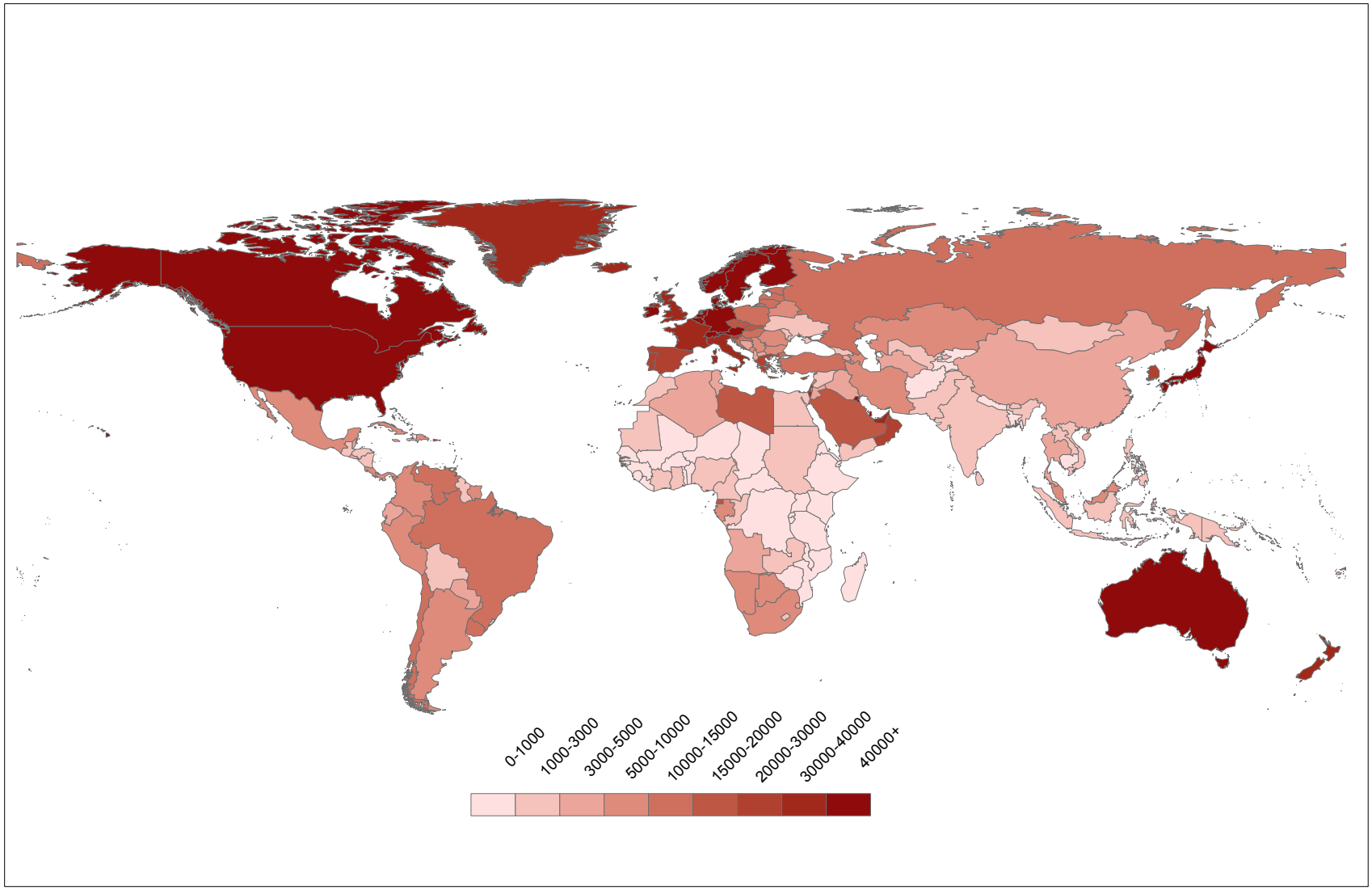
Genetic Diversity and Comparative Development

Oded Galor

Summer Workshop

Lecture IV – July 2014

Income per Capita across the Globe in 2010



Fundamental Research Questions

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- How can policy mitigate the persistent effect of historical factors on comparative development?

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    - $\Longrightarrow$ An optimal level of diversity (for each stage of development)

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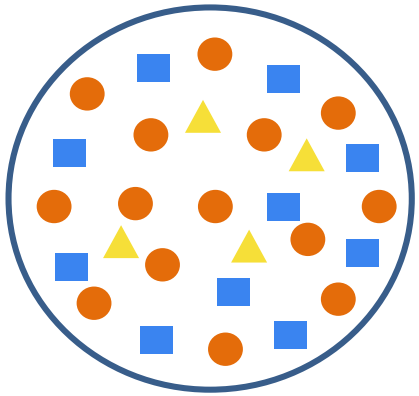
An Illustration of the The Serial Founder Effect



3 Alleles

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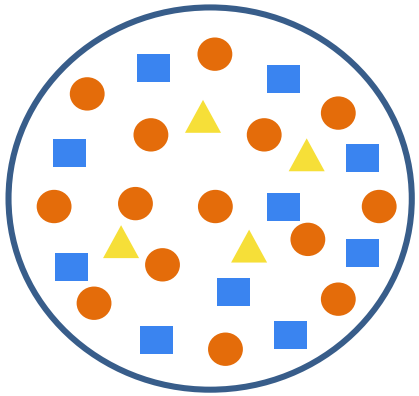

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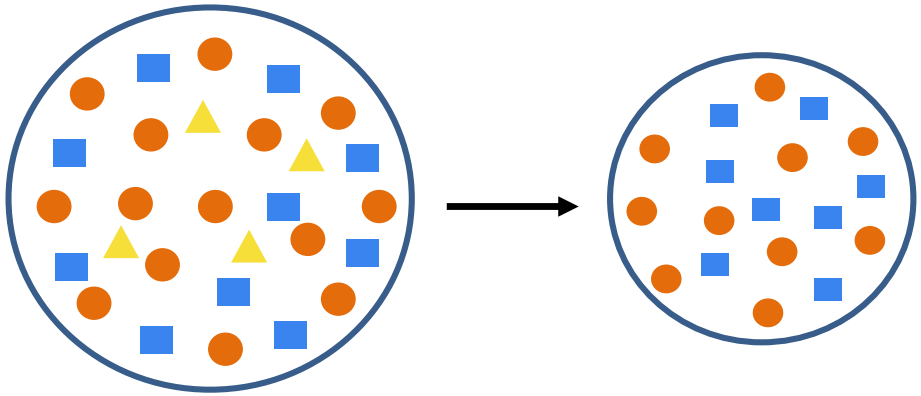

