The Geography of Development: Evaluating Migration Restrictions and Coastal Flooding

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Space, Development and Growth

- Growth economists tend to ignore the economy's spatial distribution
  - They focus on aggregate variables
- Economic geographers tend to ignore the aggregate effects of space
  - They tend to focus on local growth dynamics
- There are important links between space and aggregate growth
  - It is intuitive to think that a country's spatial distribution of economic activity should affect its aggregate growth rate
- This paper:
  - Tractable theory of development that takes into account geography
  - Bring theory to the data and do counterfactual experiments

Usefulness to Policy Makers: Examples

- Migration policy affects the spatial distribution of economic activity
  - Liberalizing migration restrictions affects where people live
  - Where people live today determines where growth happens tomorrow
  - Quantitative models are needed to evaluate these complex questions

- Spatial shocks such as climate change
  - Climate change will affect different places differently
  - This will affect where people will live and where growth will occur
  - Again, the sheer complexity of these questions require models

- Evaluating infrastructure investments
  - Improving road infrastructure in one region affects other regions
  - An interstate highway system can take many shapes and forms
  - General equilibrium models are needed to evaluate their global effects

A Theory of the Geography of Development

- Each location is unique in terms of its
  - Amenities
  - Productivity
  - Geography
- Each location has firms that
  - Produce and trade subject to transport costs
  - Innovate
- Static part of model
  - Allen and Arkolakis (2013) and Eaton and Kortum (2002)
  - Allow for migration restrictions
- Dynamic part of model
  - Desmet and Rossi-Hansberg (2014)
  - Land competition and technological diffusion

Endowments and Preferences

- Economy occupies a two-dimensional surface S
- $\bar{L}$ agents, each supply one unit of labor
- An agent's period utility

$$u_t(r) = a_t(r)\left[\int_0^1 c_t^{\omega}(r)^{\rho}\, d\omega\right]^{\frac{1}{\rho}}$$

where amenities take the form

$$a_t(r) = \overline{a}(r)\,\overline{L}_t(r)^{-\lambda}$$

Congestion through amenities: dispersion force

- Agents earn income from work and from local ownership of land

Technology

- Production per unit of land of a firm producing good ω

$$q_t^{\omega}(r) = \phi_t^{\omega}(r)^{\gamma_1} z_t^{\omega}(r) L_t^{\omega}(r)^{\mu}$$

- Productivity depends on decision to innovate
  - Invest $\nu\phi_t^{\omega}(r)^{\xi}$ units of labor to get innovation $\phi_t^{\omega}(r)$
  - Agglomeration force
- Productivity depends on random draw
  - $z_t^{\omega}(r)$ is the realization of a r.v. drawn from a Fréchet distribution
  - Average draw is increasing in
    - ★ population density: agglomeration force
    - ★ past innovation: avoids stagnation
    - ★ productivity of other locations: dispersion force

Productivity Draws and Competition

- Productivity draws are i.i.d. across goods, but correlated across space (with perfect correlation as distance goes to zero)
- Firms face perfect local competition and innovate
  - Firms bid for land up to point of making zero profits after covering investment in technology
- Next period all potential entrants have access to same technology
  - Dynamic profit maximization simplifies to sequence of static problems
- Because of perfect competition, many of the results of EK apply
  - The probability that a good produced in r is sold in s is the same as the share of goods of r sold in s
- Firms trade subject to transport costs

