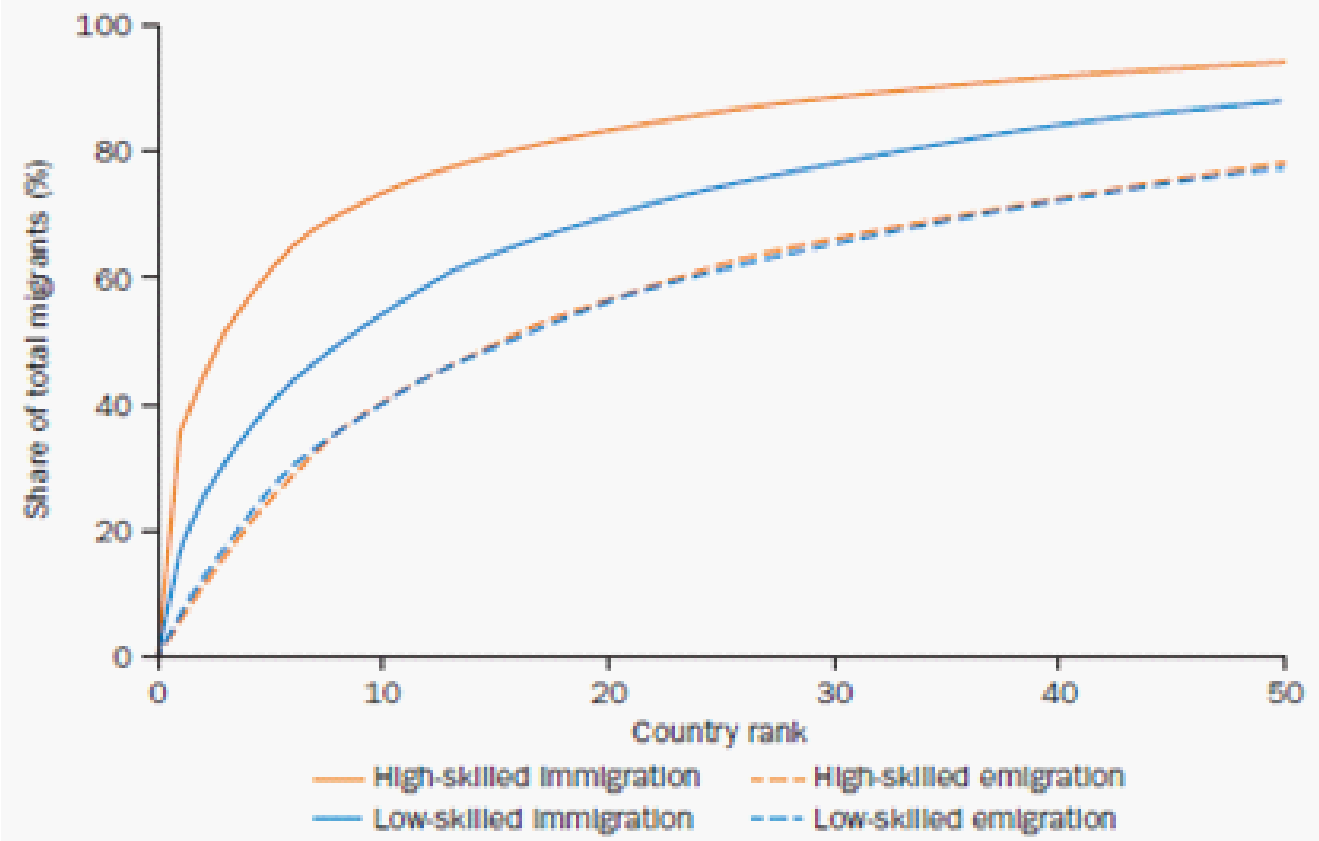
How to explain positive selection?

- South-North migration example:
  - Poor ctry: $w_i^l = 7.5$, $w_i^h = 30$, $\%h = 0.05$, $\overline{w}_i \simeq 9$
  - Rich ctry: $w_j^l = 75$, $w_j^h = 150$, $\%h = 0.33$, $\overline{w}_i \simeq 100$
- Linear utility: $\alpha(w_j^h - w_i^h) - C_{ij}^h > \alpha(w_j^l - w_i^l) - C_{ij}^l$
  - In our example: $120\alpha - C_{ij}^h > 67.5\alpha - C_{ij}^l$
  - Positive selection due to absolute wage gaps (+ mig. costs)
  - Reminder: problem when confronted to balanced growth
  - If income gaps explain everything, no selection btw rich countries

How to explain positive selection?

- South-North migration example:
  - Poor ctry: $w_i^l = 7.5$, $w_i^h = 30$, $\%h = 0.05$, $\overline{w}_i \simeq 9$
  - Rich ctry: $w_j^l = 75$, $w_j^h = 150$, $\%h = 0.33$, $\overline{w}_i \simeq 100$
- Log utility: $\left(\frac{w_j^h}{w_i^h}\right)^{\alpha}(1-c_{ij}^h) > \left(\frac{w_j^l}{w_i^l}\right)^{\alpha}(1-c_{ij}^l)$
  - In our example: $5^{\alpha}(1-c_{ij}^h) > 10^{\alpha}(1-c_{ij}^l)$
  - Positive selection must be due to Δ mig. costs ($c_{ij}^l > c_{ij}^h$)
  - Importance of mig cost differential !!!

Fact #3: location choices



High-skilled migrants agglomerate more into richest destinations

How to explain positive sorting?

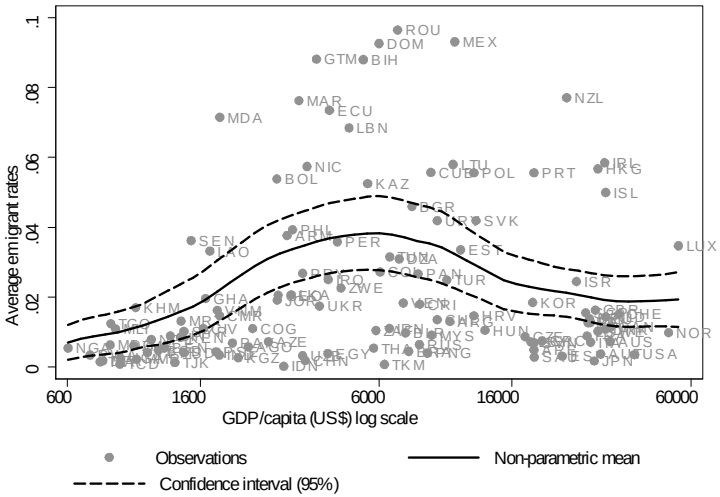
- Sorting: where do migrants go?
  - Average immig rate in the South: 2%
  - Average immig rate in high-income countries: 11%
- Sorting: if $w_j^s > w_k^s \Rightarrow m_{ij}^s > m_{ik}^s$, ceteris paribus

How to explain positive sorting?

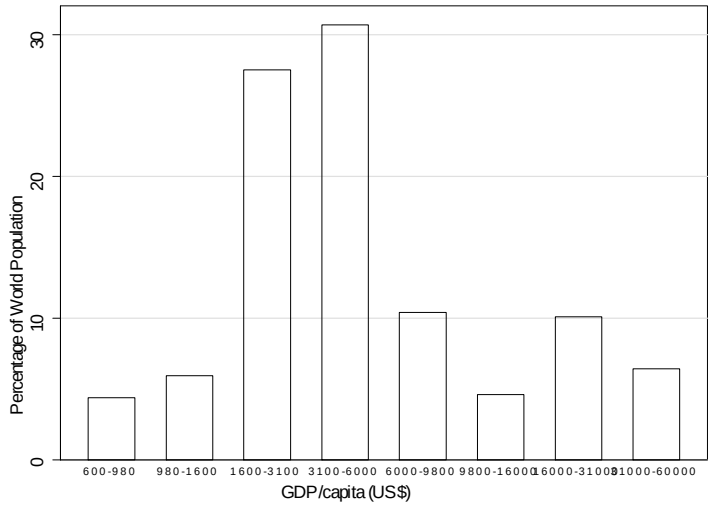
- Positive sorting: concentration increases with education
- **Non-linear model** $\frac{M_{ij}^s}{M_{ii}^s} = \left(\frac{w_j^s}{w_i^s}\right)^{\alpha} (1 - c_{ij}^s)$
  - Attractive ctry: high wage + low mig cost (complem.)
  - Effect of wage ratio is proportional to $(1 - c_{ij}^s)$
  - Sorting is greater among high-skilled migrants ($c_{ij}^l > c_{ij}^h$)
  - Importance of mig cost differential !!!

Fact #4: correlation with development

Emig rates and income pc



Pop density by income level



Dispersion due to country size, geographic distance, etc.

Influence of skill composition and liquidity constraints???

Mobility transition curve

- Standard RUM: emigration decreases with income (w_i)
- In practice, emigration first increases with economic development, before decreasing
  - Cross-sectional regularity!
  - Return point = \$6,000
  - About 2/3 of world population below \$6,000 in 2010
  - Traditional explanation: development relaxes liquidity constraints
- Traditional explanation: financial constraints?

Mobility transition: theory

- How to formalize financial constraints?
- Start from log-linear model with a pre-migration period

$$V_{ii}^{s} = \underbrace{[\alpha \ln w_i^s]}_{1st \text{ period}} + \underbrace{[\alpha \ln w_i^s]}_{2nd \text{ period}}$$

Mobility transition: theory

- How to formalize financial constraints?
- Start from log-linear model with a pre-migration period

$$V_{ii}^s = \underbrace{[\alpha \ln w_i^s]}_{1st \text{ period}} + \underbrace{[\alpha \ln w_i^s]}_{2nd \text{ period}}$$

- **And account for pre-migration costs (monetary):**

$$\begin{aligned} V_{ij}^s &= \alpha \ln \left(w_i^s - \widehat{C}_{ij}^s \right) + \alpha \ln w_j^s + \ln(1 - \widehat{c}_{ij}^s) \\ &= \alpha \ln w_i^s + \alpha \ln(1 - \frac{\widehat{C}_{ij}^s}{w_i^s}) + \alpha \ln w_j^s + \ln(1 - \widehat{c}_{ij}^s) \end{aligned}$$

Mobility transition: theory

- The optimal "migrant-to-stayer" ratio becomes

$$\frac{M_{ij}^s}{M_{ii}^s} = \exp\left(V_{ij}^s - V_{ij}^s\right) = \left(\frac{w_j^s}{w_i^s}\right)^{\alpha} \left(1 - \frac{\widehat{C}_{ij}^s}{w_i^s}\right)^{\alpha} \left(1 - \widehat{c}_{ij}^s\right)$$

- With reduced form, we calibrate

$$\left(1 - c_{ij}^s\right) = \left(1 - \frac{\widehat{C}_{ij}^s}{w_i^s}\right)^{\alpha} \left(1 - \widehat{c}_{ij}^s\right)$$

- Again, mig costs should be treated as endogenous!!!