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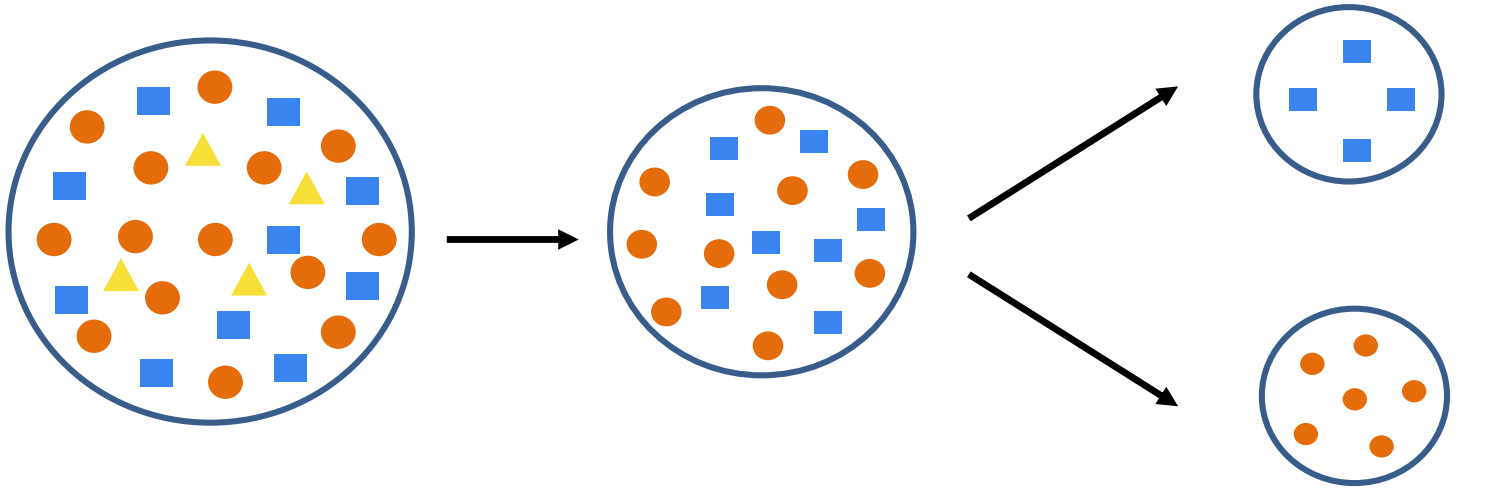

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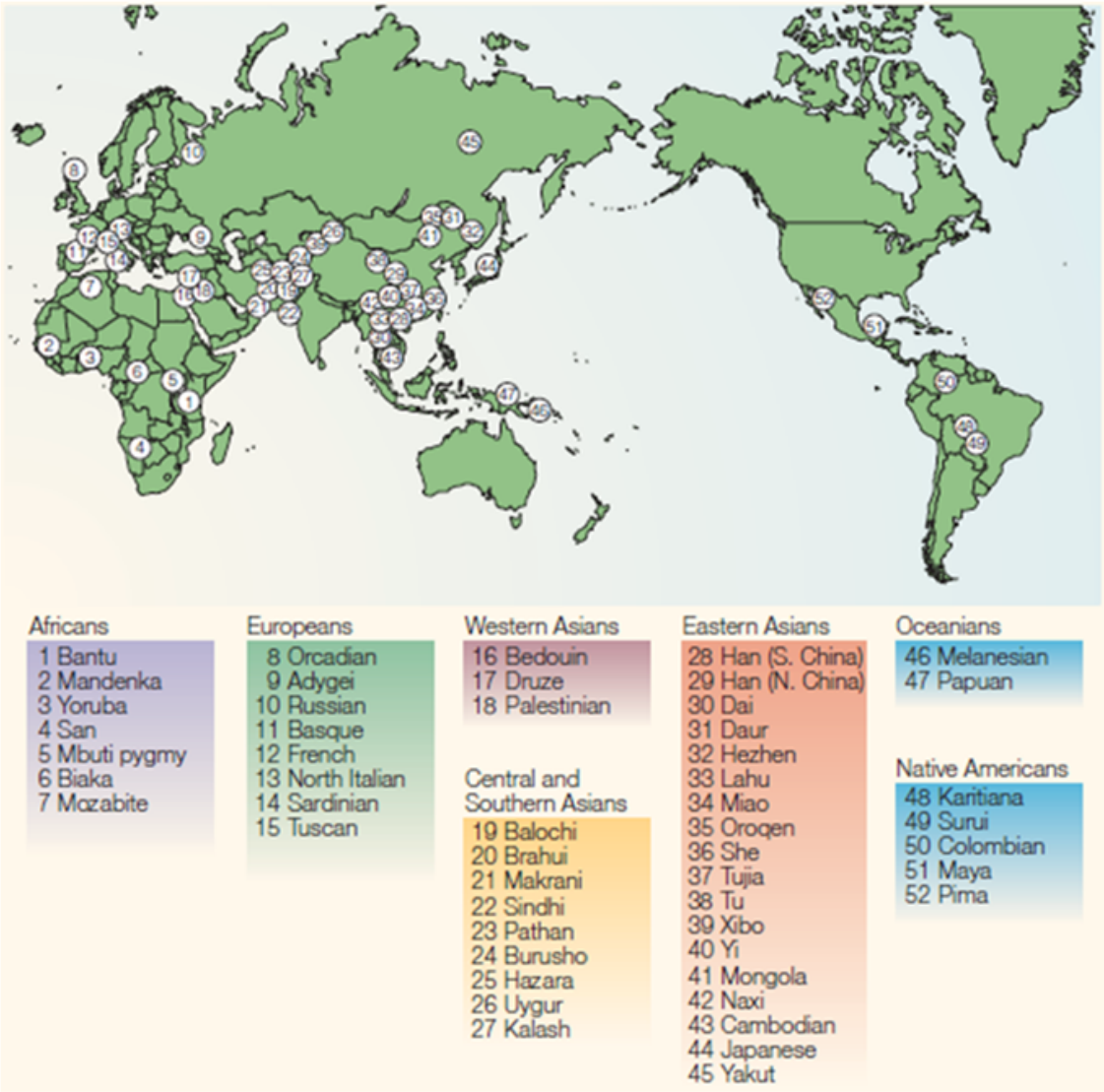
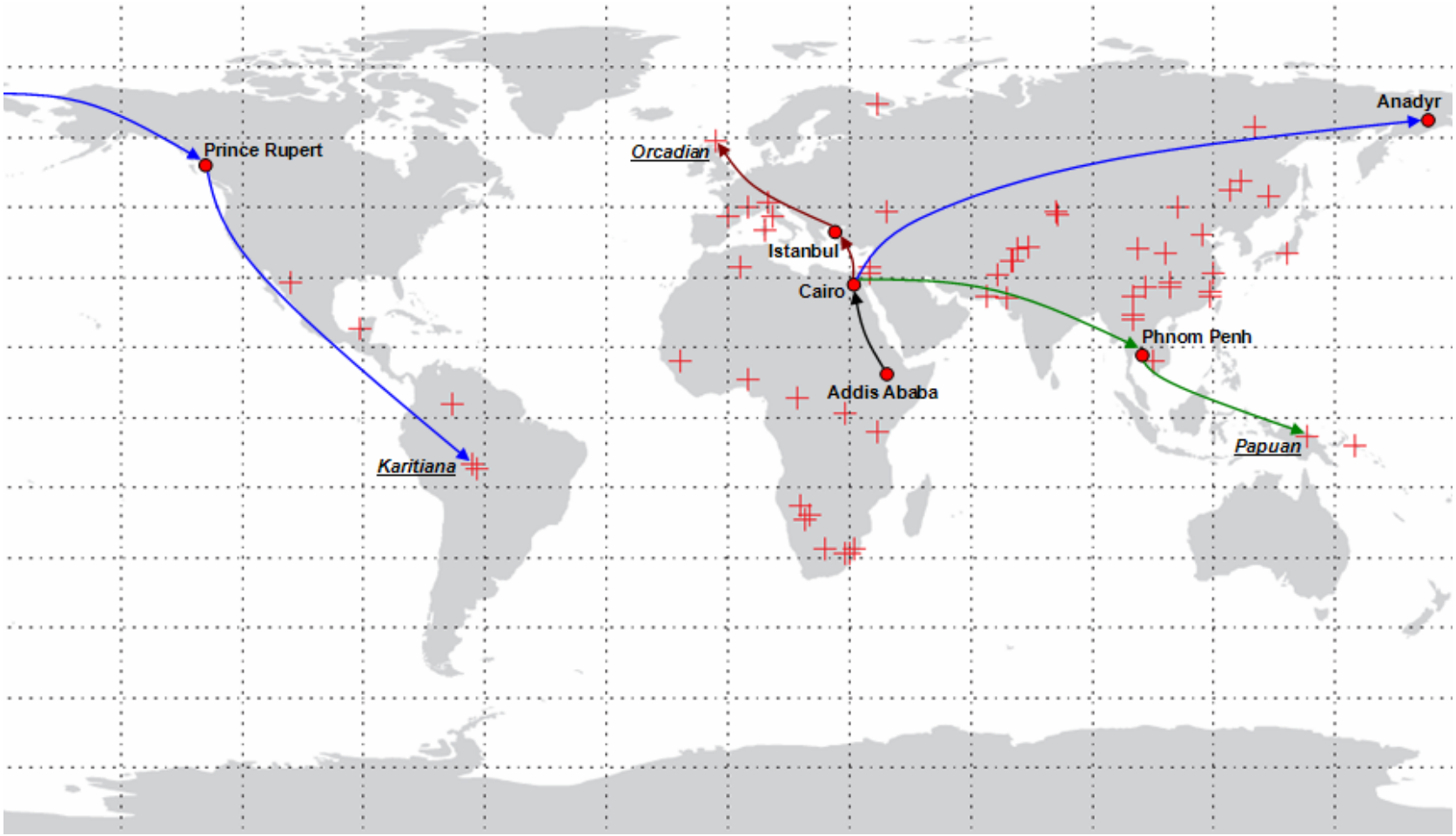
HGDP Ethnic Groups



