Genetic Diversity and Comparative Development

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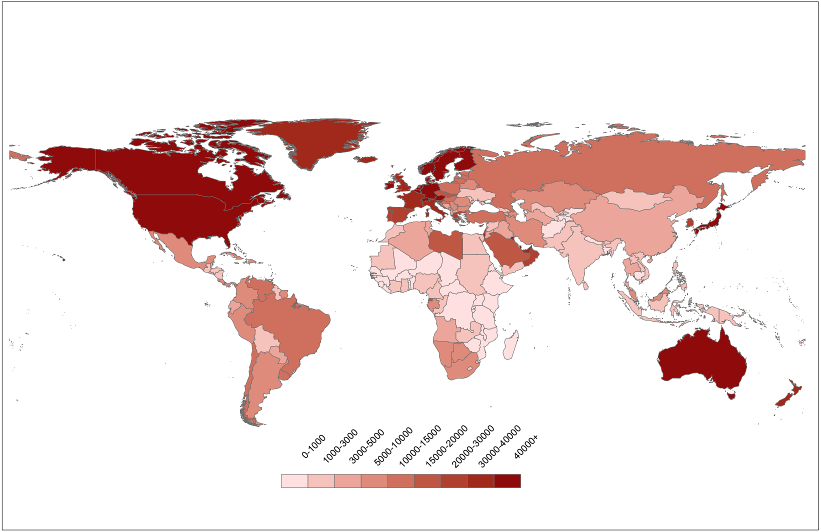
Economic Growth and Comparative Development

Income per Capita across the Globe in 2010



Fundamental Research Questions

- What is the origin of the vast inequality in income per capita across countries and regions?
- What is the impact of deep-rooted factors on the observed patterns of comparative development?
- What fraction of the variation in income per capita across countries could be attributed to the long shadow of history?
- How can policy mitigate the persistent effect of historical factors on comparative development?

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- The migration of humans out of Africa 70,000-90,000 BP affected
  - The distribution of genetic diversity across the globe
  - Comparative economic development
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Main Building Blocks of the Proposed Hypothesis

- The Serial Founder Effect:
  - Lower genetic diversity among indigenous populations at greater migratory distances from East Africa
- Existence of an optimal level of genetic diversity (for each stage of development)
  - Balances between:
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- Departing populations carry only a subset of the genetic diversity of their parental colonies
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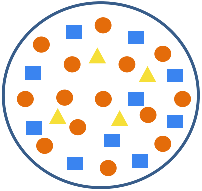
An Illustration of the Serial Founder Effect



3 Alleles

Original Population

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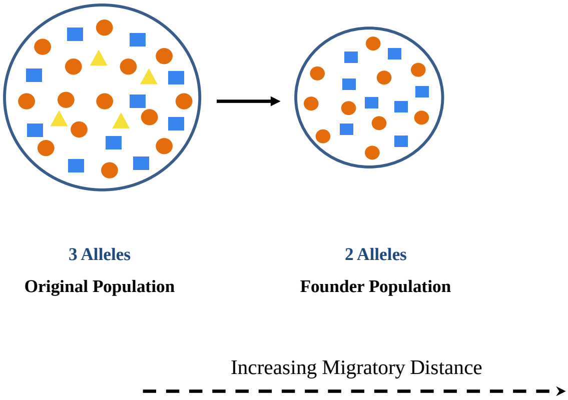

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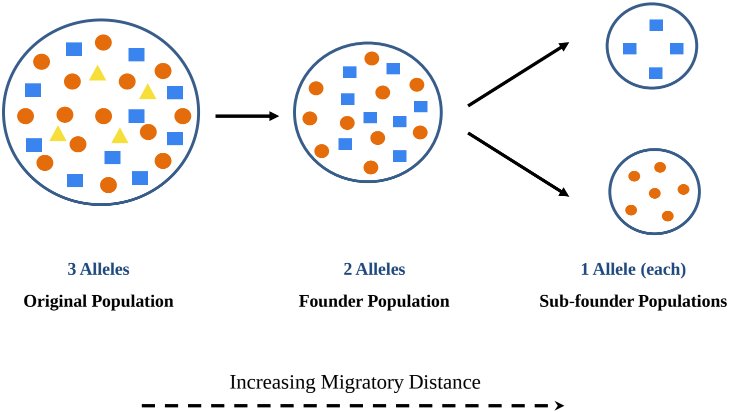

Genetic Diversity – Measurement

- Expected Heterozygosity – Index of Genetic Diversity:
  - The probability that two individuals, selected at random from a given population, are genetically different from one another (in a certain spectrum of genes)
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The Expected Heterozygosity Index

- $H_\lambda \equiv$ Locus-specific heterozygosity:
  - For a gene λ with k_λ alleles, where p_i^λ is the observed frequency of the i-th allele in gene λ :

$$H_\lambda = 1 - \sum_{i=1}^{k_\lambda} (p_i^\lambda)^2$$

- $H \equiv$ Expected heterozygosity
  - Averaging over m genes:

$$H = \frac{1}{m} \sum_{\lambda=1}^{m} H_\lambda = 1 - \frac{1}{m} \sum_{\lambda=1}^{m} \sum_{i=1}^{k_\lambda} (p_i^\lambda)^2$$

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- Designed to study GD in isolated populations in order to shed light on:
  - The scope of human diversity
  - The journey of humankind from Africa
- Consists of 53 ethnic groups (52 originally)
  - Isolated geographically
  - Resided in the same location for a prolonged period of time
  - Display insignificant genetic admixture

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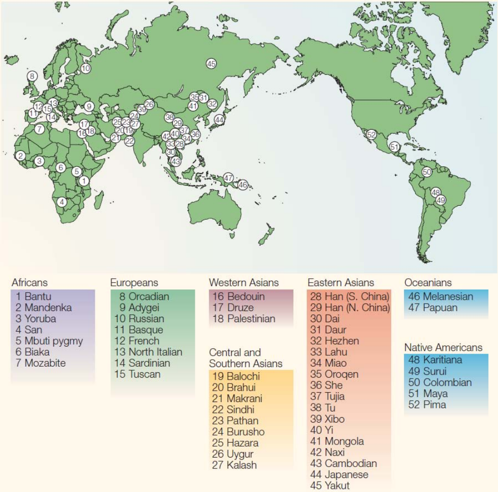
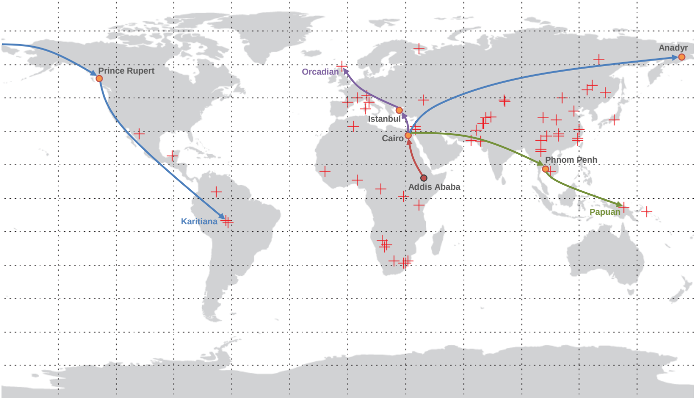
HGDP Ethnic Groups



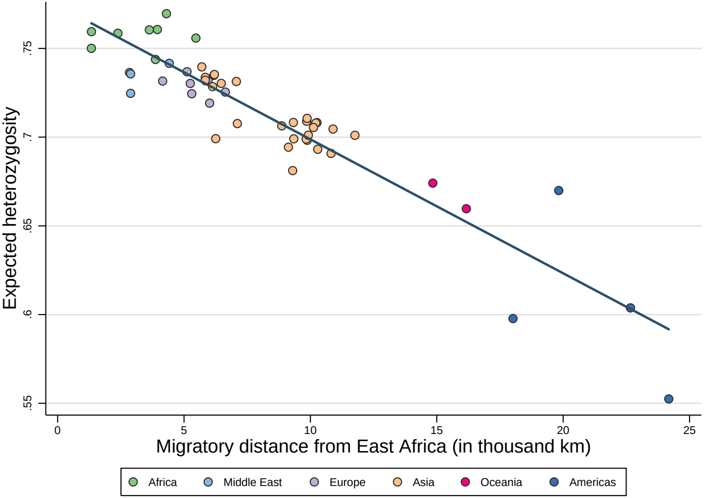
The Spatial Distribution of the HGDP Ethnic Groups



+ Marks the location of an HGDP ethnic group.

o Marks an approximate critical juncture in the journey of humankind from Africa.