Backcasts

Predictive power of the RUM?

- Calibrated RUM model helpful to understand past mig?
  - Backcast expriments
- Is it helpful to predict the future?
  - Forecast expriments
  - Later: predictions under various climate change scenarios

Backcasts

Backcast experiments:

- Non linear RUM by educ level:

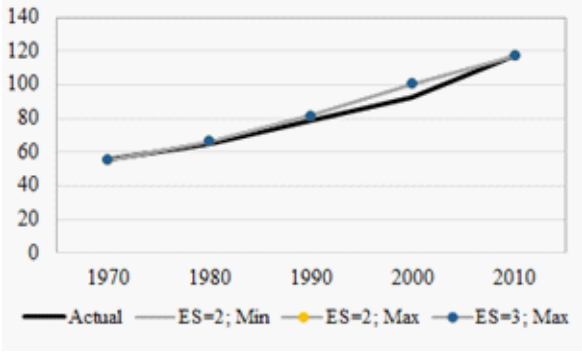
$$\frac{M_{ij}^s}{M_{ii}^s} = \left(\frac{w_j^s}{w_i^s}\right)^{\alpha} (1 - c_{ij}^s) \quad \text{and } M_i^s = \sum_j M_{ij}^s$$

- Calibrate c_{ij}^s to fit the dyadic mig data for 2010 $\forall s$
- Plug past income estimates (w_i^s) and past socio-demographic data (M_i^s) into the model, and assume constant c_{ij}^s
- Predict M_{ij}^s, and compute total dyadic stocks, $M_{ij}^h + M_{ij}^l$
- Compare this sum with census data (no educ breakdown)!

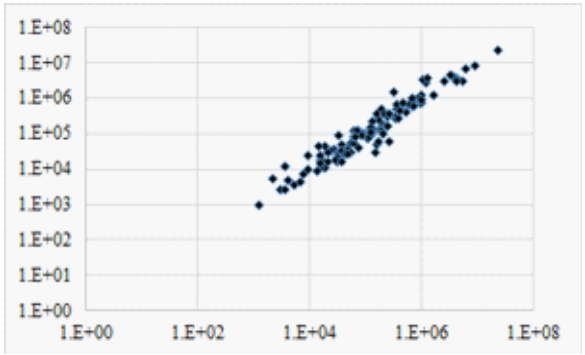
Backcasts

Backcasts with similar model (calibrated on the year 2010)

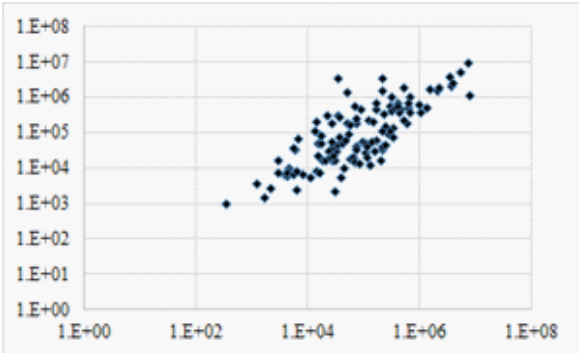
(a) World mig stock, 1970-2000



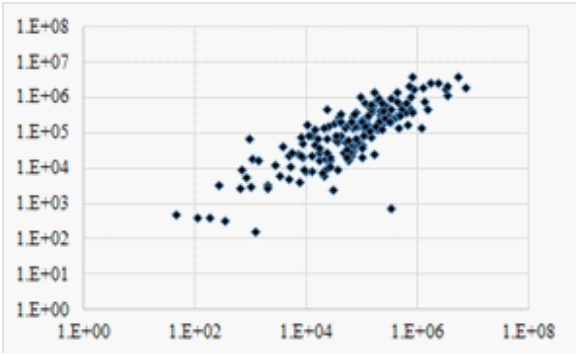
(b) Immig stocks by dest in 2000



(c) Immig stocks by dest in 1970



(d) Emig stocks by orig in 1970



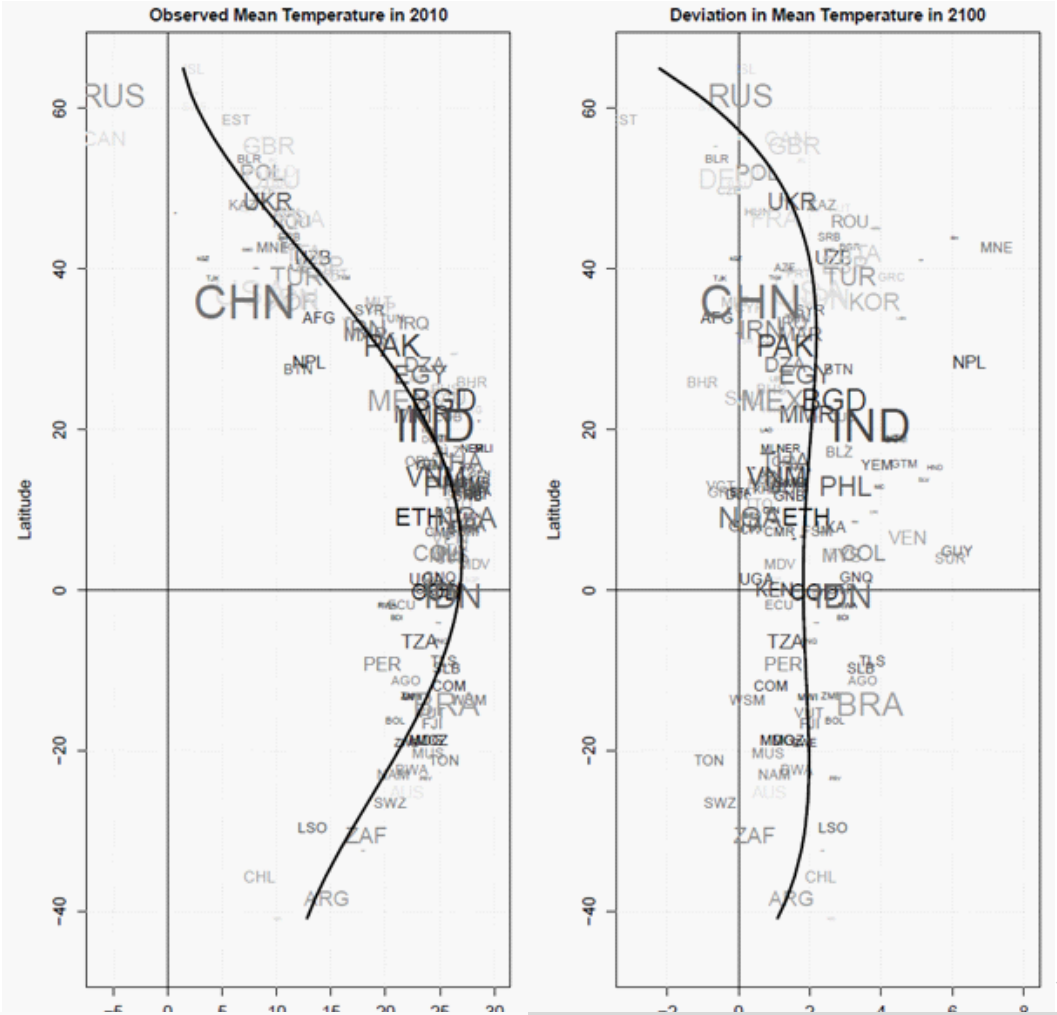
II. Climate damage functions

Intermediate scenarios

How will climate change affect inequality?

- Start from **Intermediate Scenario** ($+2.09°C$ and $+1.1m$)
  - Start from (pop-weighted) temp in 2010 (Dell et al. 2012)
  - ΔTemp: median emissions (RCP4.5) + median temp
  - LR variations in mean temperature do not vary with latitude

Intermediate scenario - Average temp



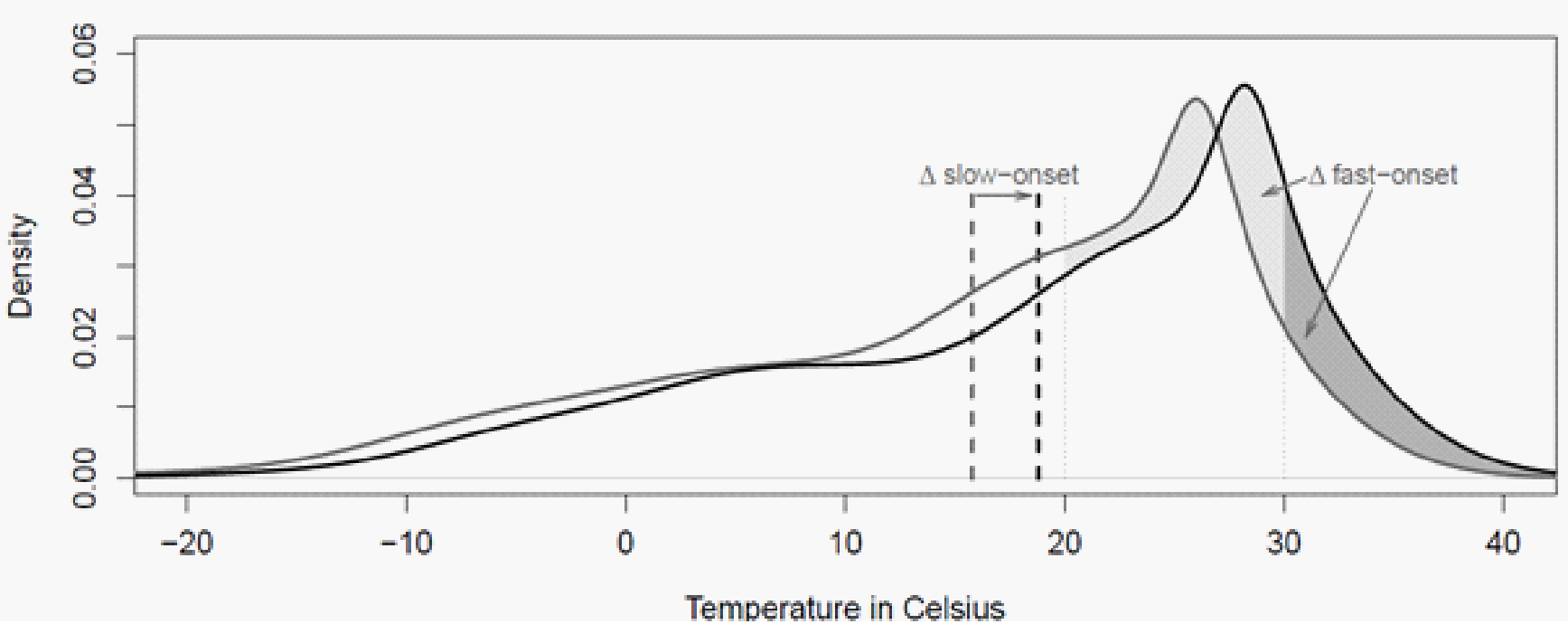
Intermediate scenarios

How will climate change affect inequality?