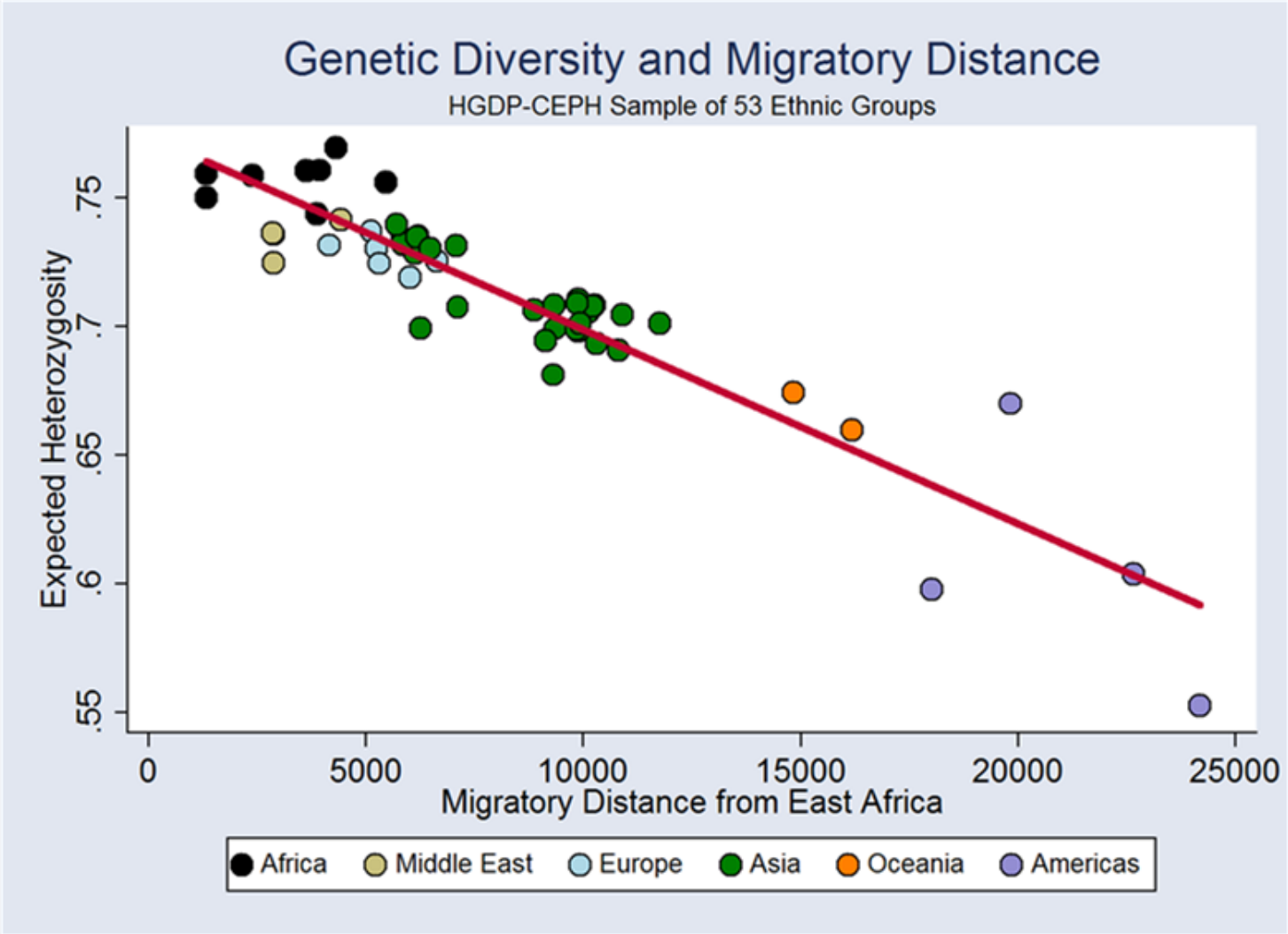
The Spatial Distribution of the HGDP Ethnic Groups