Migratory Distance from Africa and Genetic Diversity



Expected Heterozygosity in Microsatellites

- Expected heterozygosity calculated for the 53 ethnic groups in the HGDP using allelic frequencies for 783 microsatellite loci
- Advantage of using microsatellites – a class of non-protein-coding regions of the human genome:
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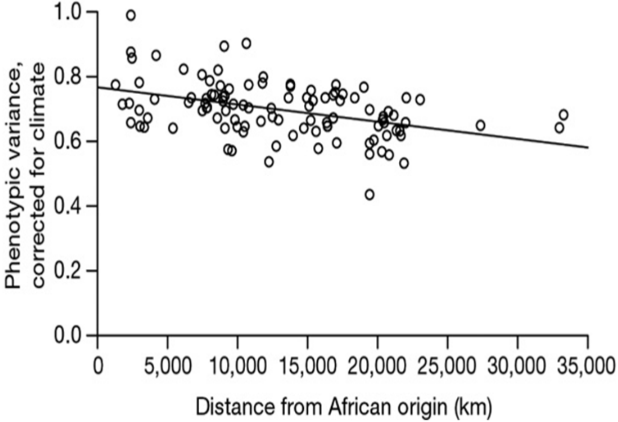
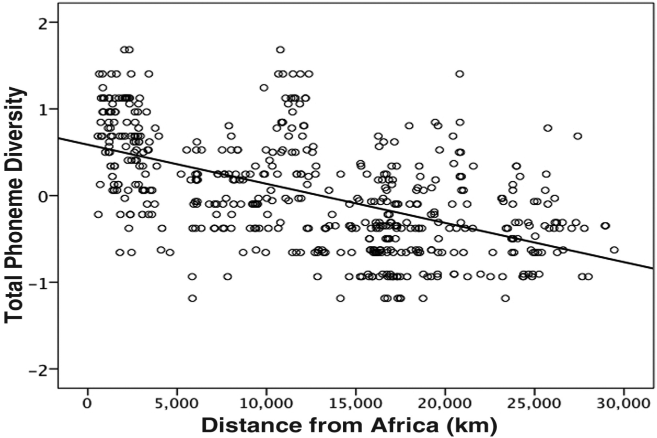
Distance from Africa and Craniometric Diversity



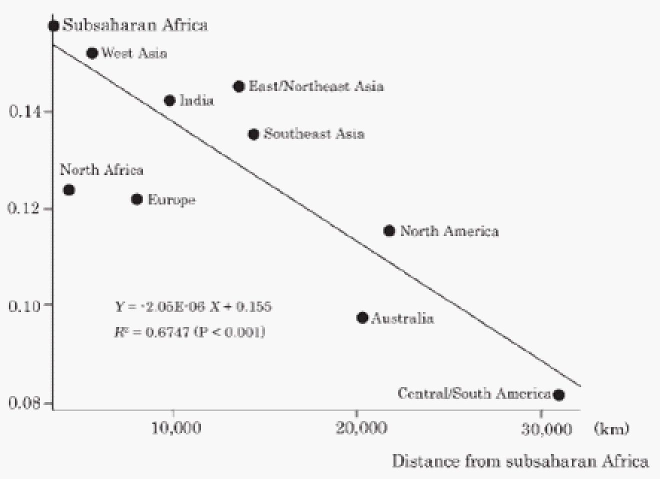
Source: Manica et al. (Nature 2007)

Distance from Africa and Linguistic Diversity



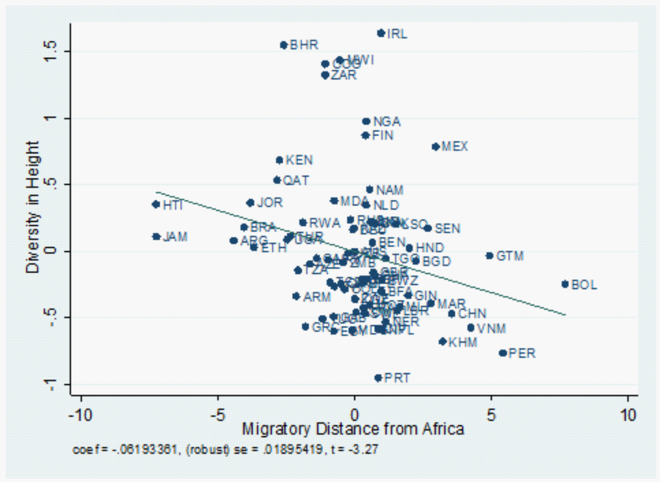
Source: Atkinson (Science 2011)

Distance from Africa and Dental Diversity



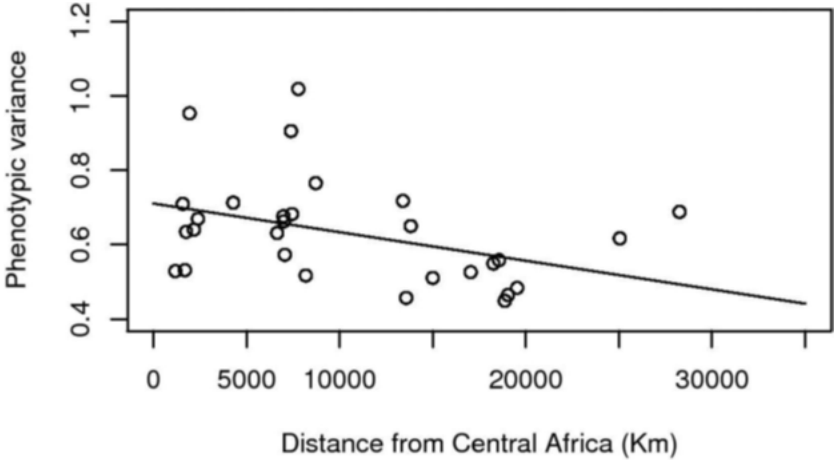
Source: Hanihara (American Journal of Physical Anthropology, 2008)

Distance from Africa and Height Diversity



Source: Galor and Klemp (2014)

Distance from Africa and Pelvic Bone Diversity



Source: Betti et al. (Human Biology, 2012)

Trade-offs: Human Diversity and Productivity

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  - Mistrust
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- Genetic diversity
  - Increases the likelihood for the existence of traits that are complementary to the adoption of newly technologies
  - Generates complementary in the production process
  - Increases the upper tail of the ability distribution that matters for innovations
  - $\Longrightarrow$ Diversity fosters innovations & expands the production possibilities

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Optimal Diversity

- Positive but diminishing effects of:
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  - Homogeneity on cohesiveness
    - $\implies$ A hump-shaped relationship between diversity and development
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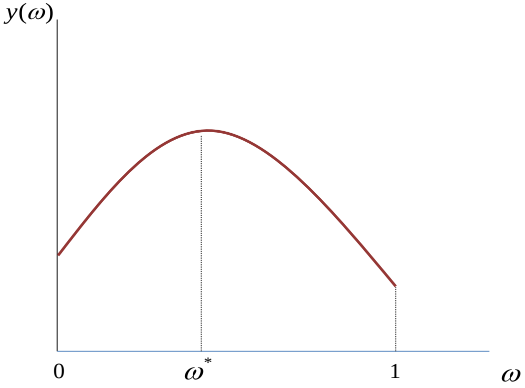
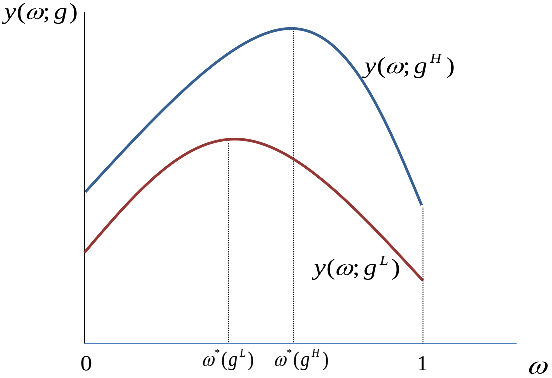
The Optimal Level of Genetic Diversity



The Rise in the Optimal Diversity – Faster Technological Progress



Empirical Strategy

- Cross-country Analysis
  - Pre-colonial era:
    - Observed genetic diversity (21 countries)
    - Projected diversity (145 countries)
  - Contemporary analysis:
    - Projected diversity (145 countries)
- Across ethnic groups
  - Observed genetic diversity (232 ethnic groups)
  - Projected diversity (1331 ethnic groups)

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  - Observed genetic diversity (232 ethnic groups)
  - Projected diversity (1331 ethnic groups)

Empirical Strategy

- Cross-country Analysis
  - Pre-colonial era:
    - Observed genetic diversity (21 countries)
    - Projected diversity (145 countries)
  - Contemporary analysis:
    - Projected diversity (145 countries)
- Across ethnic groups
  - Observed genetic diversity (232 ethnic groups)
  - Projected diversity (1331 ethnic groups)

Comparative Development in the Pre-Colonial Era

- The effect of GD on productivity in the years 1-1500 CE:
    - Productivity is captured by population density (Malthusian Epoch)
    - Disentangle effects of:
        - Genetic Diversity
        - Geographic Factors: Land productivity, Absolute latitude
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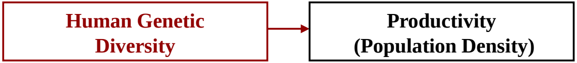
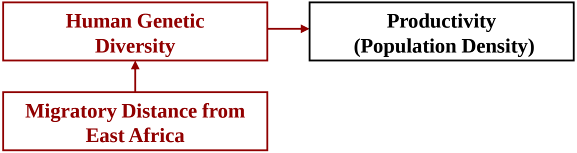
Determinants of Productivity: Channels

Productivity
(Population Density)

Determinants of Productivity: Channels



Determinants of Productivity: Channels



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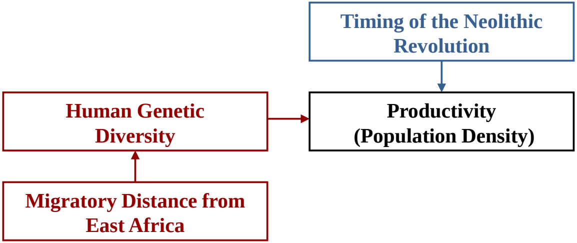

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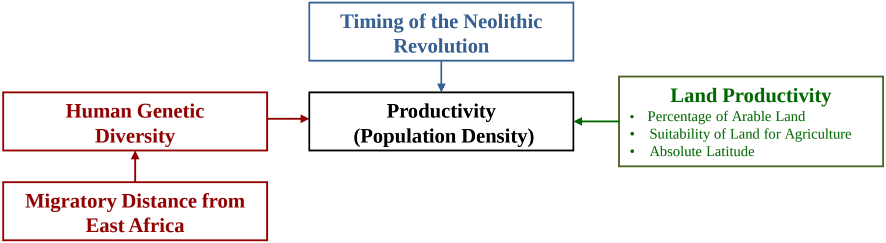
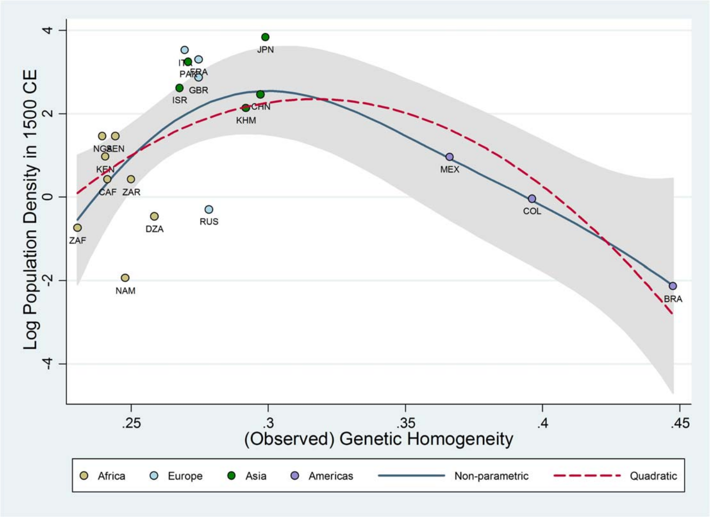