- Start from **Intermediate Scenario** ($+2.09°C$ and $+1.1m$)
  - Start from (pop-weighted) temp in 2010 (Dell et al. 2012)
  - ΔTemp: median emissions (RCP4.5) + median temp
  - LR variations in mean temperature do not vary with latitude
  - And variation in the distribution of temperature

Intermediate scenario - Heat waves

CLC also involves more frequent heat waves (world average)



Frequency of days >20 or 30° C (computed for each country & for each period)

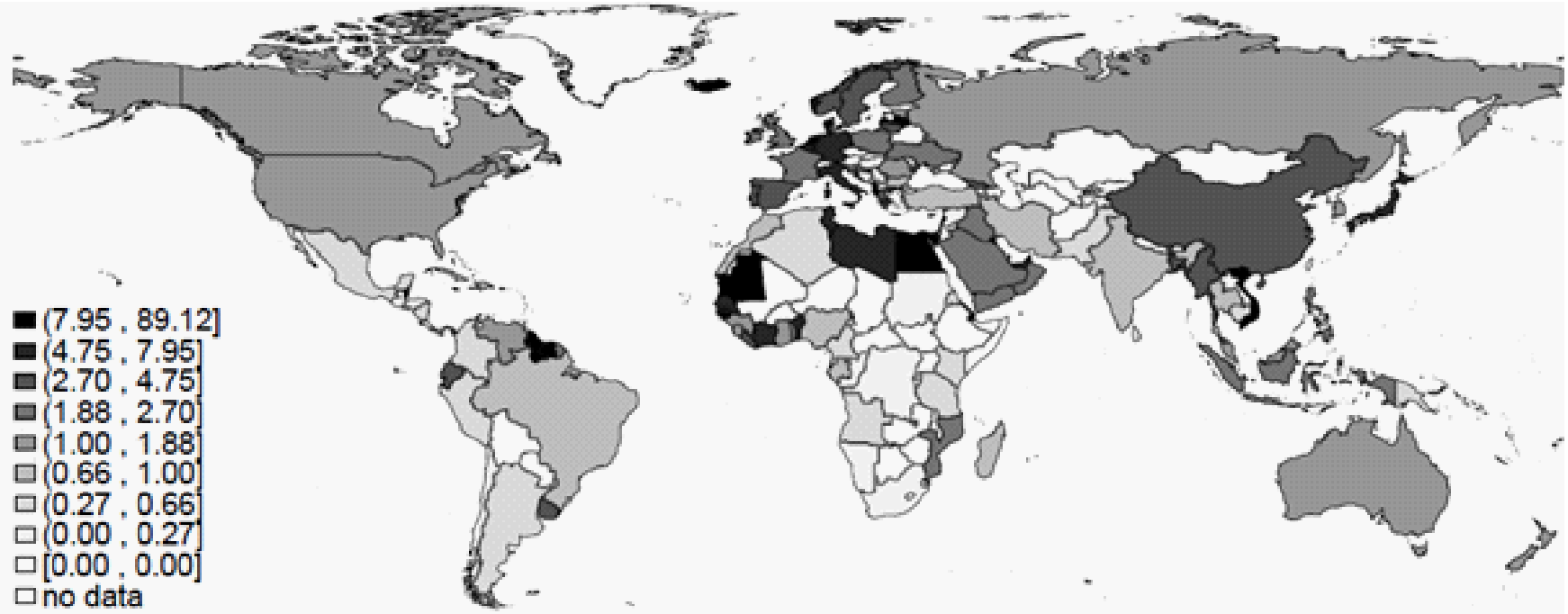
Intermediate scenarios

How will climate change affect inequality?

- Start from **Intermediate Scenario** ($+2.09°C$ and $+1.1m$)
  - Start from (pop-weighted) temp in 2010 (Dell et al. 2012)
  - ΔTemp: median emissions (RCP4.5) + median temp
  - LR variations in mean temperature do not vary with latitude
  - And variation in the distribution of temperature
  - Vermeer-Rahmstorf (2009), DeConto-Pollard (2016): $+1.1m$

Intermediate scenario - Sea level rise

Share of population below 1.1m in 2010



On transition: we link CCPK climatological windows to 2040, 2070, 2100

CLC scenarios

How will climate change affect inequality?

- Start from **Intermediate Scenario** ($+2.09°C$ and $+1.1m$)
- Alternative **Maximalist** scenario ($+4.09°C$ and $+1.3m$)
- And **Minimalist** scenario ($+0°C$ and $+0m$)
  - Likely unattainable (non-CLC reference)

$\Rightarrow$ **What are the damages caused by climarte change?**

Mean temperature and TFP

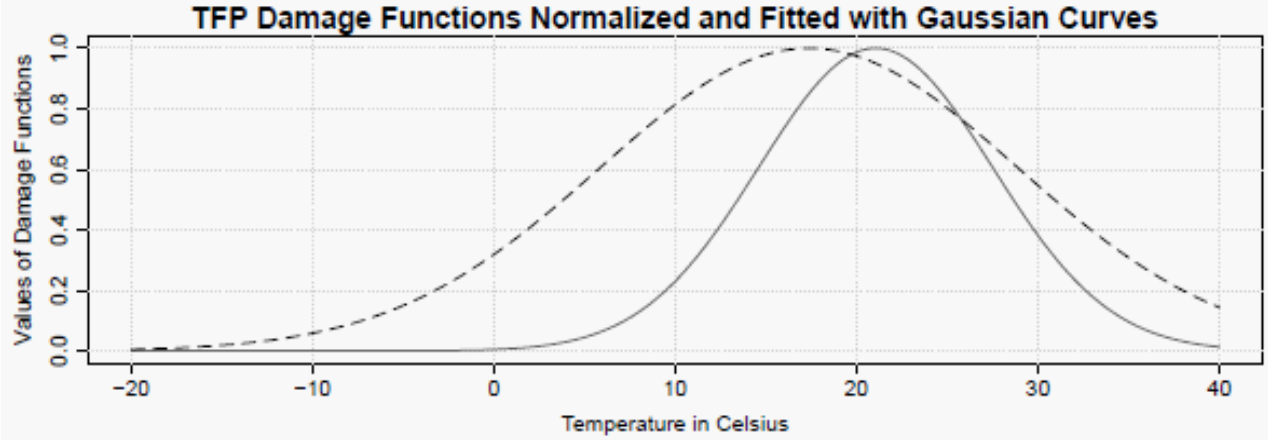
- Temperature and productivity
  - As in DRH (2015) & Shayegh (2017):

$$G_t^{jr} = G^r(T_t^{jr}) = \max\left\{g_0^r + g_1^r T + g_1^r T^2; 0\right\}$$

  - Agr: agronomic studies, envelope of crop-specific relationships
  - Nonagr: relationship between pop density & temp by latitude

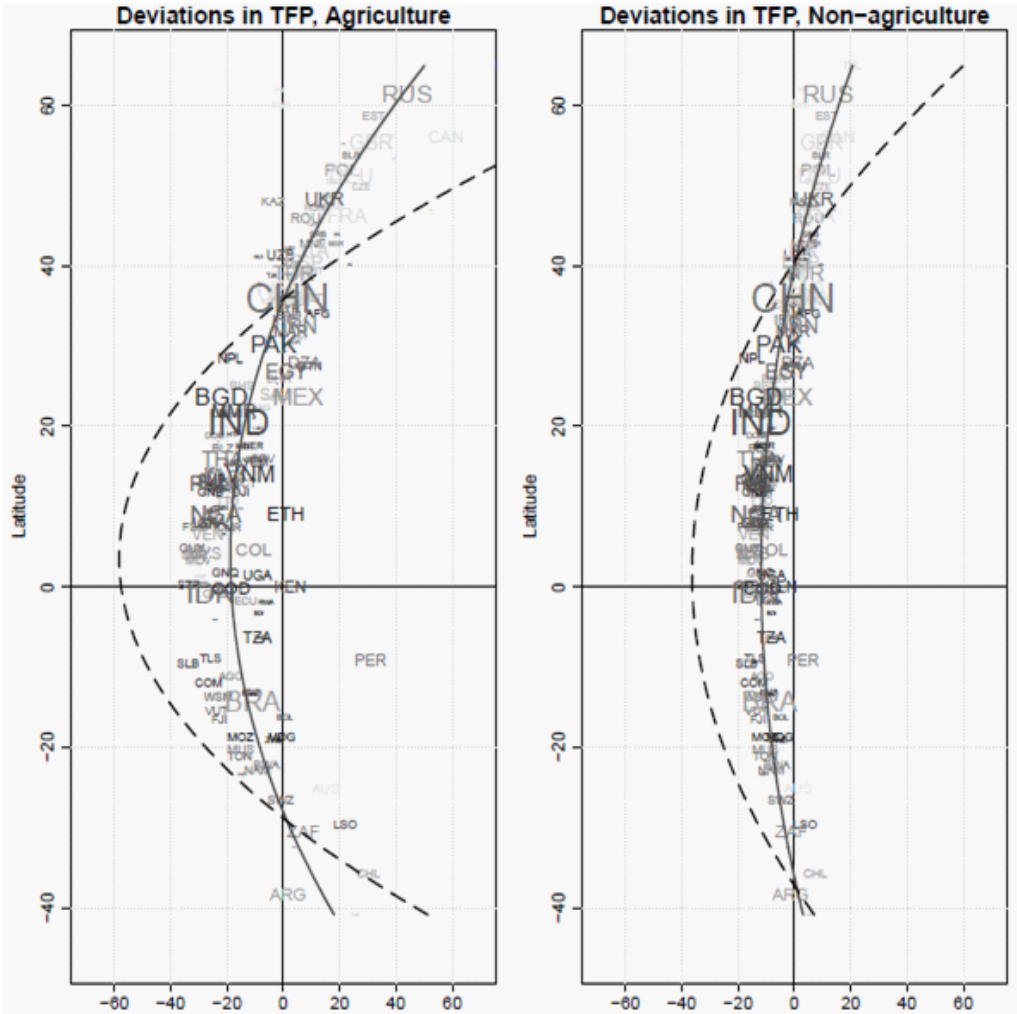
Mean temperature and TFP

Effect of temperature on TFP



Plugging future mean temperature levels into these functions gives...