+ 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



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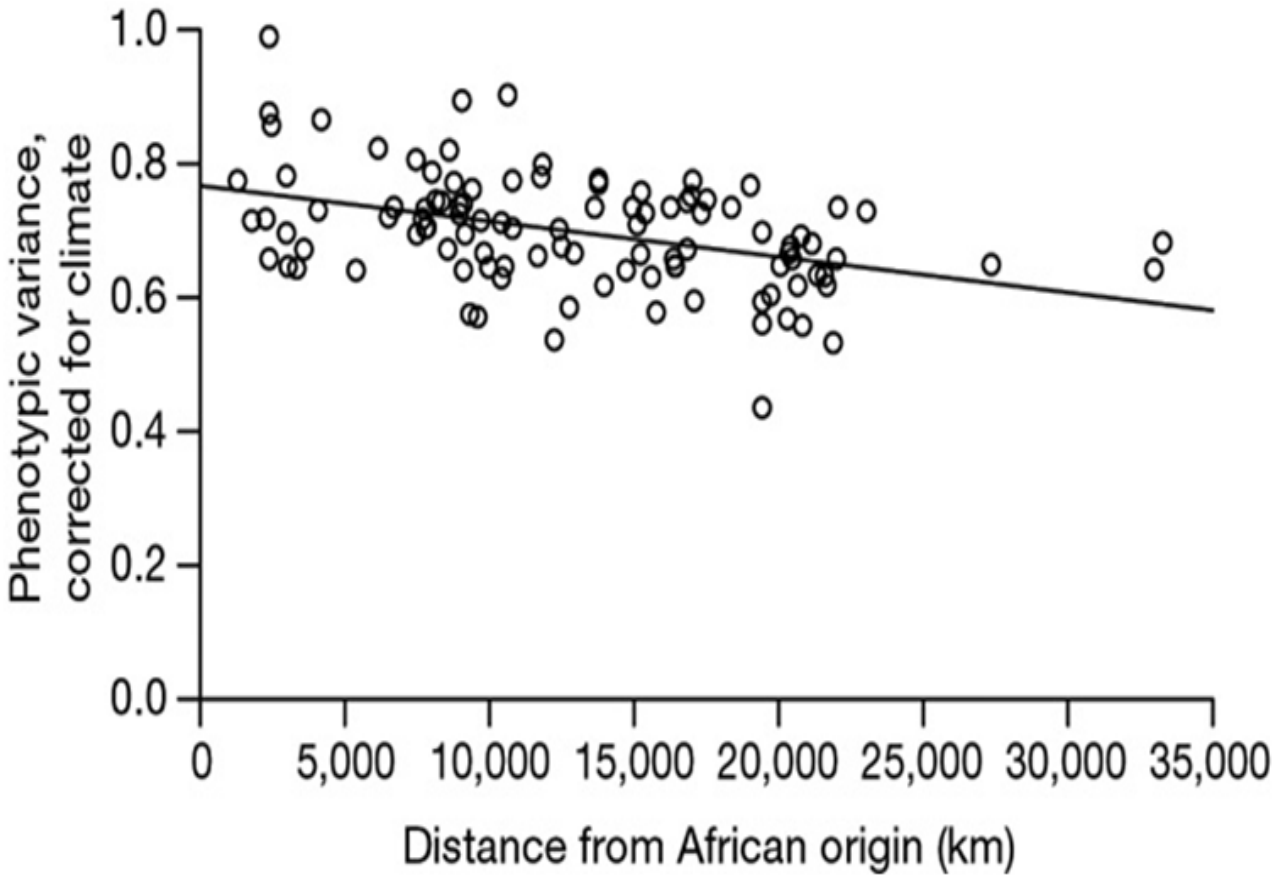
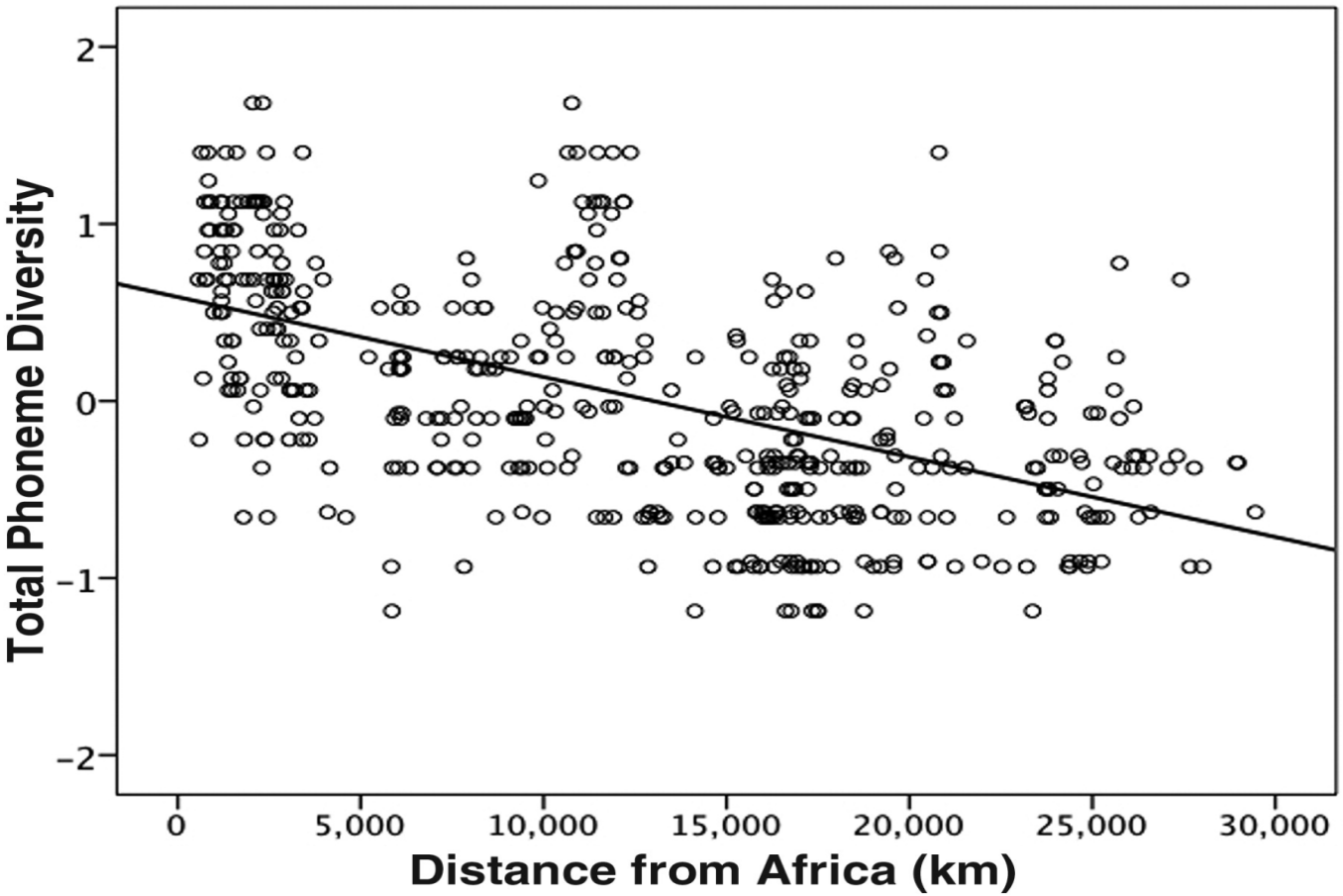
    - Permitting an exploration of the effect of GD on economic outcomes