Observed Diversity and Development in 1500: Unconditional Relationship



Empirical Model I

- Testing the hypothesis using observed genetic diversity from the HGDP
  - 21-country sample
  - Empirical specification

$$\ln P_{it} = \beta_{0t} + \beta_{1t} G_i + \beta_{2t} G_i^2 + \beta_{3t} \ln T_i + \beta_{4t}' \ln X_i + \beta_{5t}' \ln \Delta_i + \varepsilon_{it}$$

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Actual Diversity and Comparative Development in 1500

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log Population Density in 1500				
Genetic Diversity	413.51***			225.44***	203.82*
	(97.32)			(73.78)	(97.64)
Genetic Diversity Sqr.	-302.65***			-161.16**	-145.72*
	(73.34)			(56.16)	(80.41)
Log Years since NR		2.40***		1.21***	1.14
		(0.27)		(0.37)	(0.66)
Log % of Arable Land			0.73**	0.52***	0.55*
			(0.28)	(0.17)	(0.26)
Log Absolute Latitude			0.15	-0.16	-0.13
			(0.18)	(0.13)	(0.17)
Log Agri. Suitability			0.73*	0.57*	0.59
			(0.38)	(0.29)	(0.33)
Optimal Diversity	0.683			0.699	0.699
	(0.008)			(0.015)	(0.055)
Continent Dummies	No	No	No	No	Yes
Observations	21	21	21	21	21
R-squared	0.42	0.54	0.57	0.89	0.90

Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Migratory Distance from East Africa vs. Genetic Diversity

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log Population Density in 1500				
Genetic Diversity	417.003***			300.978***	361.421**
	(90.909)			(76.371)	(121.429)
Genetic Diversity Sqr.	-306.218***			-241.755***	-268.515***
	(68.308)			(61.099)	(87.342)
Migratory Distance		0.463***		-0.003	
		(0.142)		(0.178)	
Migratory Distance Sqr.		-0.021***		-0.010	
		(0.006)		(0.009)	
Mobility Index			0.353**		0.051
			(0.127)		(0.154)
Mobility Index Sqr.			-0.012***		-0.003
			(0.004)		(0.006)
Observations	18	18	18	18	18
R-squared	0.43	0.30	0.30	0.47	0.43
P-value for:					
Joint Sig. of Diversity and its Sqr.				0.006	0.027
Joint Sig. of Distance and its Sqr.				0.320	
Joint Sig. of Mobility and its Sqr.					0.905

Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Empirical Model II

- Testing the hypothesis using projected genetic diversity
  - 145-country sample
- Empirical specification

$$\ln P_{it} = \beta_{0t} + \beta_{1t}\hat{G}_i + \beta_{2t}\hat{G}_i^2 + \beta_{3t}\ln T_i + \beta_{4t}'\ln X_i + \beta_{5t}'\ln \Delta_i + \varepsilon_{it}$$

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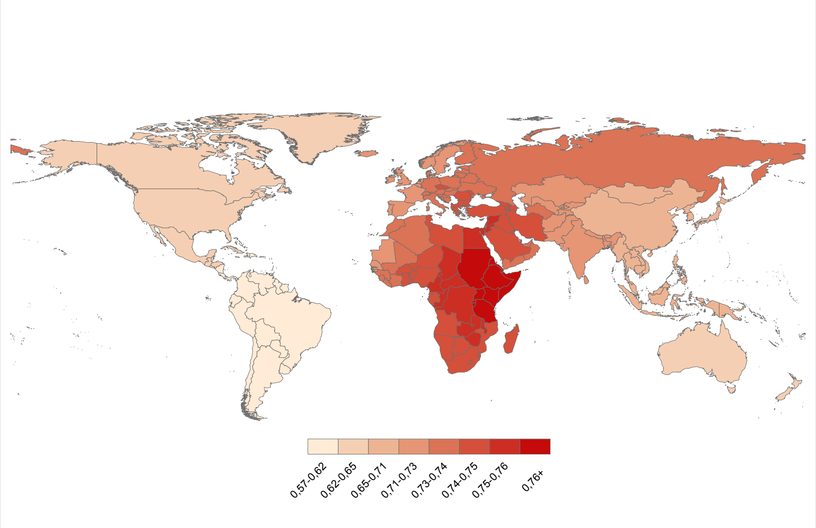
Projected Genetic Diversity across Countries in the Pre-Colonial Era



Predicted Diversity and Comparative Development in 1500

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable is Log Population Density in 1500					
Predicted Diversity	250.99***		213.54***	203.02***	195.42***	199.73**
	(68.26)		(63.50)	(61.05)	(56.09)	(80.51)
Predicted Diversity Sqr.	-177.40***		-152.11***	-141.98***	-137.98***	-146.17***
	(50.22)		(46.65)	(44.83)	(40.84)	(56.26)
Log Years since NR		1.29***	1.05***		1.16***	1.24***
		(0.18)	(0.19)		(0.15)	(0.24)
Log % of Arable Land				0.52***	0.40***	0.39***
				(0.12)	(0.09)	(0.10)
Log Absolute Latitude				-0.17*	-0.34***	-0.42***
				(0.09)	(0.09)	(0.12)
Log Agri. Suitability				0.19	0.31***	0.26***
				(0.12)	(0.10)	(0.10)
Optimal Diversity	0.707		0.702	0.715	0.708	0.683
	(0.021)		(0.025)	(0.110)	(0.051)	(0.110)
Continent Dummies	No	No	No	No	No	Yes
Observations	145	145	145	145	145	145
R-squared	0.22	0.26	0.38	0.50	0.67	0.69

Bootstrap standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

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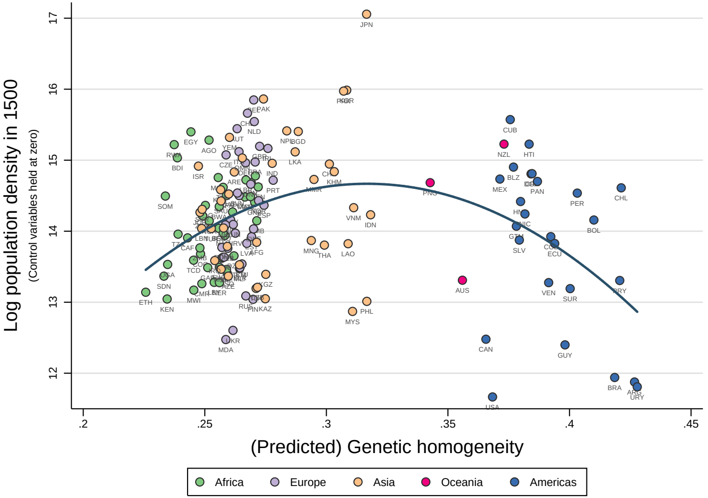

Interpretations – Diversity and Comparative Development in 1500

- Optimal GD in 1500 $= 0.6832 \approx$ GD in Japan $= 0.6835$
- Increasing GD of the most homogeneous population in South America by:
  - $0.11 \implies$ 6-fold increase in population density in 1500
  - $0.01 \implies$ 44% increase in population density in 1500
- Decreasing GD of the most heterogeneous population in East Africa by:
  - $0.09 \implies$ 3-fold increase in population density in 1500
  - $0.01 \implies$ 18% increase in population density in 1500
- 0.01 change from the optimal level of GD
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- Optimal GD in 1500 $= 0.6832 \approx$ GD in Japan $= 0.6835$
- Increasing GD of the most homogeneous population in South America by:
  - $0.11 \implies$ 6-fold increase in population density in 1500
  - $0.01 \implies$ 44% increase in population density in 1500
- Decreasing GD of the most heterogeneous population in East Africa by:
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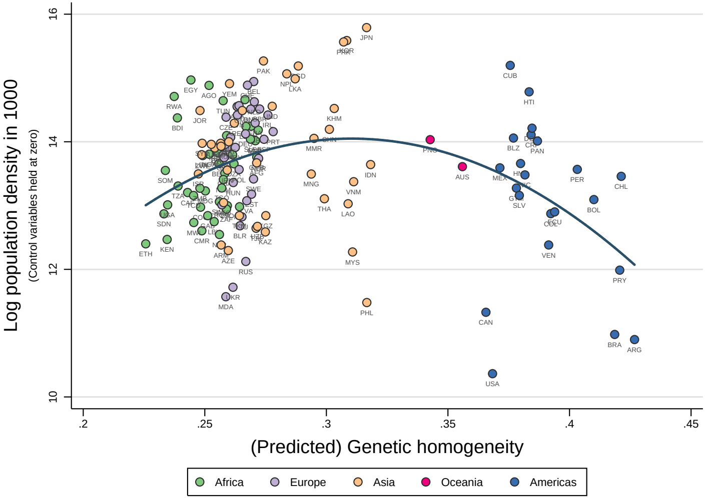
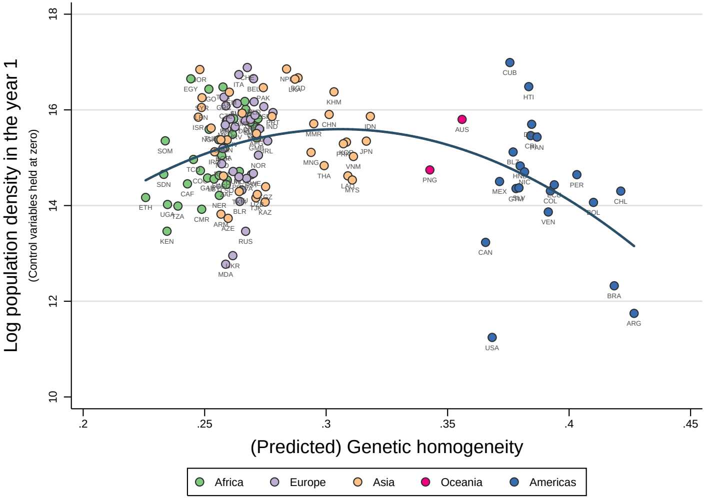
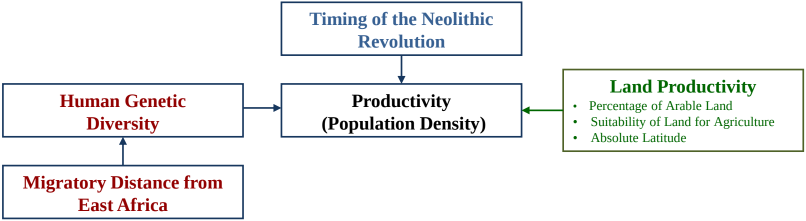
Predicted Diversity and Comparative Development in 1000 CE