Mean temperature and TFP



Mean temperature and TFP

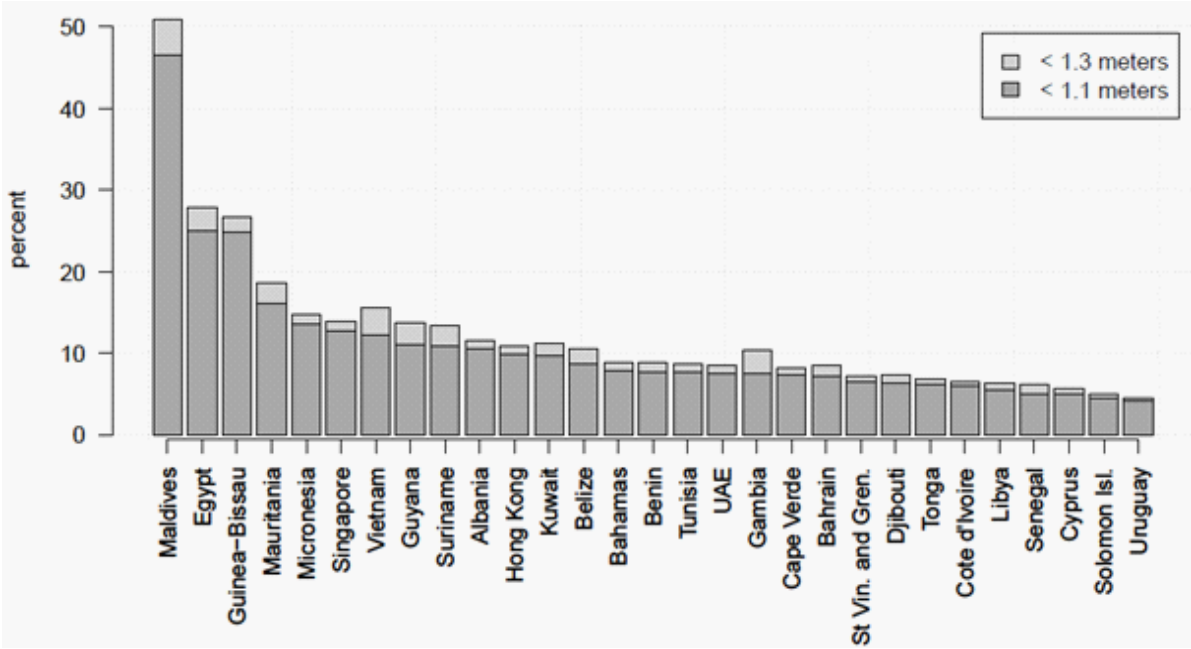
- Temperature and productivity
  - As in DRH (2015) & Shayegh (2017):

$$G_t^{jr} = G^r(T_t^{jr}) = \max\left\{g_0^r + g_1^r T + g_1^r T^2; 0\right\}$$

  - Agr: agronomic studies, envelope of crop-specific relationships
  - Nonagr: relationship between pop density & temp by latitude
- And rising level leads to forced displacements
  - In non-OECD countries only

SLR and forced displacements

Prop. of forcibly displaced persons



Forced displacements in non-OECD countries only

More questionable

- **Fast-onset mechanisms**
  - Natural disasters: % inc. loss is a function of mean T (EM-DAT)
  - Health costs above 30° C: % inc. loss as in the US
  - Productivity above 20° C: % prod. loss as in Dell et al. (2014)

More questionable

- **Fast-onset mechanisms**
  - Natural disasters: % inc. loss is a function of mean T (EM-DAT)
  - Health costs above 30° C: % inc. loss as in the US
  - Productivity above 20° C: % prod. loss as in Dell et al. (2014)
- **Permanent conflict from 2040 onwards**
  - In 7 Western Asian countries (Abel et al. 2019)
  - In 10 countries with highest levels of poverty
  - Conflict = decrease in net emigration costs doubling LR emig stocks ceteris paribus (at given wage rates)

III. Putting everything together

Aim and scope

- Objectives
  - Estimate the mobility responses to long-term climate change (CLC) over 21st century and under current migration laws and policies
- **Micro-founded model of the world economy**
  - Tools from migration literature:
    - RUM to model mobility decisions (stay, local, urban, long dist)
    - Embedded into a general equilibrium framework
    - With optimized deterministic component (cons, fertility, educ)
    - Calibrated to match current/past mobility data
  - Account for direct/indirect effects of CLC, for dynamic aspects

Aim and scope

- World economy with 145 developing countries and 34 OECD
  - Two age groups: adults (decision makers) and children
  - Two skill groups (s=h,l): college grads & less educated
  - Two regions/sectors (r=a,n): agr and nonagr (same good!!!)
  - Two areas (b=f,d): flooded and unflooded

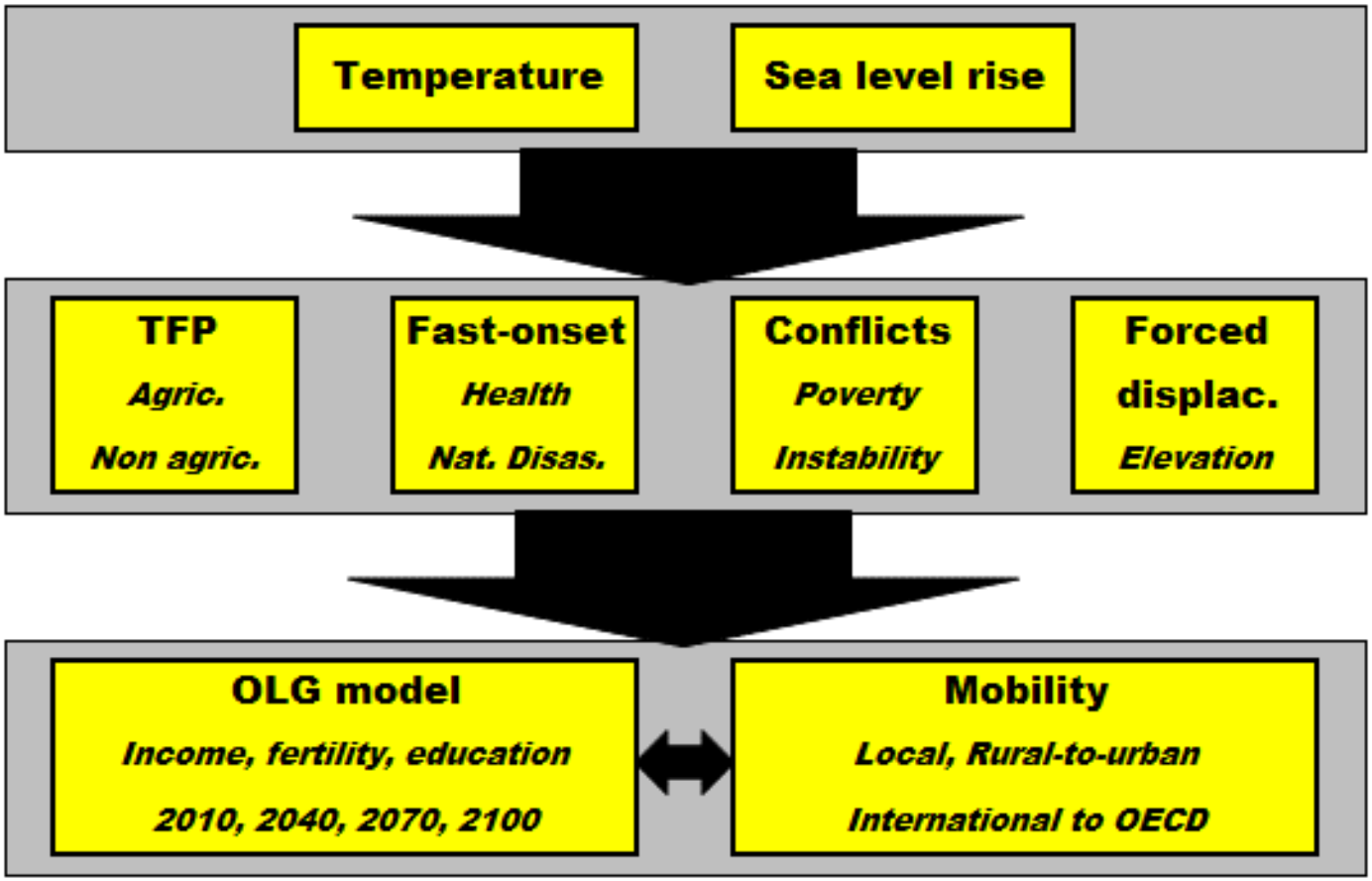
Aim and scope

- World economy with 145 developing countries & 34 OECD (j)
  - Two age groups: adults (decision makers) and children
  - Two skill groups (s=h,l): college grads & less educated
  - Two regions/sectors (r=a,n): agr and nonagr (same good!!!)
  - Two areas (b=f,d): flooded and unflooded
- **The model endogenizes:**
  - Mobility: local (very short-dist), rural-urban (short-dist), to non-OECD (med-dist), to OECD (long-dist)
  - Self-selection of migrants
  - Population dynamics: net migration, fertility and education
  - World distribution of income, hum cap, TFP and poverty

Aim and scope

- Simplifying assumption
  - Exogenous CLC scenarios and damages
  - Plug these damage functions into an OLG model
- Limitations
  - No underlying mitigation costs (e.g. optimistic CLC scenarios involves costly green-technology investments)
  - No feedback effects (e.g. urbanization/mig responses $\Rightarrow$ CLC)