Equilibrium: Existence and Uniqueness

- Standard definition of dynamic competitive equilibrium
- Equilibrium implies

$$\left[\frac{\bar{a}(r)}{\bar{u}(c)}\right]^{-\frac{\theta(1+\theta)}{1+2\theta}} \tau_t(r)^{-\frac{\theta}{1+2\theta}} H(r)^{\frac{\theta}{1+2\theta}} \bar{L}_t(r)^{\lambda\theta-\frac{\theta}{1+2\theta}\chi}$$

$$= \left[\bar{u}_t^W\right]^{-\theta} \kappa_1 \sum_{d=1}^{C} \int_{S_d} \left[\frac{\bar{a}(s)}{\bar{u}(d)}\right]^{\frac{\theta^2}{1+2\theta}} \tau_t(s)^{\frac{1+\theta}{1+2\theta}} H(s)^{\frac{\theta}{1+2\theta}} \varsigma(r,s)^{-\theta} \bar{L}_t(s)^{1-\lambda\theta+\frac{1+\theta}{1+2\theta}\chi} ds$$

- **An equilibrium exists and is unique if**

$$\frac{\alpha}{\theta} + \frac{\gamma_1}{\xi} \leq \lambda + 1 - \mu$$

  - Congestion from land $(1-\mu)$ and amenities (λ)
  - Agglomeration economies from market size on average productivity draw (α/θ) and innovation (γ_1/ξ)
  - Congestion forces should be greater than agglomeration economies

Balanced Growth Path

- In a balanced growth path (BGP) the spatial distribution of employment is constant and all locations grow at the same rate
- **There exists a unique BGP if**

$$\frac{\alpha}{\theta} + \frac{\gamma_1}{\xi} + \frac{\gamma_1}{[1-\gamma_2]\,\xi} \leq \lambda + 1 - \mu$$

  - Stronger than the condition for uniqueness and existence of the equilibrium because of dynamic agglomeration economies

- In a BGP aggregate welfare and real consumption grow according to

$$\frac{\bar{u}_{t+1}^{W}}{\bar{u}_{t}^{W}} = \left[\frac{\int_0^1 c_{t+1}^{\omega}(r)^{\rho}\,d\omega}{\int_0^1 c_{t}^{\omega}(r)^{\rho}\,d\omega}\right]^{\frac{1}{\rho}} = \eta^{\frac{1-\gamma_2}{\theta}}\left[\frac{\gamma_1/\nu}{\gamma_1+\mu\xi}\right]^{\frac{\gamma_1}{\xi}}\left[\int_S \bar{L}(s)^{\frac{\theta\gamma_1}{[1-\gamma_2]\xi}}\,ds\right]^{\frac{1-\gamma_2}{\theta}}$$

  - Growth depends on population size and its distribution in space

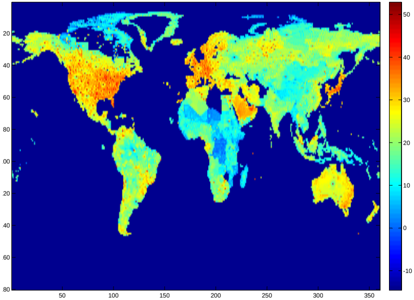
Calibration: Parameter Values

- Use relation between geographic distribution of population and aggregate growth across countries to estimate technology parameters
- Use relationship between productivity and amenities in the U.S. to estimate congestion costs
- Transport costs use evidence on seas, rivers, lakes, highways, trains, and geographic characteristics
  - 64,800 by 64,800 bilateral transport cost matrix
- Other parameter values come from the literature

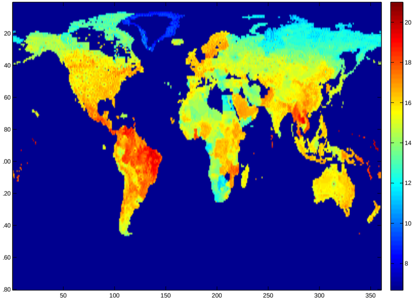
Simulation: Amenities and Productivity

- Discretize the world into 1° by 1° cells (64,800 in total)
- Use data on land, population and wages from G-Econ and data on bilateral transport costs to derive spatial distribution of productivity and $\bar{a}(r)/\bar{u}(c)$
- Does not separately identify $\bar{a}(r)$ and $\bar{u}(c)$
  - Not a problem in models with free mobility (Roback, 1982)
  - Not reasonable here: Congo would have very attractive amenities
- We need additional data on utility: subjective well-being
  Map subjective well-being
  - Correlates well with log of income (Kahneman and Deaton, 2010)
  - Transform subjective well-being into utility measure that is linear in the level of income