Predicted Diversity and Comparative Development in 1 CE



The Role of Omitted Variables



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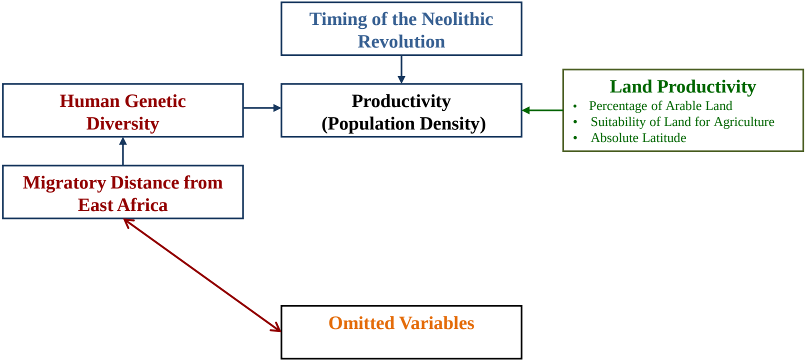

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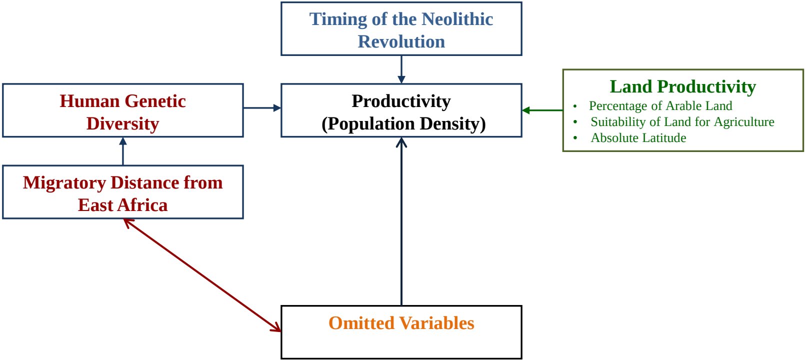
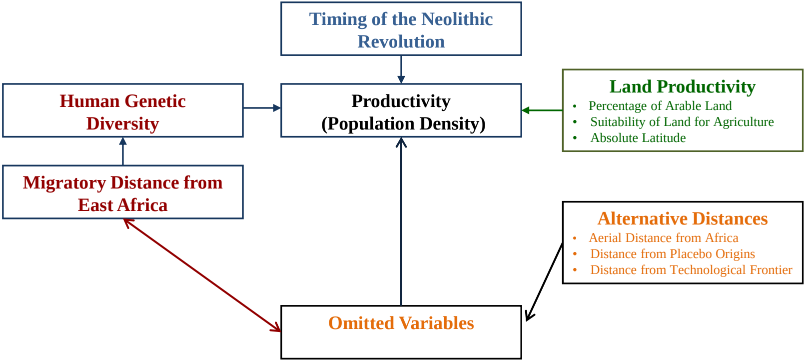


The Role of Omitted Variables – Alternative Distances



Robustness: Distances from Placebo Origins

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log Population Density in 1500				
Distance calculated from:	Addis Ababa	Addis Ababa	London	Tokyo	Mexico City
Migratory Distance	0.138**		-0.040	0.052	-0.063
	(0.061)		(0.063)	(0.145)	(0.099)
Migratory Distance Sqr.	-0.008***		-0.002	-0.006	0.005
	(0.002)		(0.002)	(0.007)	(0.004)
Aerial Distance		-0.008			
		(0.106)			
Aerial Distance Sqr.		-0.005			
		(0.006)			
Log Years since NR	1.160***	1.158***	1.003***	1.047***	1.619***
	(0.144)	(0.138)	(0.164)	(0.225)	(0.277)
Log % of Arable Land	0.401***	0.488***	0.357***	0.532***	0.493***
	(0.091)	(0.102)	(0.092)	(0.089)	(0.094)
Log Absolute Latitude	-0.342***	-0.263***	-0.358***	-0.334***	-0.239***
	(0.091)	(0.097)	(0.112)	(0.099)	(0.083)
Log Agri. Suitability	0.305***	0.254**	0.344***	0.178**	0.261***
	(0.091)	(0.102)	(0.092)	(0.080)	(0.092)
Observations	145	145	145	145	145
R-squared	0.67	0.59	0.67	0.59	0.63

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Regional Technological Frontiers

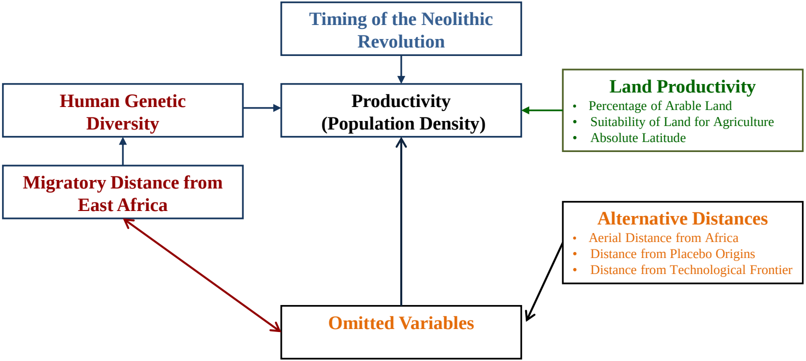
City & Modern Location	Continent	Sociopolitical Entity	Period
Cairo, Egypt	Africa	Mamluk Sultanate	1500 CE
Fez, Morocco	Africa	Marinid Kingdom of Fez	1500 CE
London, UK	Europe	Tudor Dynasty	1500 CE
Paris, France	Europe	Valois-Orléans Dynasty	1500 CE
Constantinople, Turkey	Asia	Ottoman Empire	1500 CE
Peking, China	Asia	Ming Dynasty	1500 CE
Tenochtitlan, Mexico	Americas	Aztec Civilization	1500 CE
Cuzco, Peru	Americas	Inca Civilization	1500 CE
Cairo, Egypt	Africa	Fatimid Caliphate	1000 CE
Kairwan, Tunisia	Africa	Berber Zirite Dynasty	1000 CE
Constantinople, Turkey	Europe	Byzantine Empire	1000 CE
Cordoba, Spain	Europe	Caliphate of Cordoba	1000 CE
Baghdad, Iraq	Asia	Abbasid Caliphate	1000 CE
Kaifeng, China	Asia	Song Dynasty	1000 CE
Tollan, Mexico	Americas	Classic Maya Civilization	1000 CE
Huari, Peru	Americas	Huari Culture	1000 CE
Alexandria, Egypt	Africa	Roman Empire	1 CE
Carthage, Tunisia	Africa	Roman Empire	1 CE
Athens, Greece	Europe	Roman Empire	1 CE
Rome, Italy	Europe	Roman Empire	1 CE
Luoyang, China	Asia	Han Dynasty	1 CE
Seleucia, Iraq	Asia	Seleucid Dynasty	1 CE
Teotihuacán, Mexico	Americas	Pre-classic Maya Civilization	1 CE
Cahuachi, Peru	Americas	Nazca Culture	1 CE

Robustness to Distance from Regional Technological Frontiers

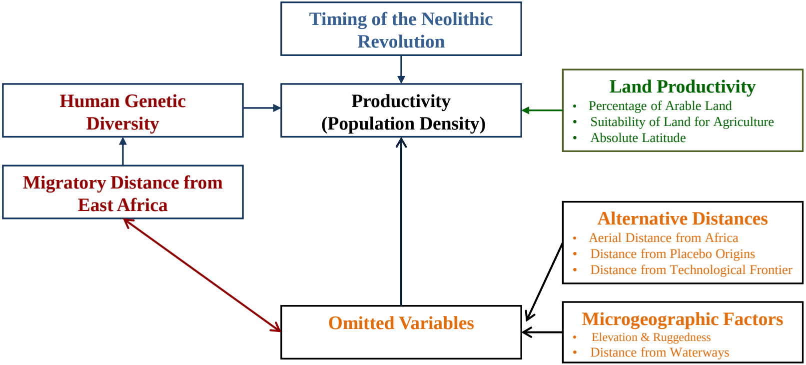
	(1)	(2)	(3)
	Log Population Density 1500 CE	Log Population Density 1000 CE	Log Population Density 1 CE
Predicted Diversity	156.74**	183.77**	215.86**
	(77.98)	(91.20)	(106.50)
Predicted Diversity Sqr.	-114.63**	-134.61**	-157.72**
	(54.67)	(63.65)	(74.82)
Log Years since NR	Yes	Yes	Yes
Land Prod. Controls	Yes	Yes	Yes
Log Distance to Frontier in 1500 CE	-0.19***		
	(0.07)		
Log Distance to Frontier in 1000 CE		-0.23**	
		(0.11)	
Log Distance to Frontier in 1 CE			-0.30***
			(0.10)
Optimal Diversity	0.684	0.683	0.684
	(0.169)	(0.218)	(0.266)
Continent Dummies	Yes	Yes	Yes
Observations	145	140	126
R-squared	0.72	0.64	0.66

Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

The Role of Omitted Variables



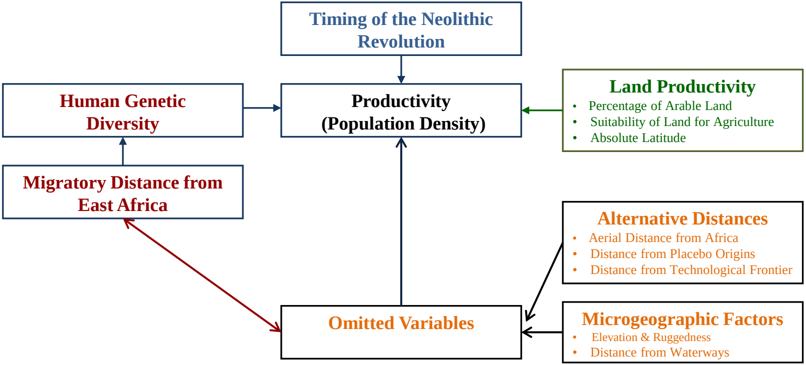
The Role of Omitted Variables – Microgeographic Factors



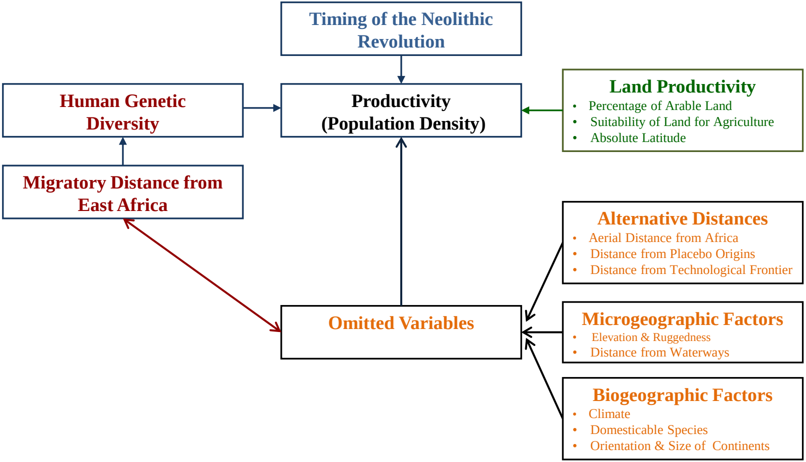
Robustness to Microgeographic Factors

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log Population Density in 1500				
Predicted Diversity	159.92***	153.20***	157.07**	150.02***	157.06**
	(56.00)	(53.39)	(78.82)	(49.36)	(68.61)
Predicted Diversity Sqr.	-110.39***	-105.33***	-112.78**	-102.76***	-114.99**
	(41.08)	(39.11)	(55.48)	(36.23)	(48.26)
Log Years since NR	Yes	Yes	Yes	Yes	Yes
Land Prod. Controls	Yes	Yes	Yes	Yes	Yes
Mean Elevation	-0.48**			0.51*	0.50*
	(0.23)			(0.27)	(0.27)
Roughness	5.15***			3.09*	4.08**
	(1.77)			(1.74)	(1.84)
Roughness Sqr.	-7.05**			-7.05**	-7.63***
	(3.11)			(2.96)	(2.91)
Distance to Nearest Waterway		-0.49***	-0.44**	-0.47**	-0.39**
		(0.18)	(0.18)	(0.18)	(0.18)
% Land within 100 km of Waterway		0.70**	0.73**	1.11***	1.18***
		(0.28)	(0.31)	(0.29)	(0.29)
Optimal Diversity	0.724	0.727	0.696	0.730	0.683
	(0.201)	(0.190)	(0.187)	(0.229)	(0.095)
Continent Dummies	No	No	Yes	No	Yes
Observations	145	145	145	145	145
R-squared	0.69	0.74	0.75	0.76	0.78

The Role of Omitted Variables



The Role of Omitted Variables – Biogeography



Robustness to Biogeography

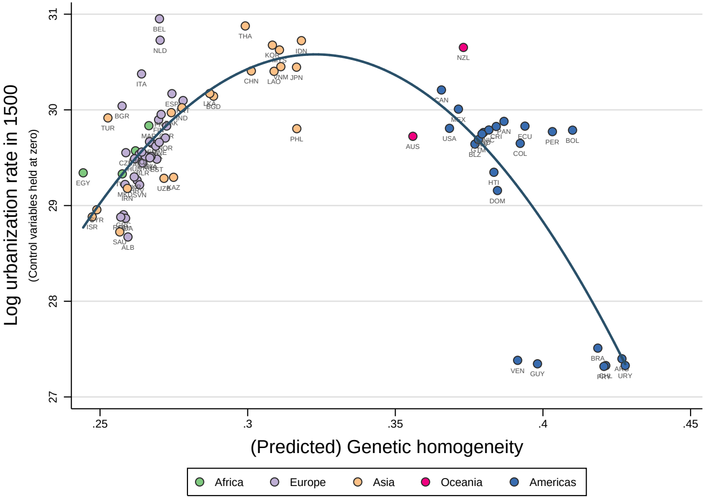
	(1)	(2)	(3)	(4)	(5)
	Dependent Variable is Log Population Density in 1500				
Predicted Diversity	216.85***	252.08***	174.41***	212.12***	274.92***
	(62.06)	(70.81)	(62.75)	(72.13)	(72.12)
Predicted Diversity Sqr.	-154.75***	-180.65***	-125.14***	-151.58***	-197.12***
	(45.19)	(51.89)	(45.72)	(52.79)	(52.40)
Log Years since NR	1.30***				1.16***
	(0.16)				(0.31)
Land Prod. Controls	Yes	Yes	Yes	Yes	Yes
Climate		0.62***		0.42	0.37*
		(0.14)		(0.27)	(0.22)
Orientation of Axis		0.28		0.04	-0.17
		(0.33)		(0.30)	(0.27)
Size of Continent		-0.01		-0.01	-0.01
		(0.02)		(0.01)	(0.01)
Domesticable Plants			0.02	-0.01	0.00
			(0.02)	(0.02)	(0.02)
Domesticable Animals			0.15**	0.12	-0.01
			(0.06)	(0.07)	(0.07)
Optimal Diversity	0.701	0.698	0.697	0.700	0.697
	(0.123)	(0.016)	(0.159)	(0.045)	(0.041)
Observations	96	96	96	96	96
R-squared	0.74	0.70	0.70	0.72	0.78

Robustness to the Use of Urbanization Rates in 1500

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log Urbanization Rate in 1500				
Predicted Diversity	120.583**	165.167***	93.467*	148.757***	234.410***
	(51.618)	(50.088)	(48.769)	(48.373)	(67.321)
Predicted Diversity Square	-84.760**	-120.124***	-62.408*	-106.165***	-166.786***
	(38.423)	(37.208)	(36.650)	(36.506)	(48.780)
Log Years since NR		0.457**		0.402**	0.752***
		(0.224)		(0.202)	(0.257)
Log % of Arable Land			-0.097**	-0.116***	-0.119**
			(0.043)	(0.044)	(0.052)
Log Absolute Latitude			-0.334**	-0.236	-0.151
			(0.151)	(0.155)	(0.170)
Log Agri. Suitability			0.002	-0.036	0.031
			(0.057)	(0.058)	(0.059)
Continent Dummies	No	No	No	No	Yes
Observations	80	80	80	80	80
R-squared	0.30	0.35	0.40	0.44	0.51

Bootstrap standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Genetic Diversity and Urbanization Rates in 1500



Measure of Contemporary Genetic Diversity

- The index of contemporary genetic diversity captures:
  - Proportional representation of each ancestral population within a country
  - Genetic diversity among the ancestral populations of each country
    - Projected based on migratory distance of this ancestral population from East Africa
  - Genetic distance between all pairs of ancestral populations of each country
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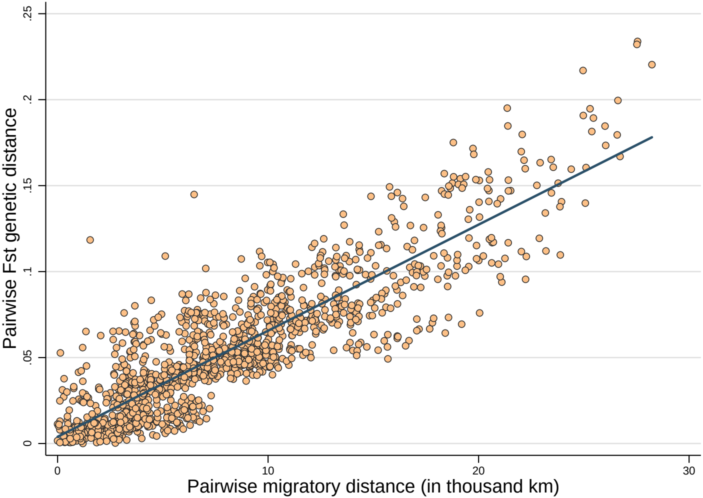
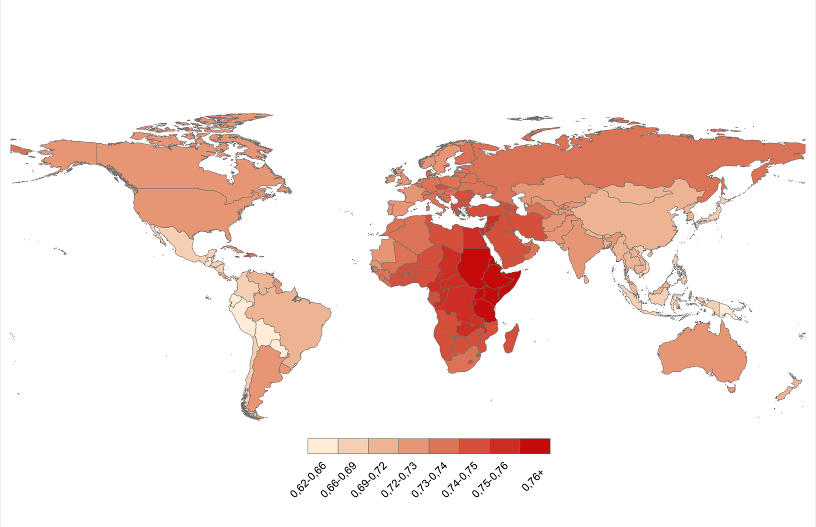
Genetic Distance