Aim and scope



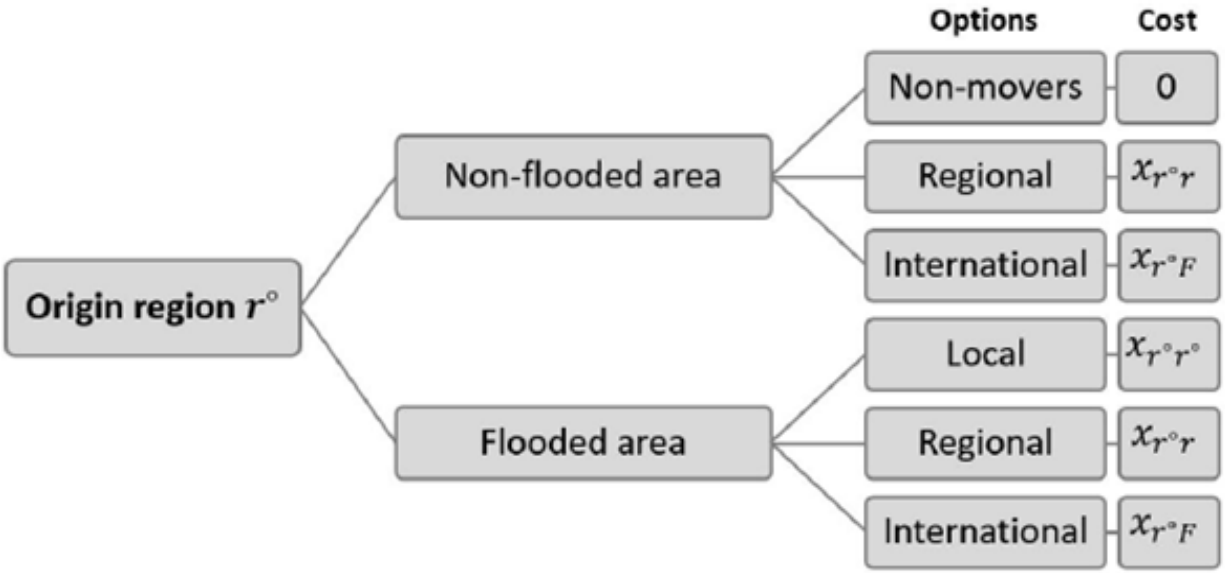
Technology

Output is feasible in unflooded areas only:

- CES technology: $Y_t^{jr} = A_t^{jr} \left(\frac{\eta_t^{jr}}{1+\eta_t^{jr}} L_{ht}^{jr\,\frac{\sigma_r-1}{\sigma_r}} + \frac{1}{1+\eta_t^{jr}} L_{lt}^{jr\,\frac{\sigma_r-1}{\sigma_r}} \right)^{\frac{\sigma_r}{\sigma_r-1}}$
  - With $s = (h, l)$ = College grads vs. Less educated
  - And $r = (a, n)$ = Agr vs. Nonagr; j = country
- Technological externalities:
  - Aggregate: $A_t^{jr} = \gamma^t \overline{A}^{jr} G_t^{jr} \left(\frac{L_{ht}^{jr}}{L_{lt}^{jr}} \right)^{\epsilon_r}$
  - Skill-bias: $\eta_t^{jr} = \overline{\eta}^{jr} \left(\frac{L_{ht}^{jr}}{L_{lt}^{jr}} \right)^{\kappa_r}$
- These eqs. govern income and productivity disparities

Preferences

Two types of adult by region and by skill group



Preferences (voluntary migrants)

Adults born in unflooded areas: $N^{jr}_{d,s,t} = (1 - \Theta^{jr}_t) N^{jr}_{s,t}$

- Two-stage random utility model:
  - Outer utility function, $jr \longrightarrow j'r'$:

$$U^{jr,j'r'}_{d,s,t} = \ln v^{j'r'}_{s,t} + \ln(1 - x^{jr,j'r'}_{d,s,t}) + \zeta^{jr,j'r'}_{d,s,t}$$

  - with $x^{jr,jr}_{d,s,t} = 0$

Preferences (voluntary migrants)

Adults born in unflooded areas: $N^{jr}_{d,s,t} = (1 - \Theta^{jr}_t) N^{jr}_{s,t}$

- Two-stage random utility model:
  - Outer utility function, $jr \longrightarrow j'r'$:

$$U^{jr,j'r'}_{d,s,t} = \ln v^{j'r'}_{s,t} + \ln(1 - x^{jr,j'r'}_{d,s,t}) + \zeta^{jr,j'r'}_{d,s,t}$$

  - Inner utility function (warm glow):

$$\ln v^{j'r'}_{s,t} = \ln c^{j'r'}_{s,t} + \theta \ln \left(n^{j'r'}_{s,t} p^{j'r'}_{s,t} \right)$$

- Budget constraint: $c^{j'r'}_{s,t} = w^{j'r'}_{s,t} (1 - \phi n^{j'r'}_{s,t}) - n^{j'r'}_{s,t} q^{j'r'}_{s,t} E^{j'r'}_t$
- Training technology: $p^{j'r'}_{s,t} = \left(\pi^{j'r'} + q^{j'r'}_{s,t} \right)^{\lambda}$

Preferences (voluntary migrants)

- Education and fertility (interior):

$$\begin{cases} q_{s,t}^{jr} = \dfrac{\lambda\phi w_{s,t}^{jr} - \pi^{jr} E_t^{jr}}{(1-\lambda) E_t^{jr}} \\ n_{s,t}^{jr} = \dfrac{\theta(1-\lambda)}{1+\theta} \cdot \dfrac{w_{s,t}^{jr}}{\phi w_{s,t}^{jr} - \pi^{jr} E_t^{jr}} \end{cases} \quad \Rightarrow \quad v_{s,t}^{jr}(w_{s,t}^{jr}, E_t^{jr}; \pi^{jr})$$

- Migration when taste shocks $\zeta_{d,s,t}^{jr,j'r'}$ are EVD$(0,\mu)$:

$$m_{d,s,t}^{jr,j'r'} \equiv \frac{M_{d,s,t}^{jr,j'r'}}{M_{d,s,t}^{jr,jr}} = \left(\frac{v_{s,t}^{j'r'}}{v_{s,t}^{jr}}\right)^{1/\mu} (1 - x_{d,s,t}^{jr,j'r'})^{1/\mu}$$

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

Preferences (forcibly displaced people)

Adults raised in flooded areas: $N^{jr}_{f,s,t} = \Theta^{jr}_t N^{jr}_{s,t}$

- One difference: utility loss $x^{jr,jr}_{f,s,t} > 0$ of relocating within the region (no compensation):
- Decrease in local utility
- Different migration responses:

$$m^{jr,j'r'}_{f,s,t} \equiv \frac{M^{jr,j'r'}_{f,s,t}}{M^{jr,jr}_{f,s,t}} = \left(\frac{v^{j'r'}_{s,t}}{v^{jr}_{s,t}}\right)^{1/\mu} \left(\frac{1 - x^{jr,j'r'}_{f,s,t}}{1 - x^{jr,jr}_{f,s,t}}\right)^{1/\mu}$$

Rest of the model

- Access to education: $E_t^{jr} = \psi^{jr} w_{s,t}^{jr}$
- Pop & labor supply in unflooded area only

$$L_{s,t}^{jr} = \sum_{b,j',r'} \frac{m_{b,s,t}^{j'r',jr} N_{b,s,t}^{j'r'} (1 - \phi n_{s,t}^{jr})}{1 + m_{b,s,t}^{j'r',j'r} + m_{b,s,t}^{j'r',F}}$$

- Population dynamics (idem for $N_{r,l,t+1}$):

$$\begin{aligned} N_{h,t+1}^{jr} &= \sum_{s,b} L_{s,t}^{jr} n_{s,t}^{jr} p_{s,t}^{jr} \\ N_{l,t+1}^{jr} &= \sum_{s,b} L_{s,t}^{jr} n_{s,t}^{jr} (1 - p_{s,t}^{jr}) \end{aligned}$$

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 $\left\{\overline{A}^{jr}, \overline{\eta}^{jr}, x_{s,t}^{jr,j'r'}, \Theta_{r,t}, \pi^{jr}, \psi^{jr}\right\}$, and a set $\left\{N_{s,0}^{jr}\right\}$ of predetermined variables, an intertemporal equilibrium is a set of endogenous variables $\left\{A_t^{jr}, \eta_t^{jr}, w_{s,t}^{jr}, E_t^{jr}, L_{s,t}^{jr}, N_{b,s,t}^{jr}, n_{s,t}^{jr}, q_{s,t}^{jr}, v_{s,t}^{jr}, m_{b,s,t}^{j'r',jr}\right\}$ satisfying technological constraints, profit & utility max conditions, and population dynamics in all countries of the world.

Parameterization

Calibration for 145 developing + 34 OECD countries

- Perfectly match data in 2010 or 1980-2010 $\forall$ countries... and $\forall$ regions/sectors (Gallup)
  - VA, skill prem, pop, fertility, HC, dyadic mig stocks by skill level
  - Relocation cost=0.5 (Fiala 2015; Ibanez-Moya 2006; Kellenberg-Mobarak 2011)
- Quadratic (partial) convergence in access to education in the Intermediate scenario
  - Good fit UN socio-demographic projections for 2040

IV. Projections for 21st Century

World economy responses

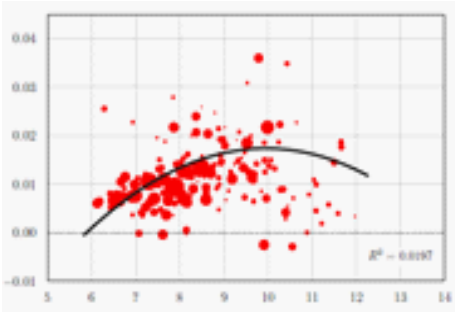
	Δ Intermediate			Δ Maximalist		
	2040	2070	2100	2040	2070	2100
Total GDP	+1.8%	+1.8%	+2.8%	+2.9%	+3.1%	+5.4%
Population	0.0%	-0.1%	-0.4%	0.0%	-0.3%	-0.9%
GDP per worker*	+1.8%	+1.9%	+3.2%	+2.9%	+3.4%	+6.3%
HS share	0.0pp	0.1pp	0.2pp	0.0pp	0.2pp	0.4pp
Urban share	0.3pp	0.6pp	0.8pp	0.7pp	1.4pp	2.0pp
Migrant share	0.1pp	0.2pp	0.2pp	0.3pp	0.4pp	0.5pp

* But welfare can be decreasing (costs of heat waves, migration costs)

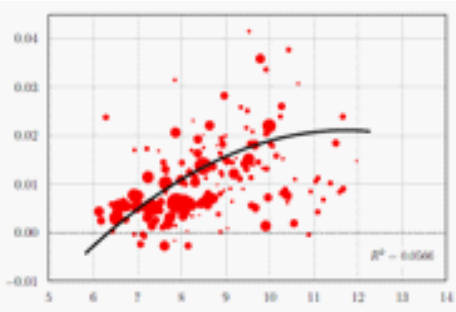
TFP convergence?