Distance from Africa and Craniometric Diversity



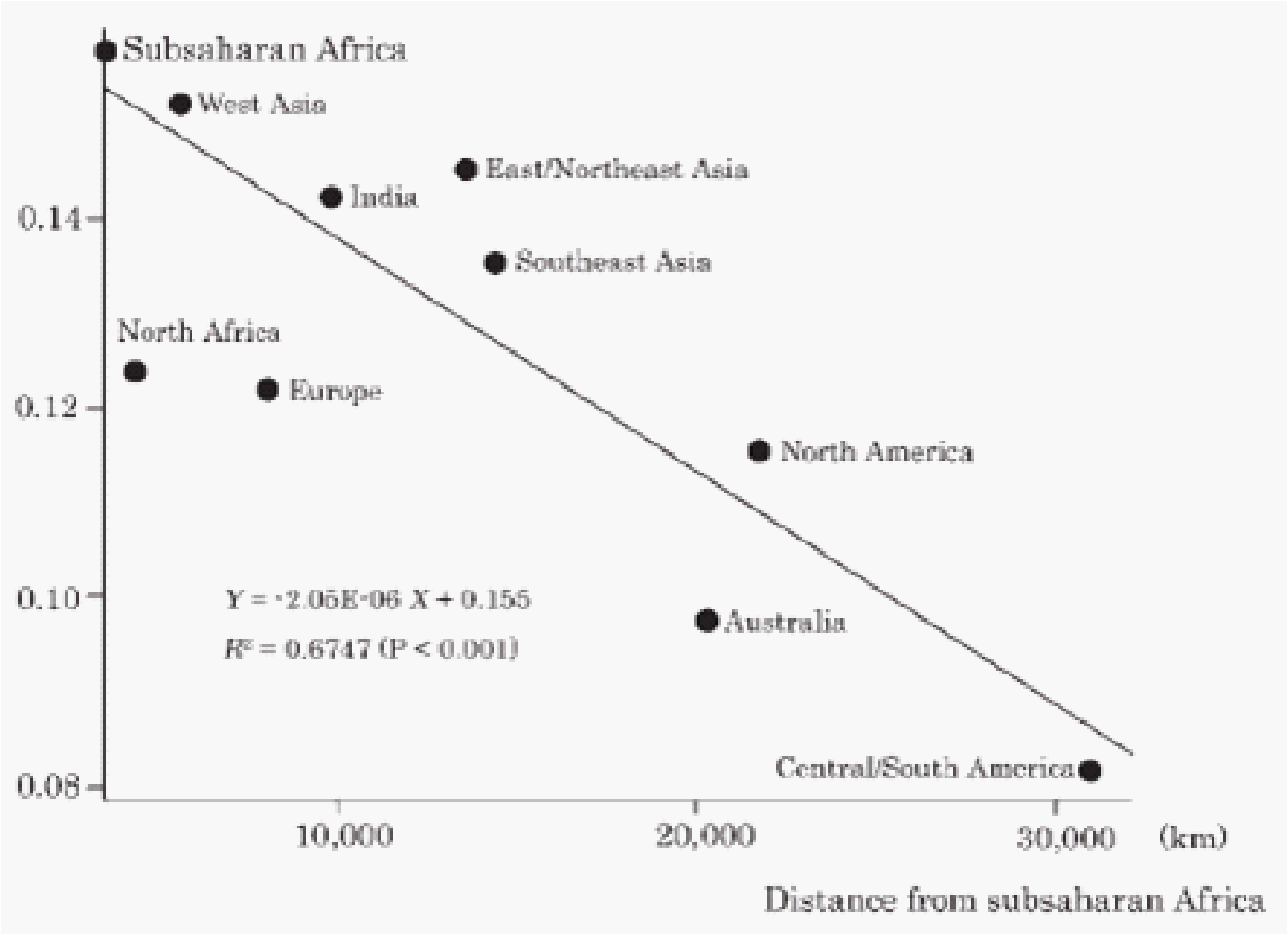
Source: Manica et al. (Nature 2007)

Distance from Africa and Linguistic Diversity



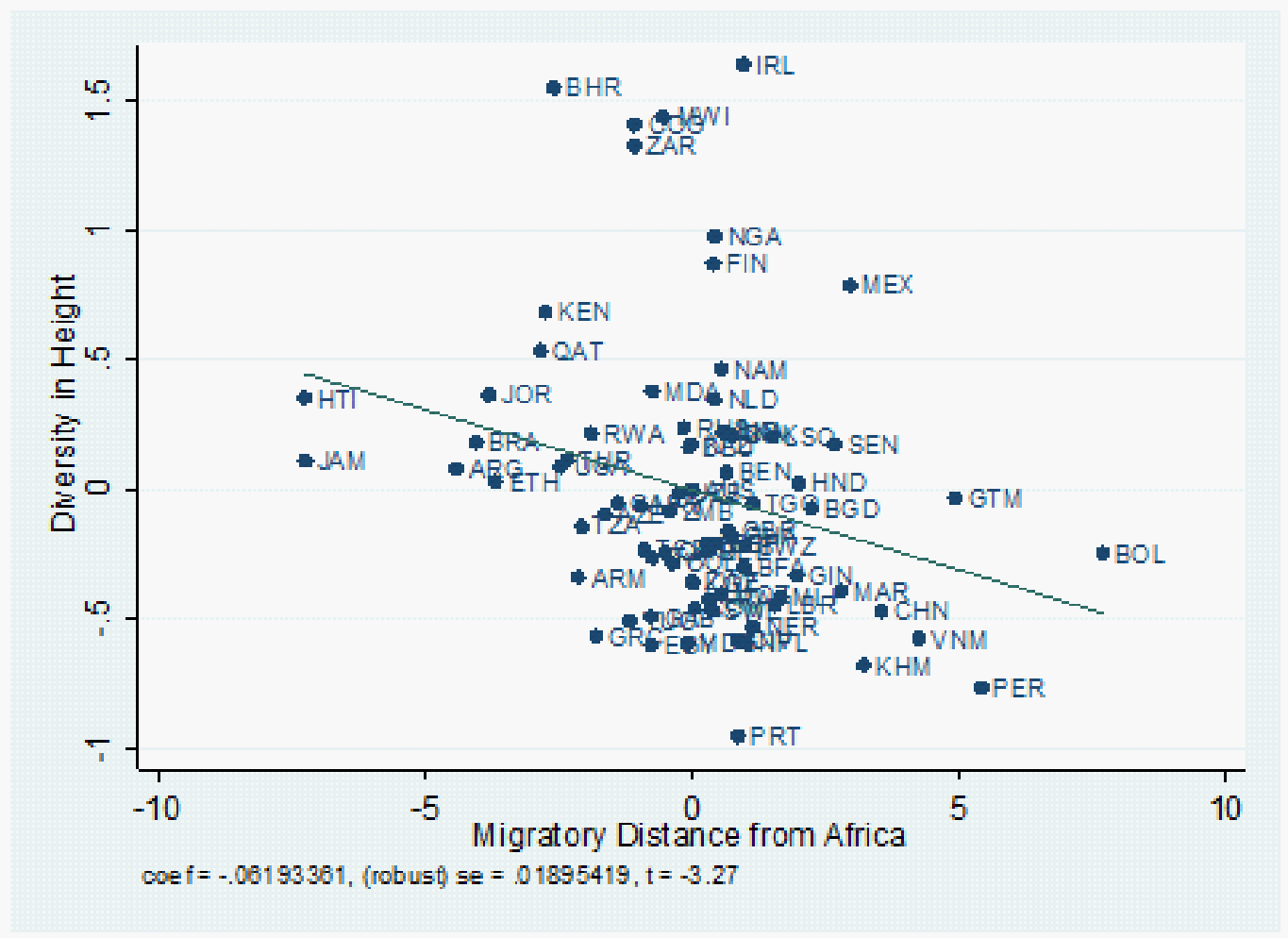
Source: Atkinson (Science 2011)