Genetic Diversity across Countries in 2000



Empirical Model III

- Testing the hypothesis using contemporary genetic diversity
  - 145-country sample
- Empirical specification

$$\ln y_i = \gamma_0 + \gamma_1 \hat{G}_i + \gamma_2 \hat{G}_i^2 + \gamma_3 \ln T_i + \gamma_4' \ln X_i + \gamma_5' \ln \Lambda_i + \gamma_6 \ln \Gamma_i + \eta_i$$

  - $y_i \equiv$ income per capita of country i in the year 2000
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  - $y_i \equiv$ income per capita of country i in the year 2000
  - $\hat{G}_i \equiv$ index of contemporary genetic diversity of country i
  - $T_i \equiv$ years elapsed since the Neolithic Revolution (NR) for country i
  - $X_i \equiv$ vector of land productivity controls for country i
  - $\Lambda_i \equiv$ vector of institutional and cultural controls for country i
  - $\Gamma_i \equiv$ vector of additional geographical controls for country i
  - $\eta_i \equiv$ error term for country i

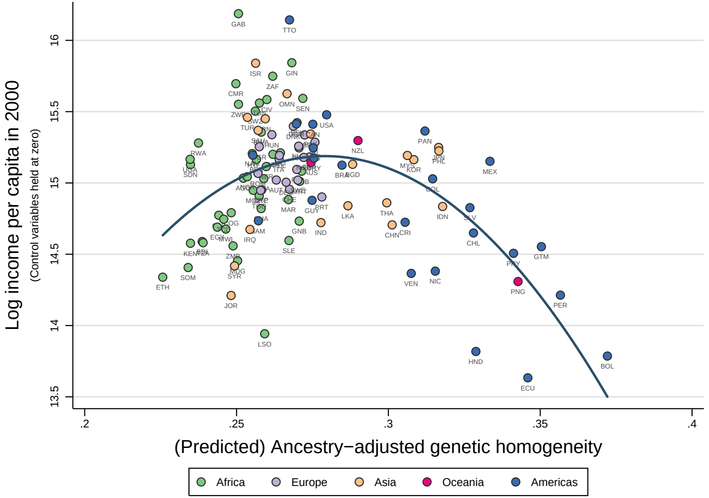
Genetic Diversity and Economic Development in 2000 and 1500

	(1)	(2)	(3)	(4)
	Log Income per Capita in 2000			Log Population Density in 1500
Adjusted Diversity	204.610**	237.238***	244.960***	
	(88.466)	(86.278)	(85.454)	
Adjusted Diversity Sqr.	-143.437**	-166.507***	-171.364***	
	(62.545)	(61.363)	(60.843)	
Unadjusted. Diversity				198.587**
				(79.110)
Unadjusted. Diversity Sqr.				-145.320***
				(55.472)
Log Adj. Years since NR		0.061	0.002	
		(0.262)	(0.305)	
Log Years since NR	-0.151			1.238***
	(0.186)			(0.230)
Log % of Arable Land	-0.110	-0.119	-0.137	0.378***
	(0.100)	(0.107)	(0.111)	(0.100)
Log Absolute Latitude	0.164	0.172	0.192	-0.423***
	(0.125)	(0.119)	(0.143)	(0.124)
Log Agri. Suitability	-0.193**	-0.177*	-0.189*	0.264***
	(0.095)	(0.102)	(0.102)	(0.096)
Log Population Density in 1500			0.047	
			(0.097)	
Optimal Diversity	0.713	0.712	0.715	0.683
	(0.100)	(0.036)	(0.118)	(0.095)
Continent Dummies	Yes	Yes	Yes	Yes
Observations	143	143	143	143
R-squared	0.57	0.57	0.57	0.68

Genetic Diversity and Comparative Development in 2000

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log Income per Capita in 2000				
Adjusted Diversity	315.282***	225.858***	204.102***	277.342***	215.675***
	(84.215)	(67.669)	(66.984)	(70.232)	(63.954)
Adjusted Diversity Sqr.	-220.980***	-155.826***	-140.850***	-192.386***	-150.871***
	(59.562)	(47.962)	(47.393)	(49.675)	(45.554)
Log Adj. Time from NR	-0.273	-0.092	-0.062	0.396*	-0.046
	(0.269)	(0.200)	(0.203)	(0.233)	(0.208)
Log % of Arable Land	-0.218***	-0.159***	-0.163***	-0.183***	-0.084
	(0.061)	(0.049)	(0.050)	(0.051)	(0.056)
Log Absolute Latitude	0.123	0.083	0.080	0.009	-0.006
	(0.122)	(0.100)	(0.101)	(0.108)	(0.087)
Social Infrastructure		2.359***	2.069***	1.826***	0.880**
		(0.269)	(0.377)	(0.417)	(0.418)
Democracy			0.036		
			(0.029)		
Ethnic Fractionalization				-0.333	-0.122
				(0.280)	(0.265)
% Population at Risk				-0.502	-0.723**
of Contracting Malaria				(0.351)	(0.353)
Avg. Schooling					0.134***
					(0.042)
Optimal Diversity	0.713	0.725	0.725	0.721	0.715
	(0.014)	(0.032)	(0.045)	(0.008)	(0.073)
Continent Dummies	Yes	Yes	Yes	Yes	Yes
Legal Origin Dummies	No	No	No	Yes	Yes
Major Religion Shares	No	No	No	Yes	Yes
Observations	109	109	109	109	94

Genetic Diversity and Comparative Development in 2000



Interpretations – Diversity and Comparative Development in 2000

- Optimal GD in 2000 $= 0.7208 \approx$ GD in US $= 0.7206$
- Increasing GD of Bolivia (0.63), the most homogeneous country, by:
  - $0.09 \implies$ 5.4-fold increase income per capita in 2000
    - From 9% to 40% of that of the US
  - $0.01 \implies$ 39% increase income per capita in 2000
- Decreasing GD of Ethiopia (0.77), the most heterogeneous country, by:
  - $0.05 \implies$ 1.7-fold increase in income per capita in 2000
    - From 2% to 4% of that of the US
  - $0.01 \implies$ 21% increase in income per capita in 2000
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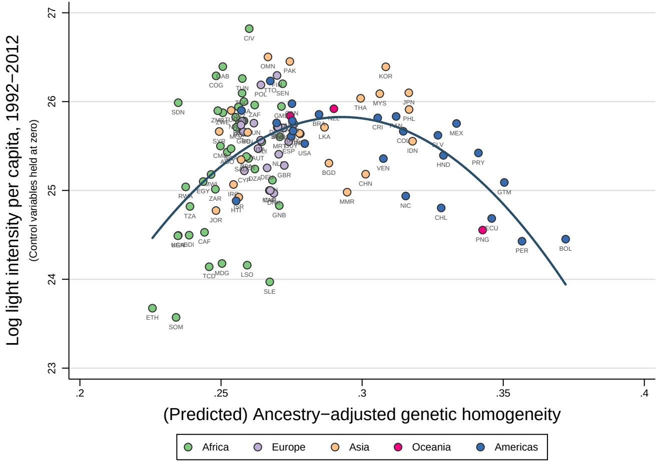
Addressing Endogenous Post-1500 Migrations

	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample	Non OECD	w/o Neo Europes	w/o Latin America	w/o Sub Sahara	>0.97 Indigenous
	Dependent Variable is Log Income per Capita in 2000					
Adjusted Diversity	277.342***	271.979***	261.367***	412.222***	264.805**	304.735**
	(70.232)	(88.479)	(70.533)	(148.584)	(111.365)	(111.588)
Adjusted Diversity Sqr.	-192.386***	-188.974***	-181.811***	-287.067***	-183.863**	-213.389**
	(49.675)	(62.096)	(49.671)	(101.906)	(80.398)	(77.255)
Log Adj. Time of NR	0.396*	0.390	0.355	0.518*	0.068	0.448*
	(0.233)	(0.281)	(0.231)	(0.298)	(0.442)	(0.254)
Log % of Arable Land	-0.183***	-0.236***	-0.201***	-0.189***	-0.211**	-0.104
	(0.051)	(0.060)	(0.055)	(0.050)	(0.097)	(0.061)
Log Absolute Latitude	0.009	-0.021	-0.025	-0.139	0.218	-0.074
	(0.108)	(0.119)	(0.111)	(0.126)	(0.242)	(0.130)
Social Infrastructure	1.826***	1.313**	1.416***	2.044***	1.585***	1.311*
	(0.417)	(0.579)	(0.507)	(0.545)	(0.486)	(0.716)
Ethnic Frac.	-0.333	-0.437	-0.390	-0.752**	0.104	-0.044
	(0.280)	(0.375)	(0.300)	(0.348)	(0.408)	(0.412)
% Population at Risk	-0.502	-0.605	-0.591	-0.308	-0.425	-0.153
of Malaria	(0.351)	(0.381)	(0.370)	(0.486)	(0.581)	(0.434)
% Population Living	-0.319	-0.196	-0.302	-0.520**	-0.528	-0.339
in Tropical Zones	(0.204)	(0.239)	(0.219)	(0.252)	(0.341)	(0.312)
Optimal Diversity	0.721	0.720	0.719	0.718	0.720	0.714
	(0.083)	(0.085)	(0.015)	(0.023)	(0.180)	(0.012)
Observations	109	83	105	87	71	37
R-squared	0.90	0.82	0.89	0.93	0.86	0.98