Beta-convergence by sector (2010-2100)

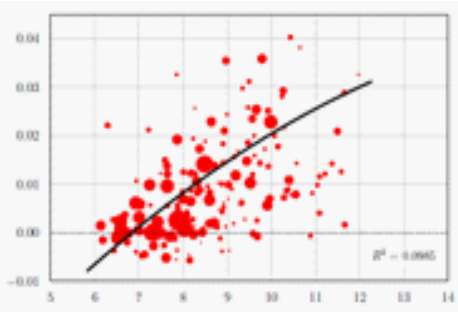
Agriculture – Minimalist



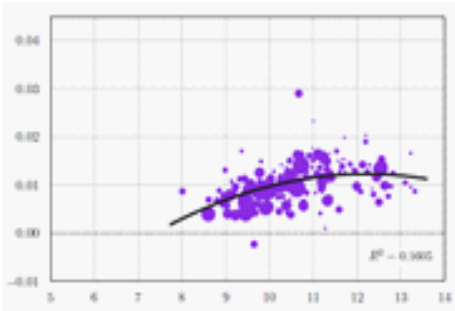
Agriculture – Intermediate



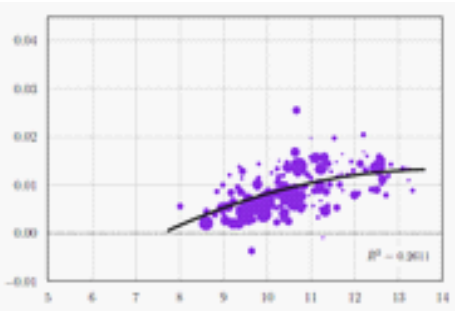
Agriculture – Maximalist



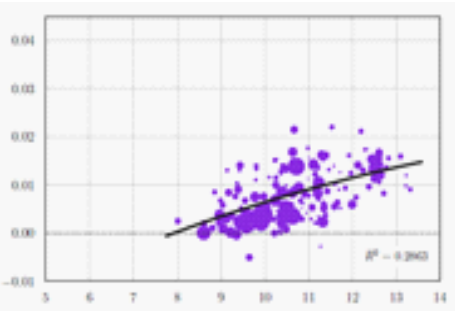
Nonagric – Minimalist



Nonagric – Intermediate



Nonagric – Maximalist



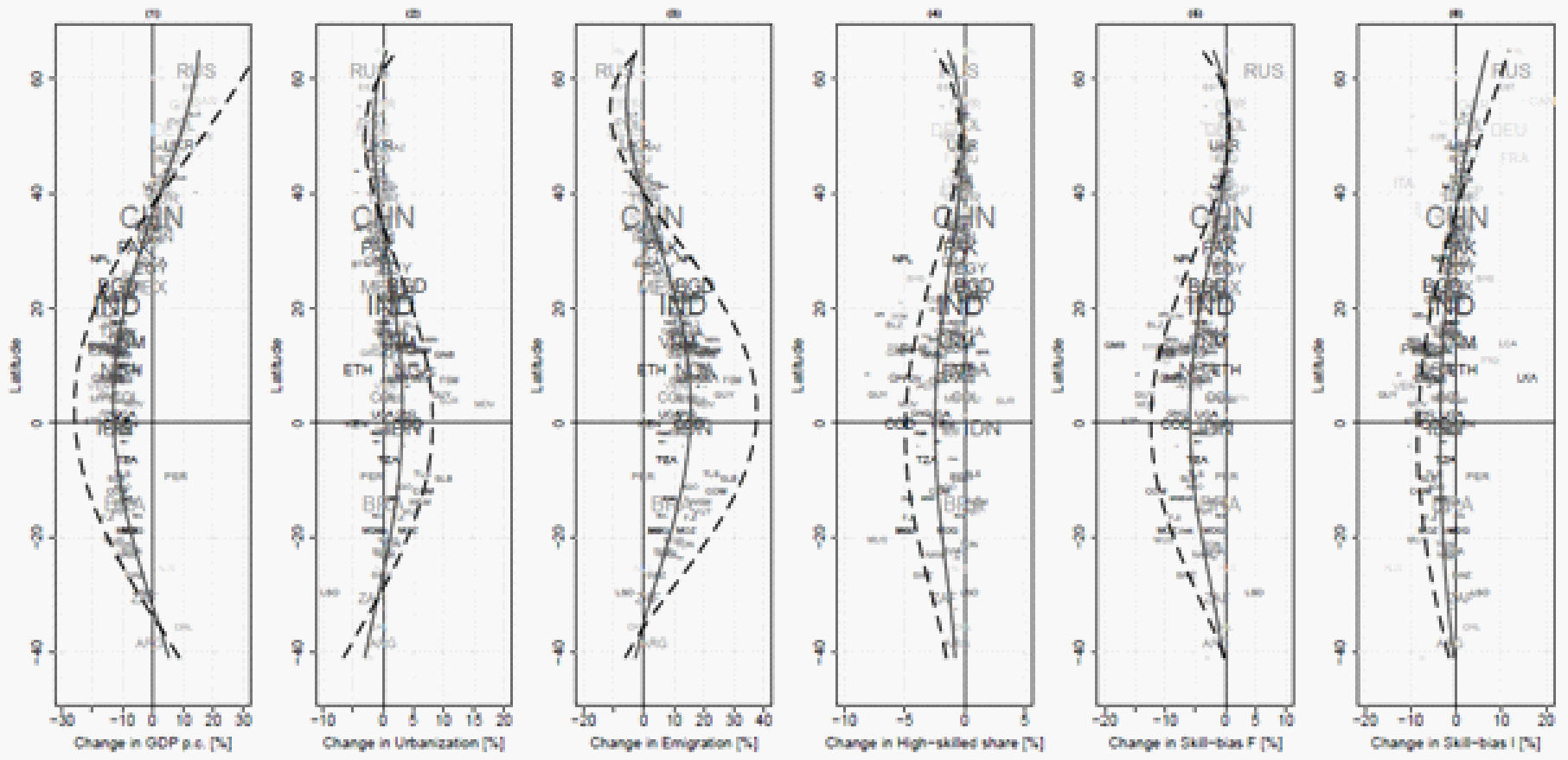
Country-specific responses

Country-specific effect (year 2100) on...

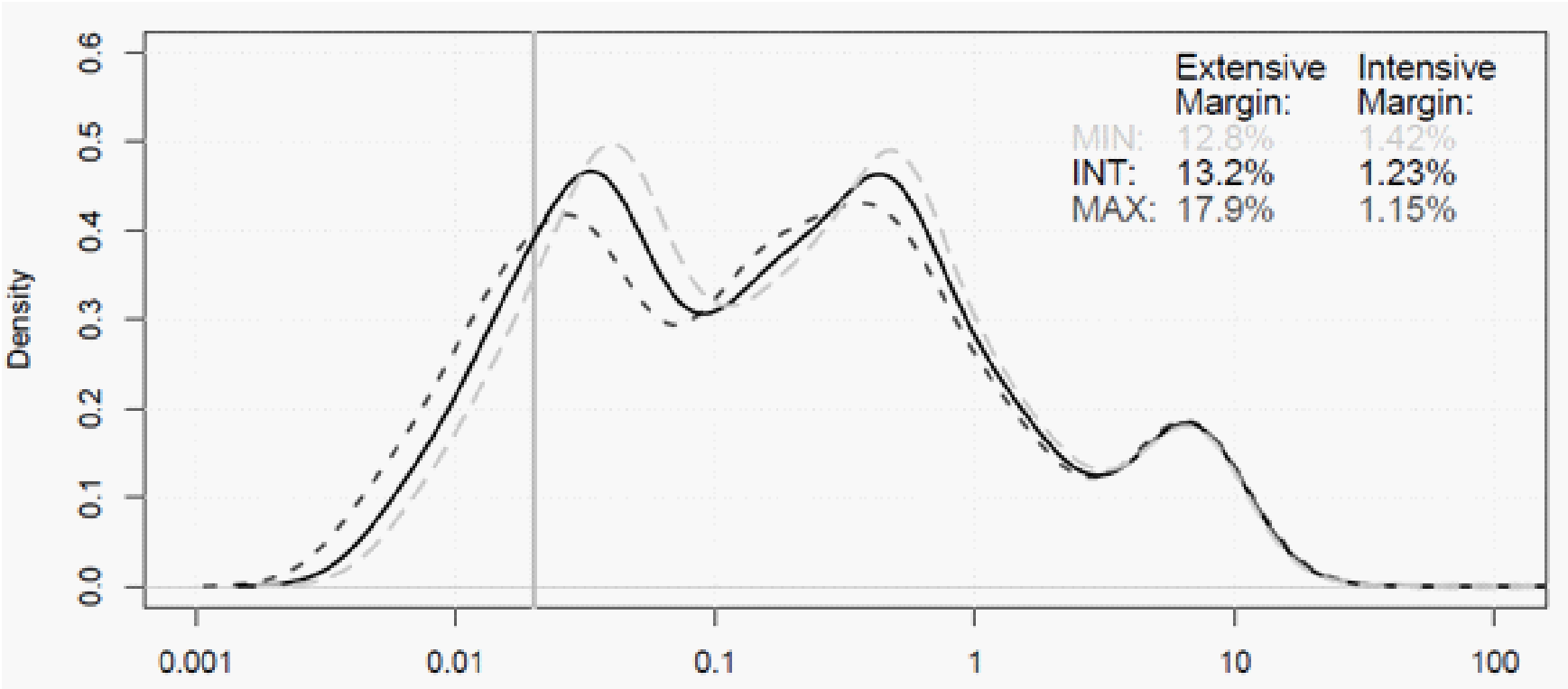
- Income pc
- College grads
- Urbanization
- Emigration
- Self-selection

by latitude!