Benchmark Calibration: Results from Inversion



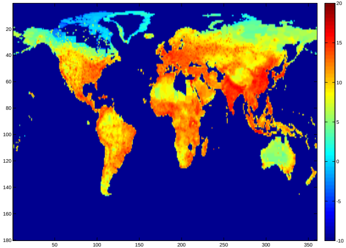
a. Fundamental Productivities: $\tau_0\left(r\right)$



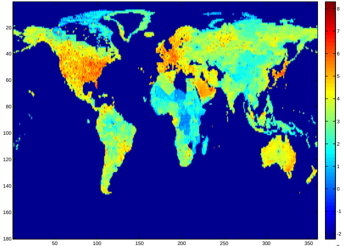
b. Fundamental Amenities: $\overline{a}\left(r\right)$

Correlation amenities

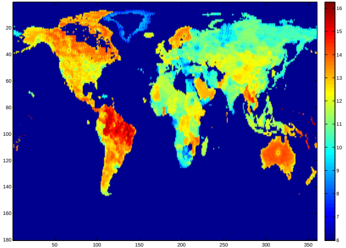
Benchmark Calibration: Period 1



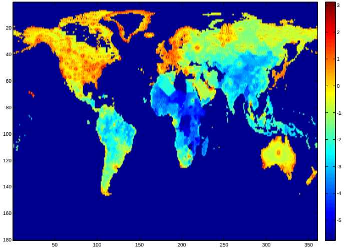
a. Population Density



b. Productivity: $\left[\tau_t\left(r\right)\overline{L}_t\left(r\right)^{\alpha}\right]^{\frac{1}{\theta}}$

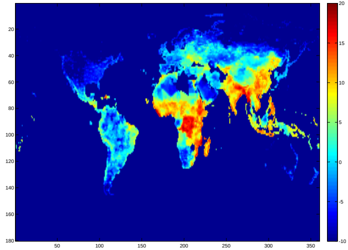


c. Amenities: $\overline{a}\left(r\right)\overline{L}_t\left(r\right)^{-\lambda}$



d. Real Income per Capita

Keeping Migratory Restrictions Unchanged: Period 600



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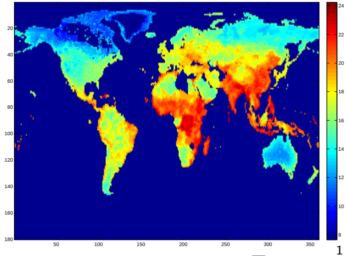

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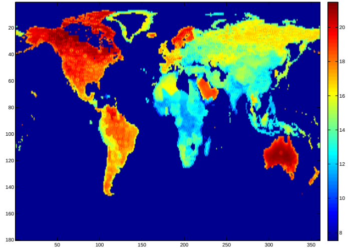

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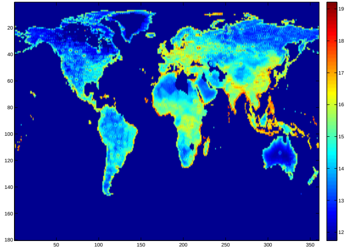
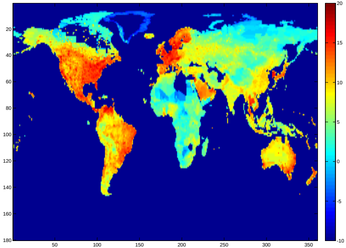