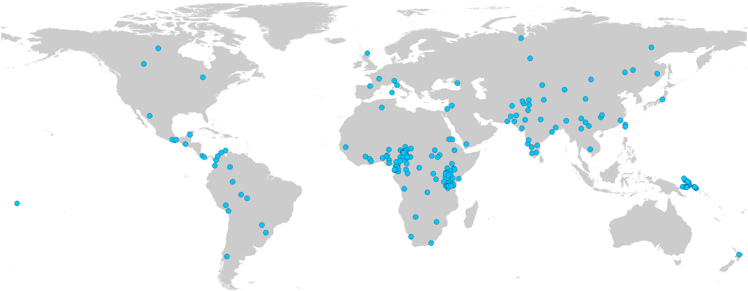
Bootstrap standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Genetic Diversity and Light Intensity per Capita 1992-2012

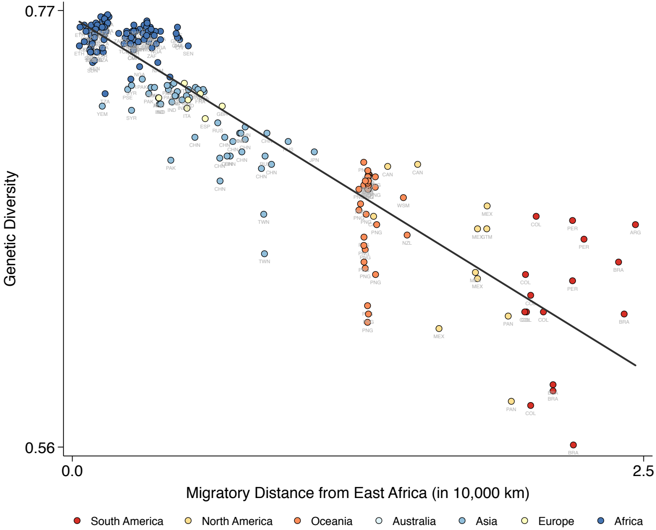


Source: Ashraf-Galor-Klemp (2014)

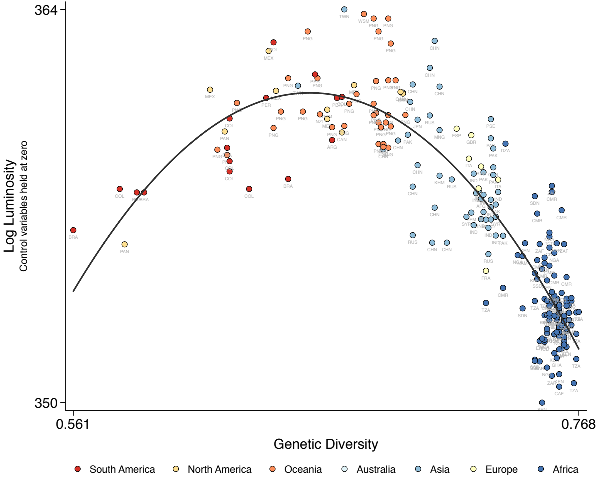
Observed Genetic Diversity - 232 Ethnic Groups



Migratory Distance from Africa and Genetic Diversity

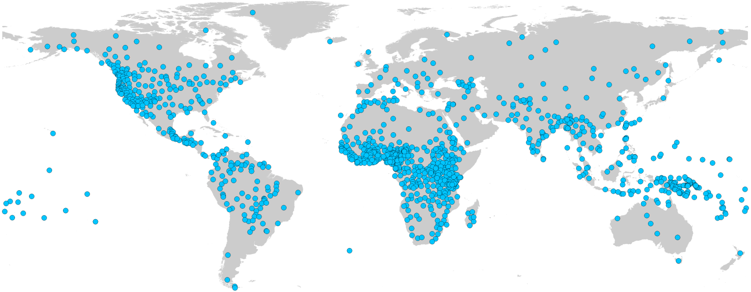


Genetic Diversity and Productivity of Ethnic Group - (IV Regressions)



Source: Ashraf-Galor-Klemp (2015)

Predicted Genetic Diversity - 1331 Ethnic Groups



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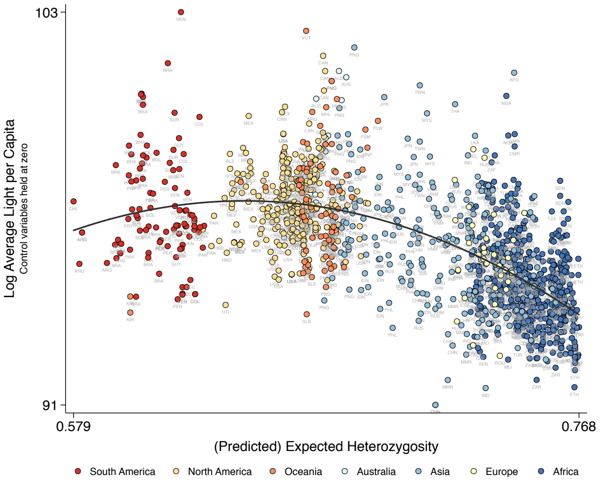
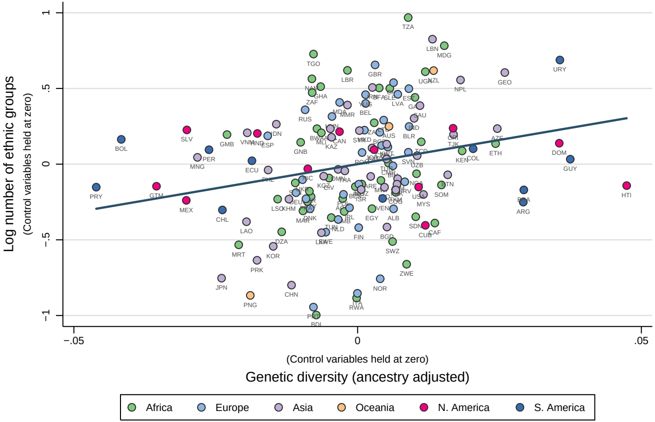


Source: Ashraf-Galor-Klemp (2015)

Cost of Diversity: Genetic Diversity & Cultural Fragmentation

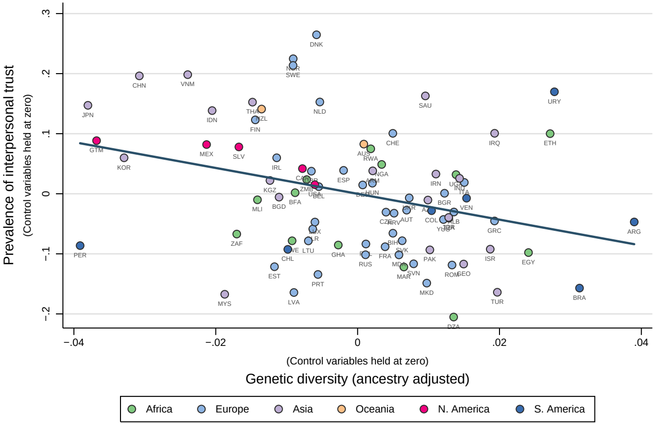


Relationship conditional on historical and geographical controls, as well as continent fixed effects
Slope coefficient = 6.397; (robust) standard error = 1.973; t−statistic = 3.242; partial R−squared = 0.059; observations = 144

Source: Ashraf and Galor (2013b)

Source: Ashraf-Galor (AER, May 2013)

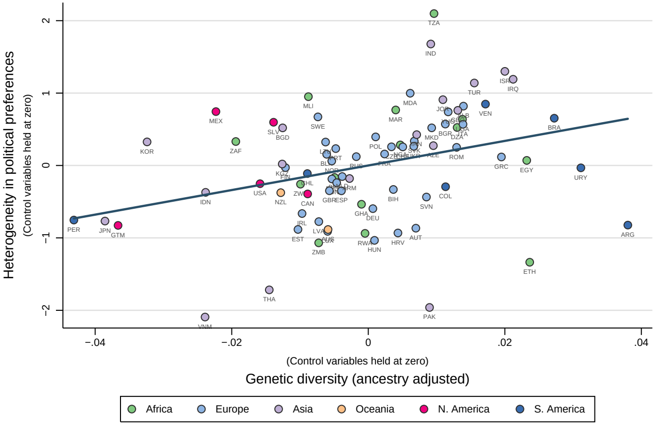
Cost of Diversity: Genetic Diversity & Trust



Relationship conditional on geographical controls and region fixed effects
Slope coefficient = −2.151; (robust) standard error = 0.756; t−statistic = −2.845; partial R−squared = 0.105; observations = 84

Source: Arbatli, Ashraf, and Galor (2015)

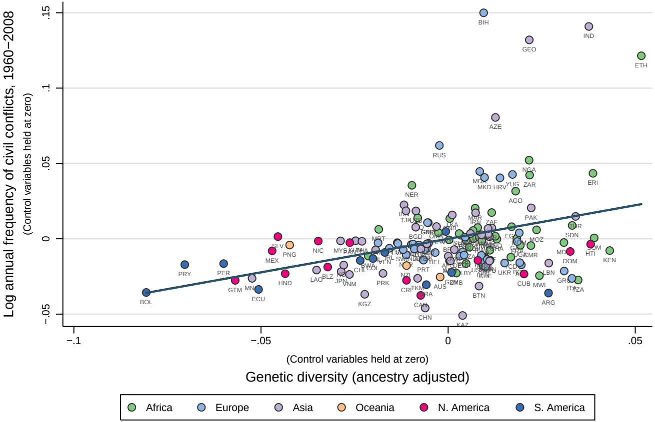
Cost of Diversity: Genetic Diversity & Heterogeneity in Preferences



Relationship conditional on geographical controls and region fixed effects
Slope coefficient = 16.963; (robust) standard error = 5.954; t−statistic = 2.849; partial R−squared = 0.111; observations = 81