Country-specific responses



Income distribution



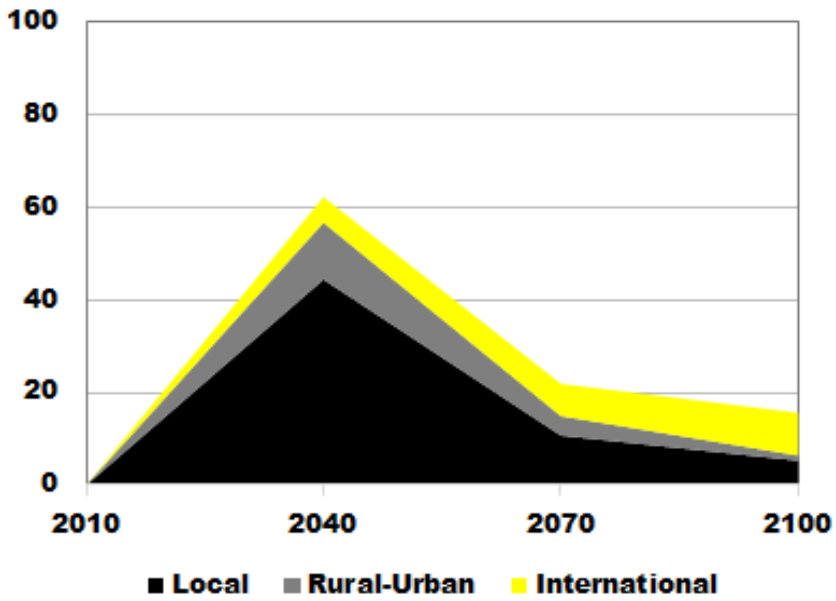
CLC increases poverty at extensive (headcounts) and intensive margin (depth)

Mobility responses

Under current migration laws and policies, is a juggernaut of climate refugees headed for OECD countries?

Mobility responses

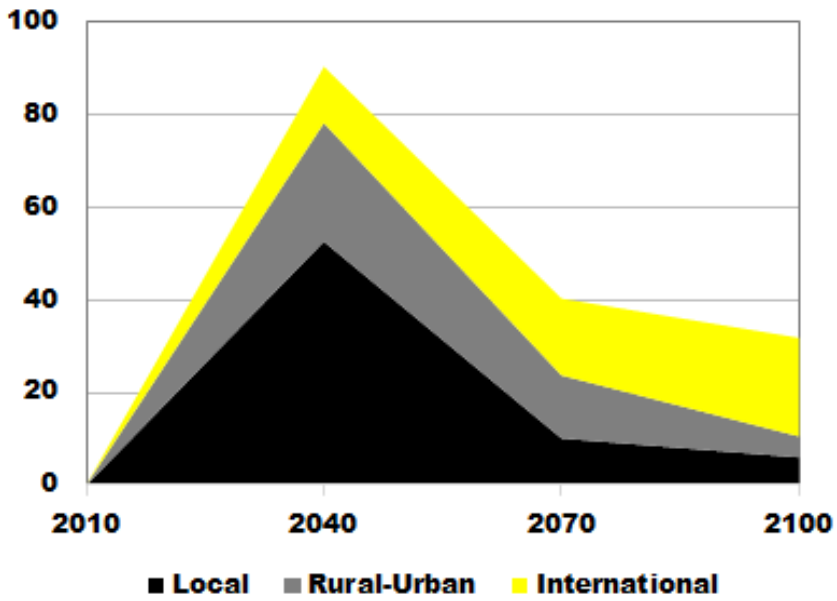
Intermediate



21st tot = 99.7M (22% int)

Int in 2100: from 3.2 to 3.4%

Maximalist

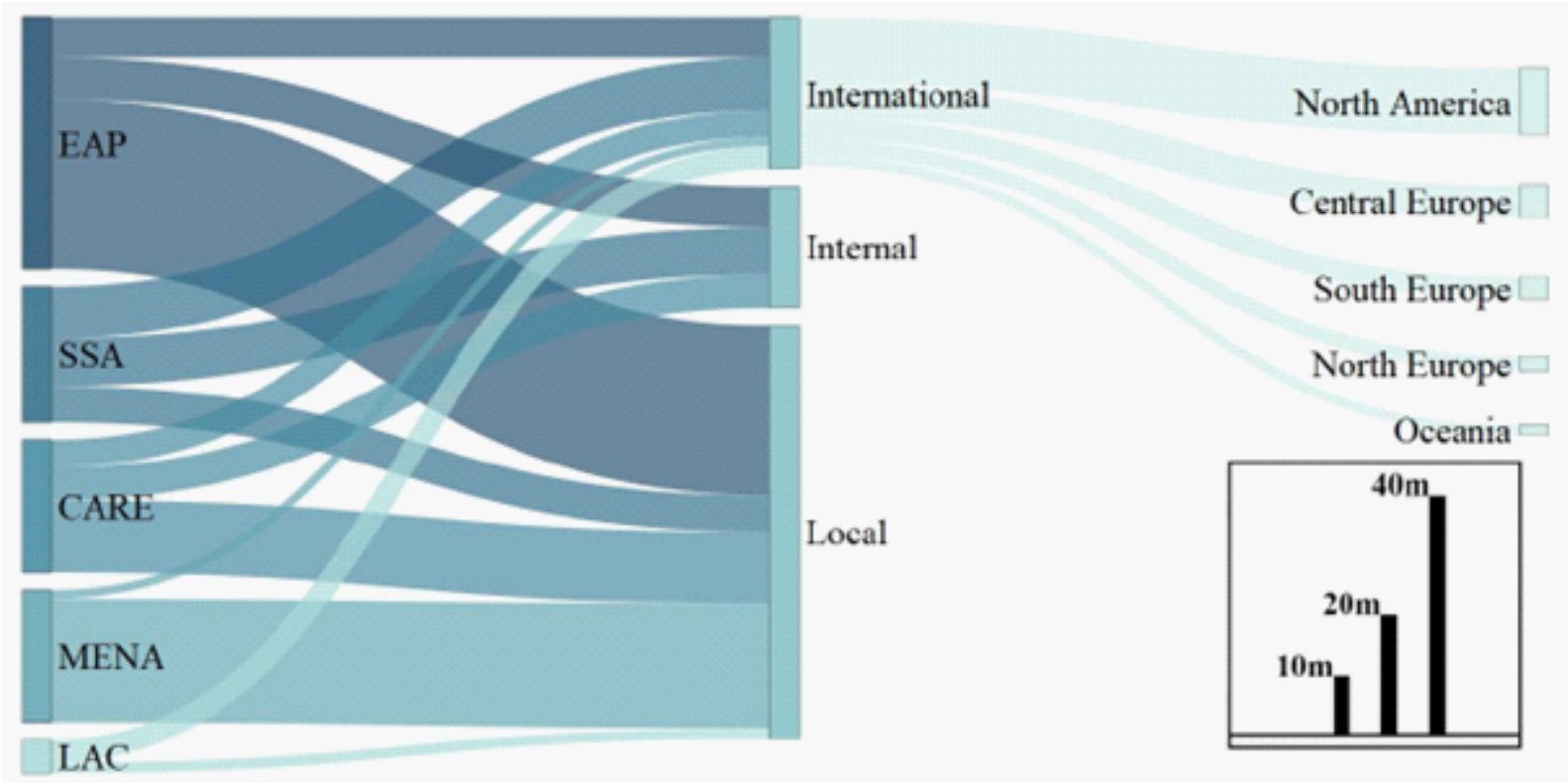


21st tot = 162.5M (31% int)

Int in 2100: from 3.2 to 3.7%

Mobility responses

Dyadic structure over the 21st century



Int'l migration

Emigration rates by region (as % of native pop 25-64)

	Intermediate				Mini.	Max.
	2010	2040	2070	2100	2100	2100
LAC	3.8	5.3	6.1	6.7	6.3	6.9
SSA	1.3	1.8	2.1	2.2	2.0	2.4
MENA	2.8	4.0	4.3	4.6	4.4	4.8
Asia	1.1	1.9	2.5	3.0	2.8	3.2
OECD	4.7	5.6	5.2	4.7	4.8	4.9

Emi rates increase due to (slow) convergence in education

Cont of CLC (x1.05-1.10) to rising emig (x2) is limited

Int'l migration

Immigration to OECD countries (as % of resident pop 25-64)

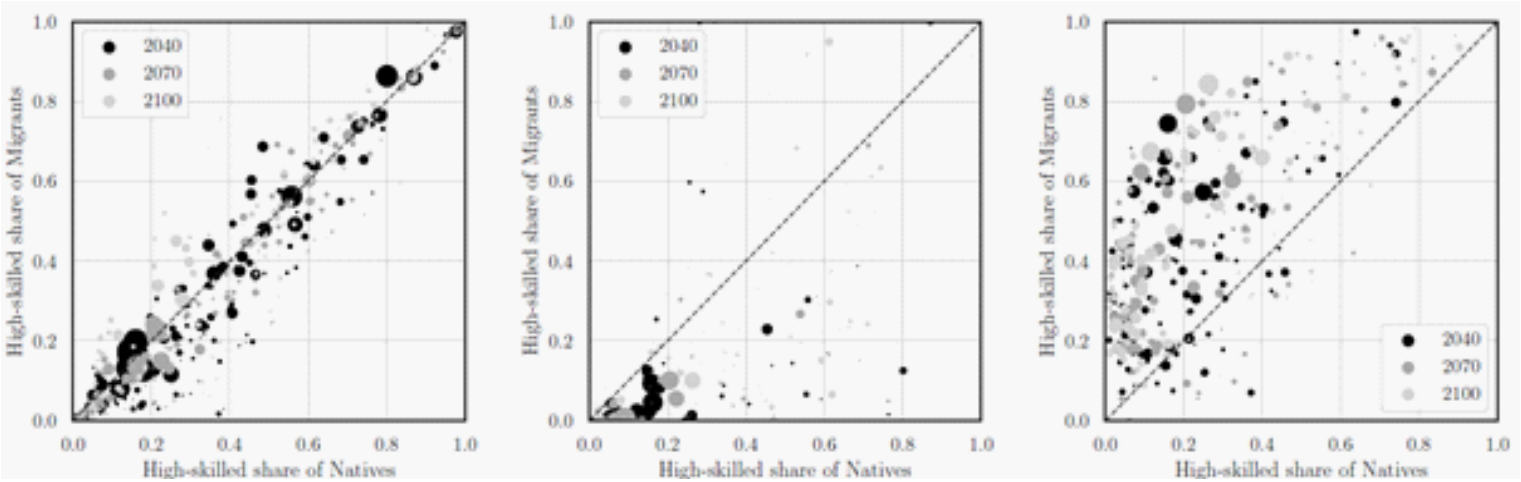
	Intermediate				Min.	Max.
	2010	2040	2070	2100	2100	2100
USA	16.0	21.4	23.0	23.1	22.7	23.6
Canada	18.7	26.5	28.5	28.4	28.2	28.6
Australia	24.9	29.4	29.2	28.1	27.8	28.5
EU15	13.6	20.3	23.3	24.6	24.2	25.1
Germany	15.0	22.5	25.4	26.4	26.1	26.8
France	12.2	18.8	20.5	22.1	21.6	22.6
UK	14.6	22.2	25.4	26.6	26.3	26.9
Italy	10.9	17.2	20.6	22.5	21.9	23.1