Distance from Africa and Dental Diversity



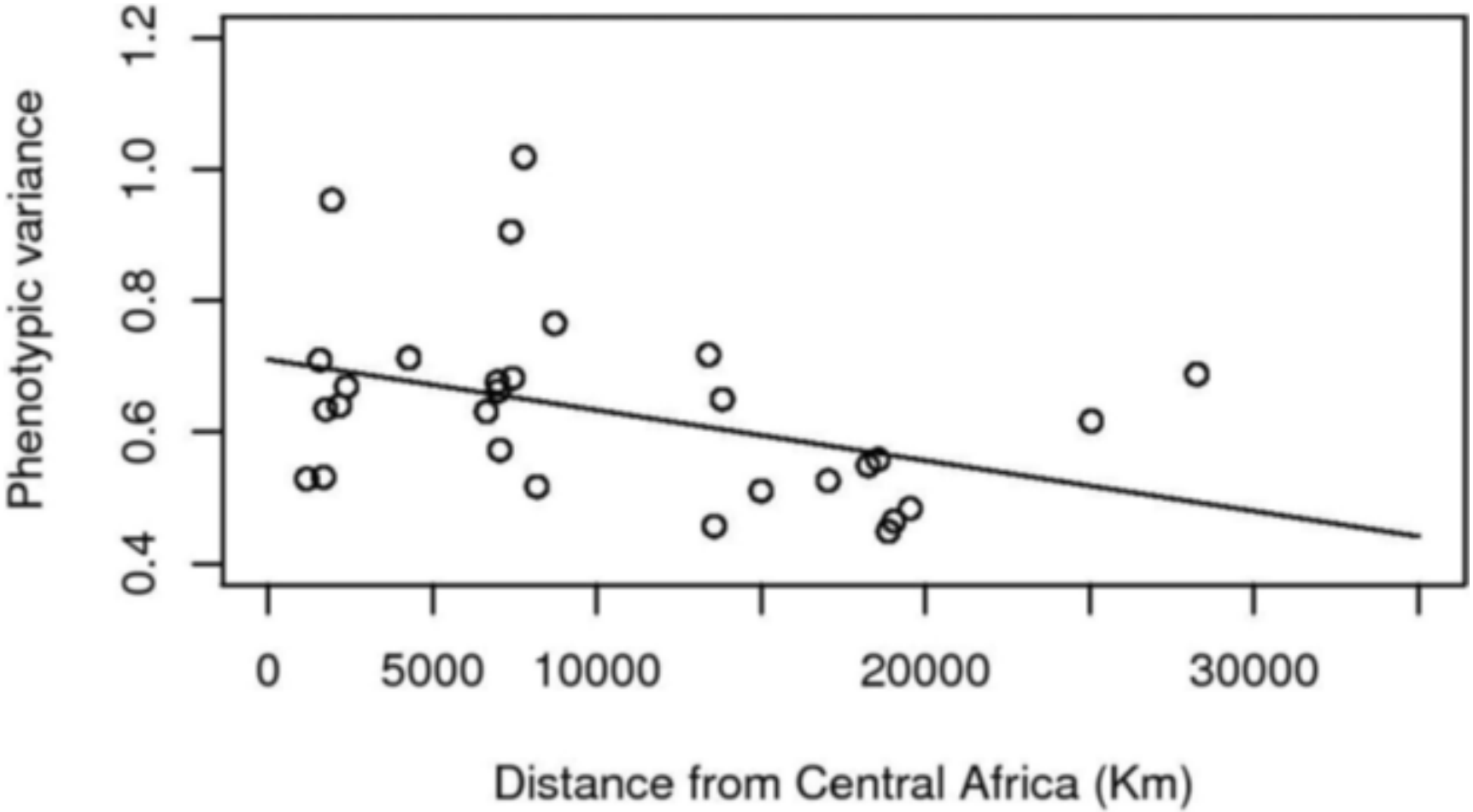
Source: Hanihara (American Journal of Physical Anthropology, 2008)

Distance from Africa and Height Diversity



Source: Galor and Klemp (2014)

Distance from Africa and Pelvic Bone Diversity



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  - $\Longrightarrow$ Diversity fosters innovations, shifting the PPF outward

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    - Genetic distance between the ancestral populations of each country

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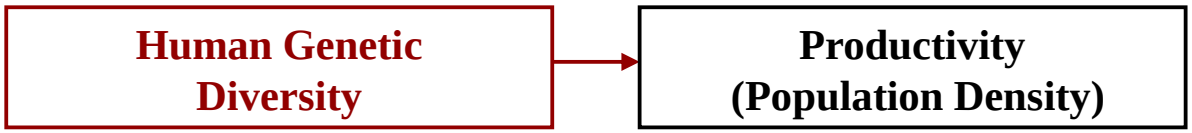
    - Time elapsed since the Neolithic Revolution

Determinants of Productivity: Channels

Productivity
(Population Density)

Determinants of Productivity: Channels



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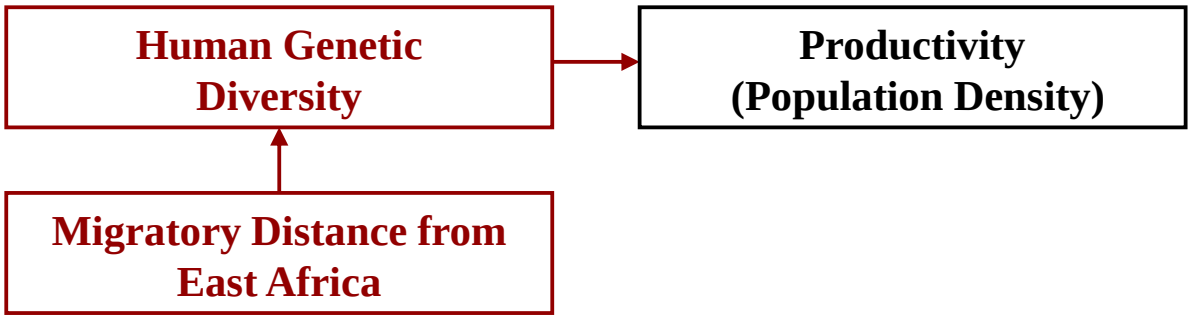
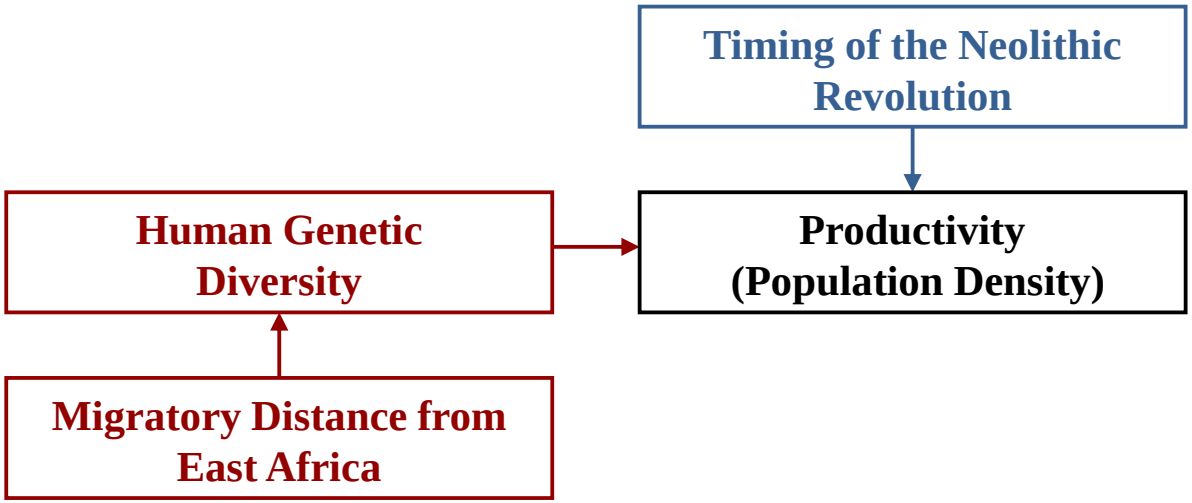
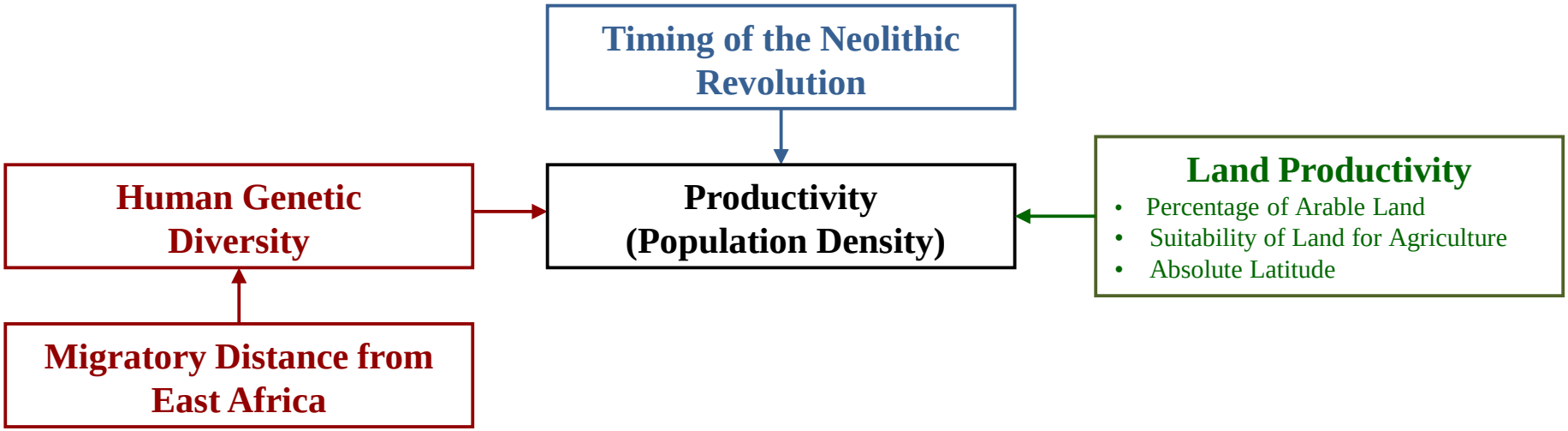