d. Real Income per Capita

▸ Empirical correlation density and income

Free Mobility: Period 1



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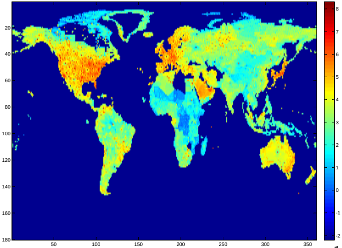
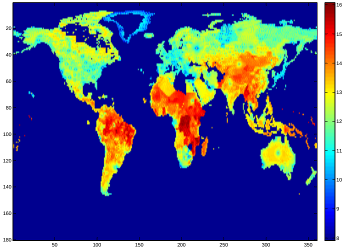
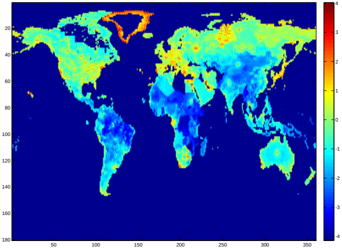


b. Productivity: $\left[\tau_t(r)\,\overline{L}_t(r)^{\alpha}\right]^{\frac{1}{\theta}}$

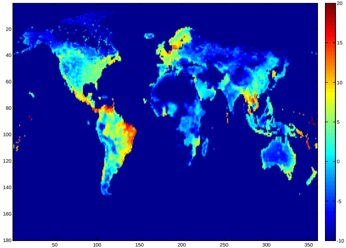


c. Amenities: $\overline{a}(r)\,\overline{L}_t(r)^{-\lambda}$



d. Real Income per Capita

Free Mobility: Period 600



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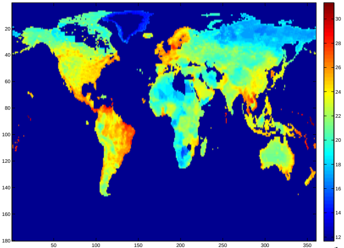
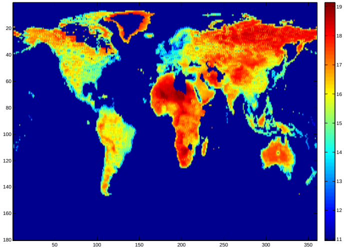


b. Productivity: $\left[\tau_t(r)\,\overline{L}_t(r)^{\alpha}\right]^{\frac{1}{\theta}}$



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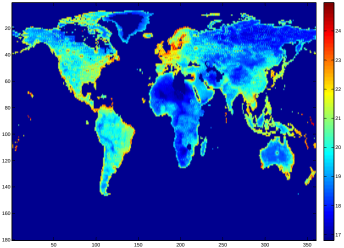


d. Real Income per Capita

Welfare and Migratory Restrictions

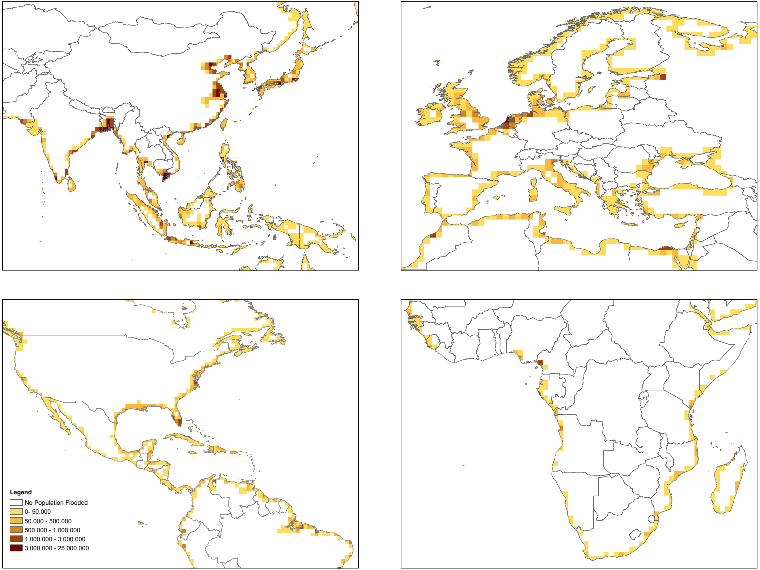
Mobility	Discounted Real Income*	Discounted Utility**	Migration Flows***
ψ	%Δ w.r.t. $\psi = 0$	%Δ w.r.t. $\psi = 0$	
0.0^a	0%	0%	0.74%
0.3	3.5%	71%	24.5%
0.5	13.9%	131%	42.0%
0.9	39.8%	244%	65.0%
1.3	56.2%	298%	73.9%
1.8^b	68.6%	312%	78.2%