Immig rates increase due to demog imbalances + education

LR contr. of CLC to rising immig (x2 in EU) is limited

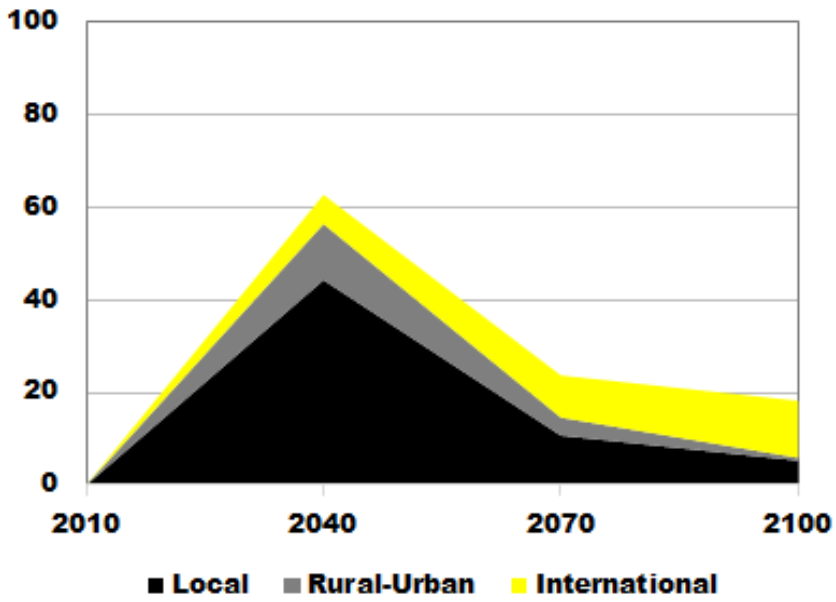
Self-selection

Local migration (forced) Rural-to-Urban mig. International (OECD)



Mobility responses

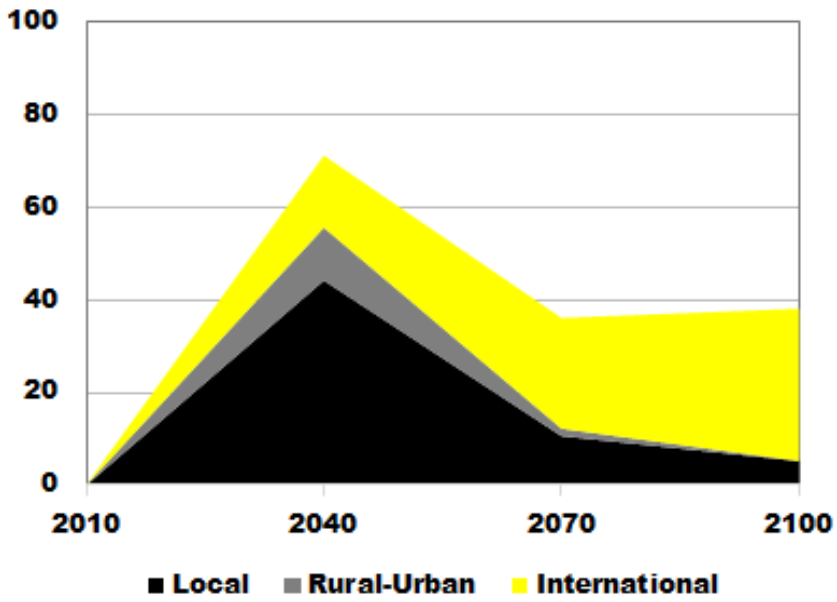
Fast-onset



21st tot = 104.6M (26% int)

Int in 2100: from 3.2 to 3.5%

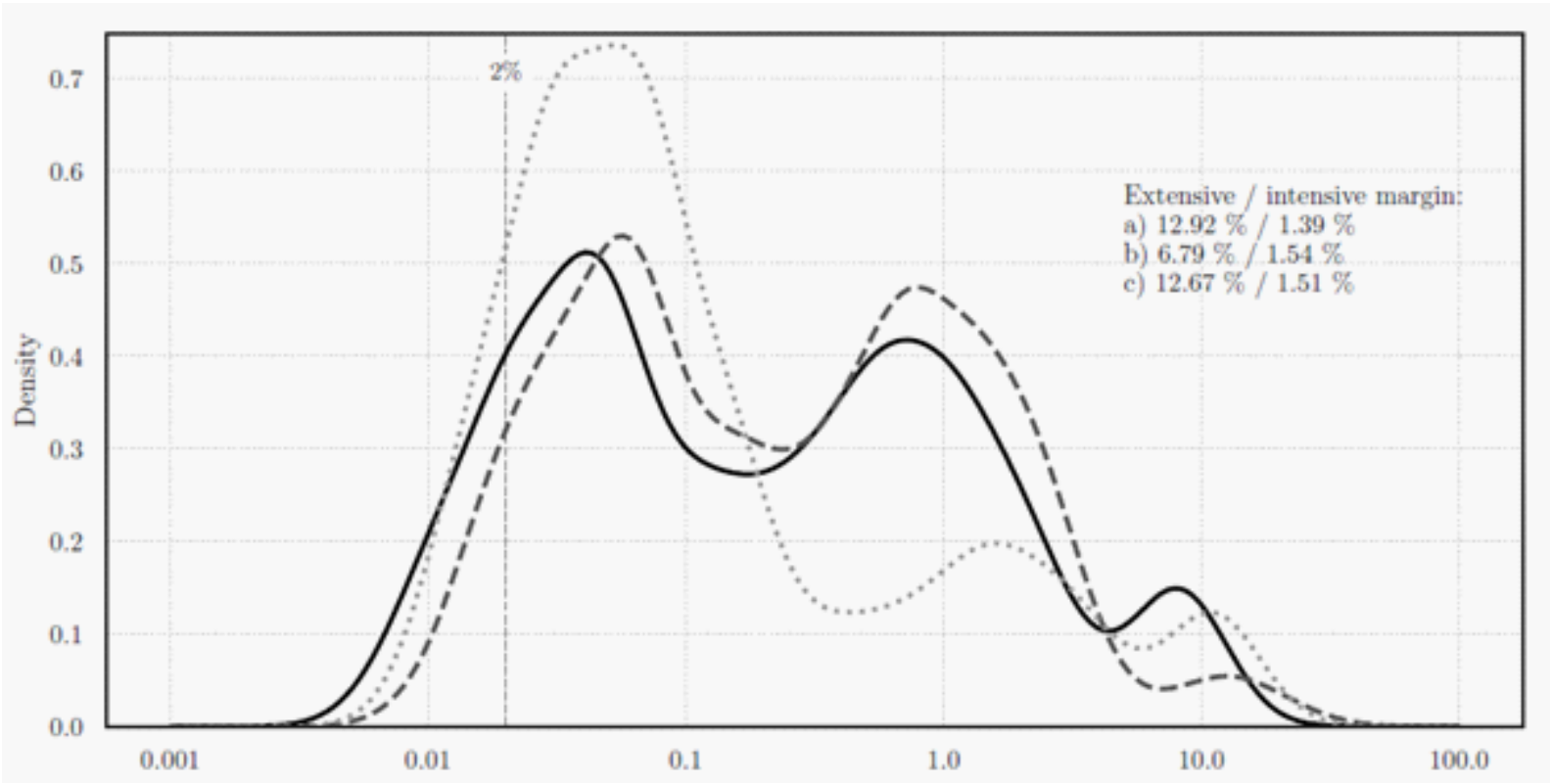
Fast-onset + Conflict



21st tot = 145.4M (50% int)

Int in 2100: from 3.2 to 3.9%

Income distribution



No international (dashed): smaller effect on extreme poverty (self-sel.)

vs. No internal (dotted): loss for middle income countries

V. Conclusion

Summary of findings

- CLC increases extreme poverty... and income disparities
  - Increases global inequality and extreme poverty
  - Needs local policy responses
- Limited effect international mobility responses
  - Adult movers: +100-200M in 21st century (>200-400 w. kids)
  - Only 20% migrate internationally (last resort option)
  - Robust to temperature and sea level scenarios
  - Sensitive to conficts over resources

Policy implications

- Role of migration policies
  - Climate migration is skill-biased
  - Relaxing migration constraints may increase extr. poverty
- What is a climate refugee?
  - 85% of forced displacements are local, 10% are internal
  - Half of non-local movements... and 95% of international movements are voluntary (indirect economic channel)

References

Climate Change, Inequality, and Human Migration*

Michał Burzyński[a], Christoph Deuster[b],
Frédéric Docquier[c] and Jaime de Melo[d]

[a] LISER, Luxembourg Institute of Socio-Economic Research (Luxembourg)

[b] IRES, UCLouvain (Belgium), and Universidade Nova de Lisboa (Portugal)

[c] LISER (Luxembourg), FNRS and IRES, UCLouvain (Belgium), and FERDI (France)

[d] Université de Genève (Switzerland), CEPR (United Kingdom) and FERDI (France)

August 30, 2019

The Geography of Climate Migration*

Michał Burzyński[a], Frédéric Docquier[b], and Hendrik Scheewel[c]

[a] LISER, Luxembourg Institute of Socio-Economic Research (Luxembourg)

[b] LISER (Luxembourg), FNRS and IRES, UCLouvain (Belgium), and FERDI (France)

[c] Université de Liège and IRES, UCLouvain (Belgium)

November 15, 2019