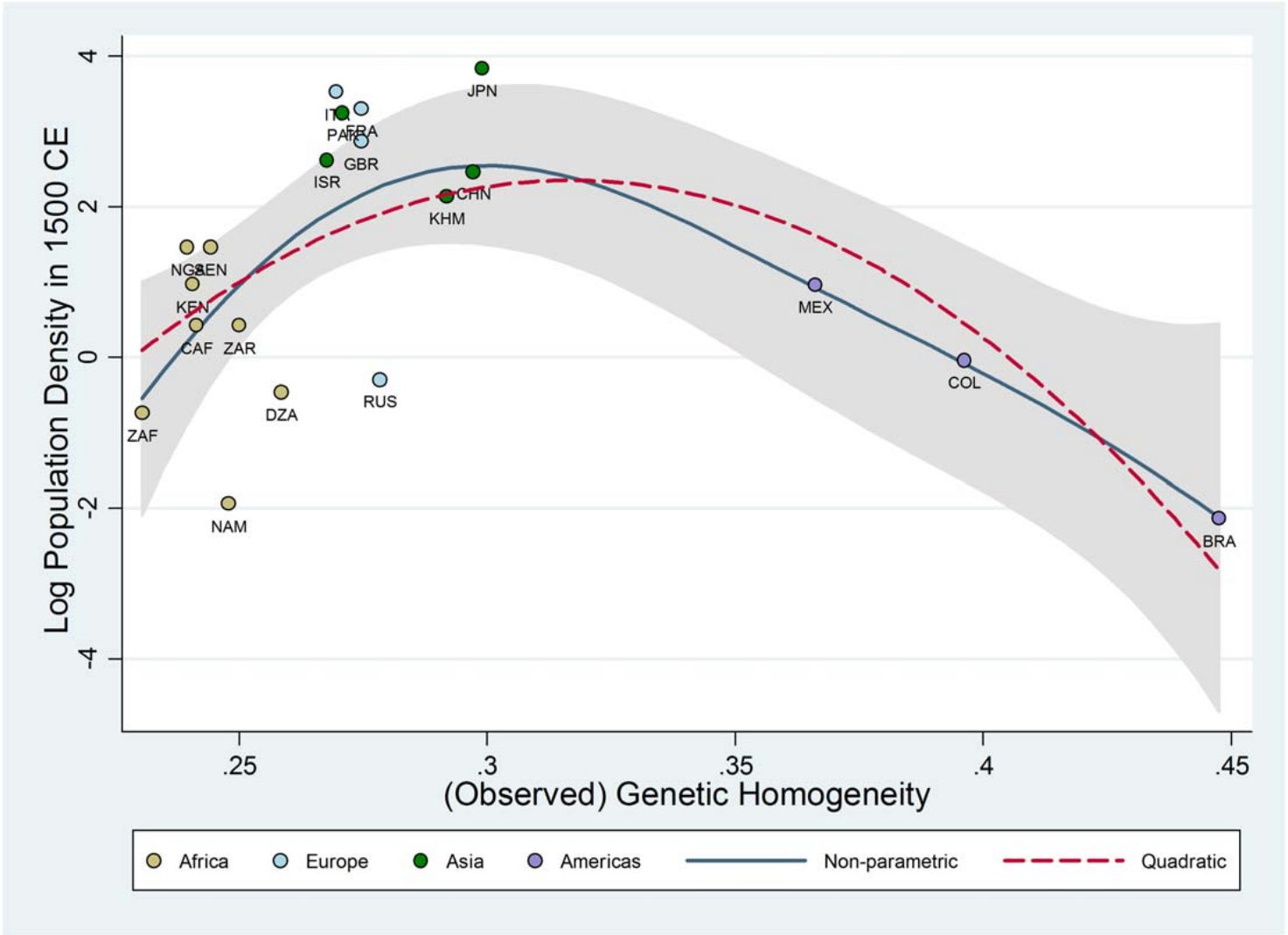
Determinants of Productivity: Channels



Determinants of Productivity: Channels



Observed Diversity and Development in 1500: Unconditional Relationship



Empirical Model I

- Testing the hypothesis using observed genetic diversity from the HGDP

Empirical Model I

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

Empirical Model I

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

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  - $T_i \equiv$ years elapsed since the Neolithic Revolution (NR) for country i
  - $X_i \equiv$ vector of land productivity controls for country i

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  - $\varepsilon_{it} \equiv$ a country-year specific error term for country i