We use $\beta = 0.95$. a: Observed Restrictions. b: Free Mobility. *: Normalized by world average for $t = 1$. **: Population-weighted average of cells' utility levels. ***: Share of world population moving to countries that grow between period 0 and 1 (immediately after the change in ψ).

Rise in Sea Levels

- The rise in sea level is a major consequence of global warming
  - Thermal expansion of the oceans
  - Melting of glaciers and depletion of ice sheets
  - Next millennium expected rise by 7 meters
    - Likely increase by 0.5 to 1 meter by 2100 (IPCC)
- Disproportionate part of the world's population lives in coastal areas
- Existing literature
  - Accounting exercises based on current data (Dasgupta et al., 2007)
  - Studies contemplating different future scenarios (Nicholls, 2004)
- Here: dynamic analysis of rise in sea level by 6 meters

Population Flooded based on Today's Population



Dynamic Effects of Flooding

Mobility	Discounted Present Value of Real Income*	Welfare**
ψ	Ratio (NF/F)	Ratio (NF/F)
0.0^a	1.037	1.082
0.3	1.028	1.079
0.5	1.021	1.075
0.9	1.016	1.072
1.3	1.024	1.076
1.8^b	1.037	1.078

We use $\beta = 0.95$. a: Observed Restrictions. b: Free Mobility.
*: Normalized by world average GDP without flooding for $t = 1$.
**: Population-weighted average of cells' utility levels.

▸ Sea level rise by 1 meter

Dynamic Effects of Flooding

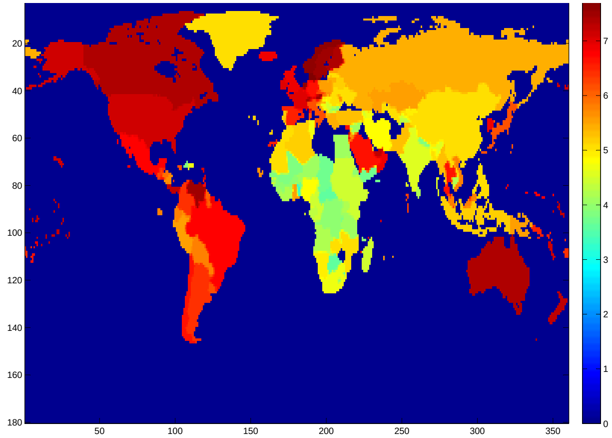
- Flooding reduces real income by 1.6% – 3.7%
- It reduces welfare by 7.2% – 8.2%
  - Loss in amenities due to flooding are large
- In PDV mobility has little effect on the welfare impact of flooding
- We would have expected mobility to mitigate negative effects
  - Mobility moves more people to coastal areas
  - People move to places that are individually, not socially, beneficial
  - Local migration argument no longer works with complex geography

Conclusion

- Interaction between geography and economic development through trade, technology diffusion and migration
- Connect to real geography of the world at fine detail
- Relaxing migration restrictions can lead to very large welfare gains
- Level of migration restrictions will have important effect on which regions of the world will be the productivity leaders of the future
- Coastal flooding will have important welfare effects
  - Mobility has little effect on the welfare effect of flooding

Map Subjective Well-Being

Subjective Well-being from the Gallup World Poll (Max = 10, Min = 0)