Source: Arbatli, Ashraf, and Galor (2015)

Cost of Diversity: Genetic Diversity & Ethnic Civil Conflict

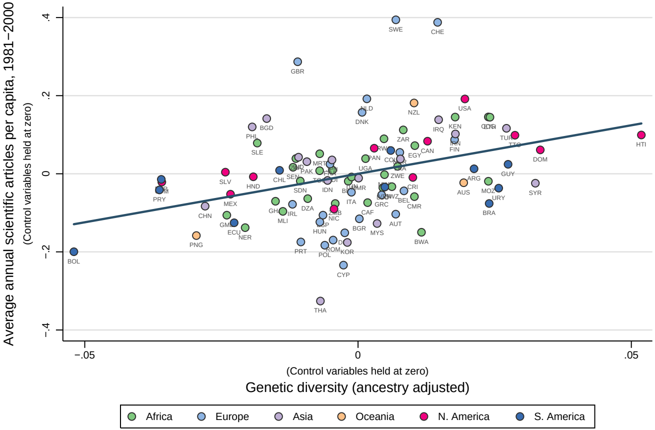


Relationship conditional on geographical controls
Slope coefficient = 0.445; (robust) standard error = 0.117; t−statistic = 3.790; partial R−squared = 0.112; observations = 151

Source: Arbatli, Ashraf, and Galor (2015)

Source: Arbatli-Ashraf-Galor-Klemp (2016)

Benefits of Diversity – Genetic Diversity & Scientific Research



Relationship conditional on historical, geographical, and institutional controls, as well as continent fixed effects
Slope coefficient = 2.484; (robust) standard error = 0.511; t−statistic = 4.864; partial R−squared = 0.131; observations = 93

Source: Ashraf and Galor (2013a)

Conclusions: Roots of Comparative Development

- The migration of humans out of Africa 70,000-90,000 BP affected
  - The distribution of genetic diversity across the globe
  - Comparative economic development
    - Accounts for 16% of the variation in the income per capita across countries
- Variation in the onset of the Neolithic Revolution
  - Affected comprative developmemt till around 1500
  - Has no persistent effect on comparative development in the modern era

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- Diversity adversely affects the cohesiveness of society, increasing the incidence of:
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Policy Implications

- Education policy
    - In overly-diverse societies:
        - Education geared towards: social cohesiveness & tolerance
        - $\Longrightarrow$ Mitigating the cost of diversity
    - In overly-homogeneous societies:
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        - $\Longrightarrow$ substitute for low genetic diversity
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  - In overly-diverse societies:
    - Education geared towards: social cohesiveness & tolerance
    - $\implies$ Mitigating the cost of diversity
  - In overly-homogeneous societies:
    - cultivation of cultural diversity
    - $\implies$ substitute for low genetic diversity
- Optimal level of cultural assimilation

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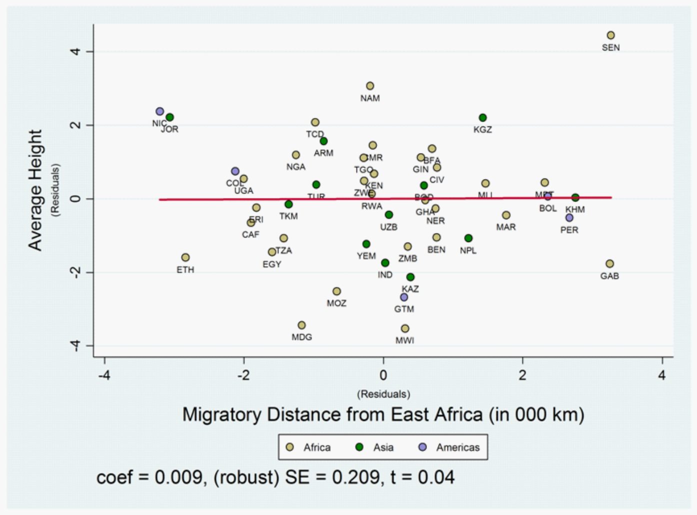
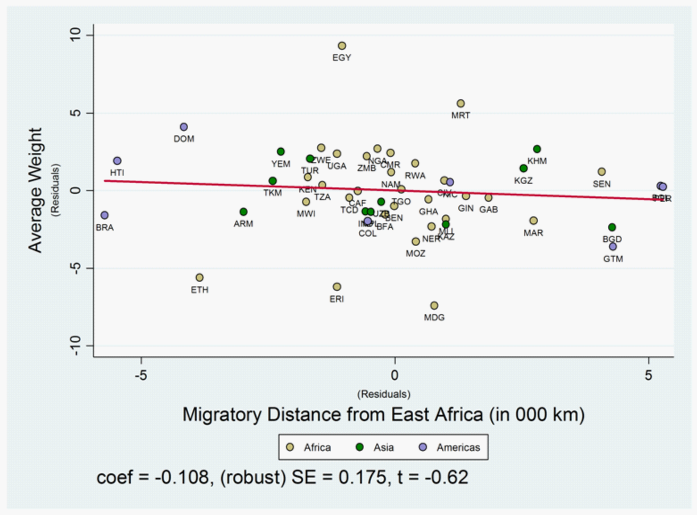
Migratory Distance from East Africa and Height



Accounting for distance from the equator.

Migratory Distance from East Africa and Weight



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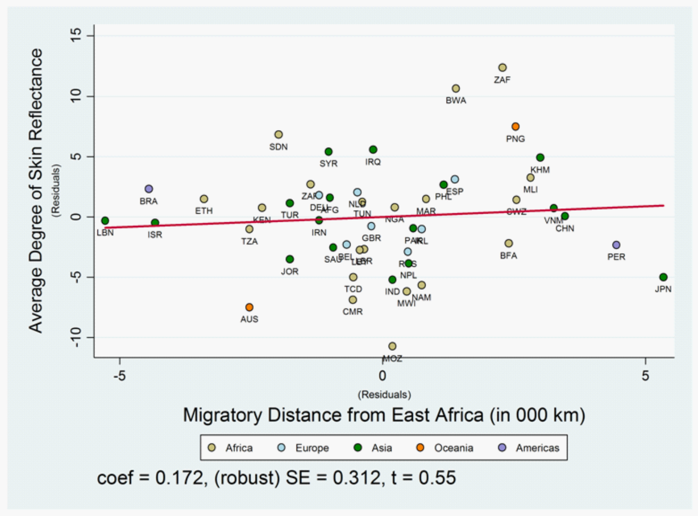
Migratory Distance from East Africa and Skin Reflectance



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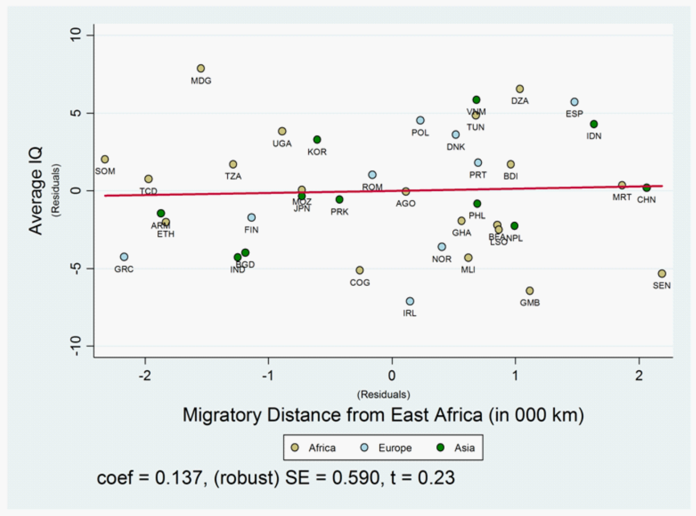
Migratory Distance from East Africa and IQ



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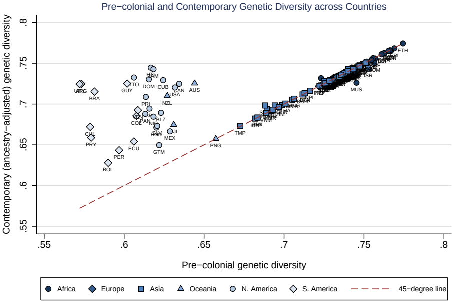
The Impact of Post-1500 Migrations on Genetic Diversity



Correlation in the global sample = 0.750; correlation in the Old−World sample = 0.993

Theoretical Foundations of the Hump-Shaped Effect of Diversity

$$y = (1 - \alpha\omega)A(z, \omega)f(x) \equiv y(\omega); \qquad \alpha \in (0, 1)$$

- $y \equiv$ output per capita
- $A(z, \omega) \equiv$ technological level
- $\omega \in [0, 1] \equiv$ degree of diversity
- $z \equiv$ institutional, geographical, and human capital factors
- $f(x) \equiv$ production function
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Theoretical Foundations of the Hump-Shaped Effect of Diversity

- Diversity and TFP growth

$$A(z,\omega) > 0,\ A_\omega(z,\omega) > 0,\ \ A_{\omega\omega}(z,\omega) < 0$$

$$\lim_{\omega \longrightarrow 0} A_\omega(z,\omega) = \infty;\ \lim_{\omega \longrightarrow 1} A_\omega(z,\omega) = 0$$

- For instance:

$$A(z,\omega) = z \int_0^\omega \omega_i^\theta di \qquad \theta \in (0,1)$$

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Theoretical Foundations of the Hump-Shaped Effect of Diversity

- Properties of $y(\omega)$

$$y'(\omega) = [(1 - \alpha\omega)A_\omega(z, \omega) - \alpha A(z, \omega)]f(x)$$

$$y''(\omega) = [(1 - \alpha\omega)A_{\omega\omega}(z, \omega) - 2\alpha A_\omega(z, \omega)]f(x) < 0$$

$$\lim_{\omega \longrightarrow 0} y'(\omega) > 0; \quad \lim_{\omega \longrightarrow 1} y'(\omega) < 0$$