▸ Return

Correlation Amenities

Correlations with Estimated Amenities (logs)					
	(1) All cells	(2) U.S.	(3) One cell per country	(4) Placebo of (1)	(5) Placebo of (3)
A. Water					
Water $<$ 50 km	0.2198***	0.1286***	0.1232**	0.1064***	-0.1363**
B. Elevation					
Level	-0.4152***	-0.1493***	-0.2816***	-0.2793***	0.1283**
Standard deviation	-0.4599***	-0.2573***	-0.3099***	-0.3285***	0.1121*
C. Precipation					
Average	0.4176***	0.08643***	0.3851***	0.3185***	0.1830***
Maximum	0.4408***	0.1068***	0.3128***	0.4286***	0.3200***
Minimum	0.2035***	0.2136***	0.2108***	-0.0096	-0.1965**
Standard deviation	0.4160***	0.0212	0.2746***	0.4715***	0.4535***
D. Temperature					
Average	0.6241***	0.6928***	0.3087***	0.6914***	0.5692***
Maximum	0.5447***	0.7388***	0.1276***	0.6589***	0.4635***
Minimum	0.6128***	0.6060***	0.2931***	0.6565***	0.5389***
Standard deviation	-0.5587***	-0.3112***	-0.3313***	-0.5539***	-0.3679***
E. Vegetation					
Desert, ice or tundra	-0.3201***	-0.3993***	-0.1827***	-0.2440***	-0.1291*

- Correlations using all cells, U.S. cells, or one cell per country are similar (see (1), (2) and (3))
  - Also consistent with Albouy et al. (2014) and Morris & Ortalo-Magné (2007)
- Placebo correlations under free mobility are not (see (2), (4) and (5))

Return

Population Density and Income

Correlation between population density and real income per capita

- Across all cells of the world: -0.38
- Weighted average across cells within countries: 0.10
- Across richest and poorest cells of the world
  - 50% poorest cells: -0.02
  - 50% richest cells: 0.10
- Weighted average across richest and poorest cells within countries
  - 50% poorest cells: 0.14
  - 50% richest cells: 0.23
- Across cells of different regions
  - Africa: -0.04
  - Asia: 0.06
  - Latin America and Caribbean: 0.14
  - Europe: 0.15 (Western Europe: 0.20)
  - North America: 0.28
  - Australia and New Zealand: 0.48 (Oceania: -0.08)

Changing Relation between Population Density and Income

- Correlation between population density and income today is -0.4
- Model predicts that this correlation should increase with income
  - Dynamic agglomeration economies greater in high-productivity places
  - Mobility
- Consistent with evidence from U.S. zip codes

Correlation between Population Density and Per Capita Income (logs)*

Year	$<$ 25th	25-50th	50th-75th	$>$75th	$<$ Median	$\geq$ Median
2000	-0.1001***	0.0495***	0.1499***	0.2248***	-0.0609***	0.3589***
2007-2011	-0.0930***	0.0175	0.0733***	0.2420***	-0.0781***	0.3234***

*Percentiles based on per capita income

- Also holds across zip codes within CBSAs

Return

Rise in Sea Level by 1 Meter

- We consider rise in sea levels that flood 0.4% of land
- On-impact flooding of population for sea level rise today
  - 1 meter: 1.6% (with restrictions) and 5.5% (free mobility)
  - 6 meters: 6.6% (with restrictions) and 11.2% (free mobility)
- Effects are smaller, but less than proportionally so

Dynamic Effects of Rise in Sea Level by 1 Meter

Mobility	Discounted Present Value of Real Income*	Welfare**
ψ	Ratio (NF/F)	Ratio (NF/F)
0.0[a]	1.011	1.036
0.3	1.011	1.040
0.5	1.010	1.041
0.9	1.008	1.041
1.3	1.012	1.039
1.8[b]	1.014	1.034

We use $\beta = 0.95$. a: Observed Restrictions. b: Free Mobility.
*: Normalized by world average GDP without flooding for $t = 1$.
**: Population-weighted average of cells' utility levels.

Return