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

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  - 145-country sample

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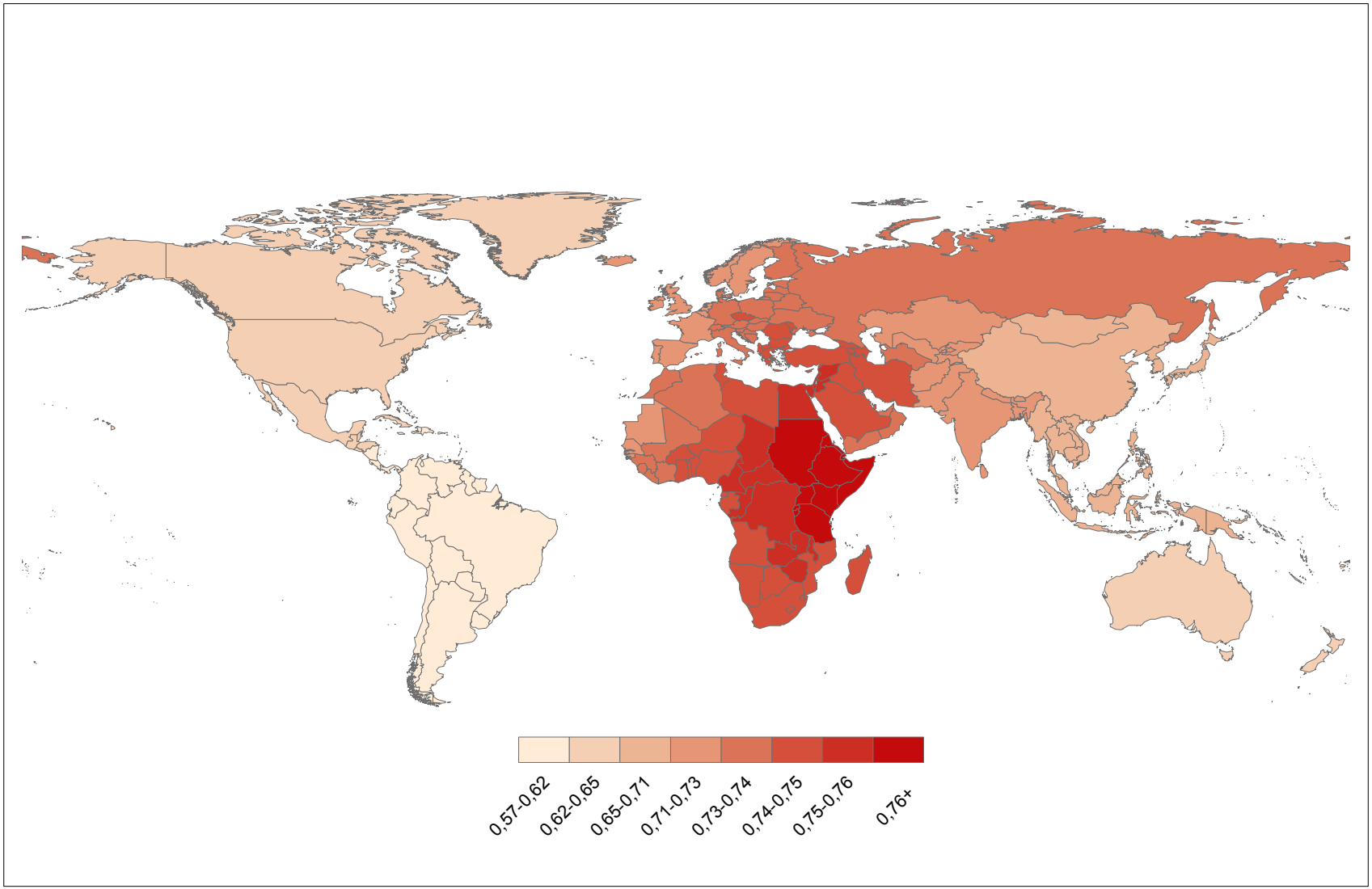
Genetic Diversity across Countries in the Pre-Colonial Era

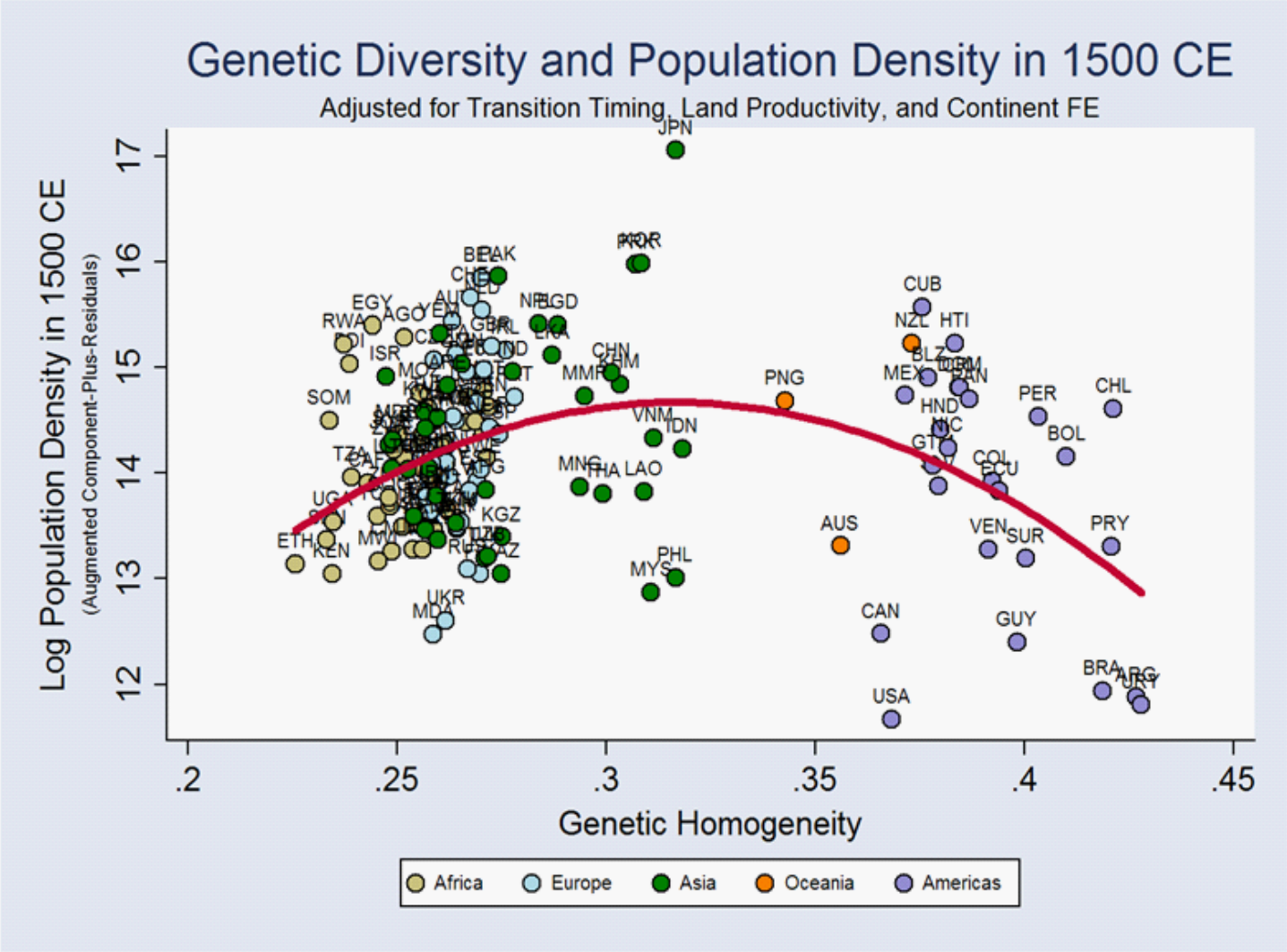


Predicted Diversity and Comparative Development in 1500

	(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.

Predicted Diversity and Comparative Development in 1500



Interpretations – Diversity and Comparative Development in 1500

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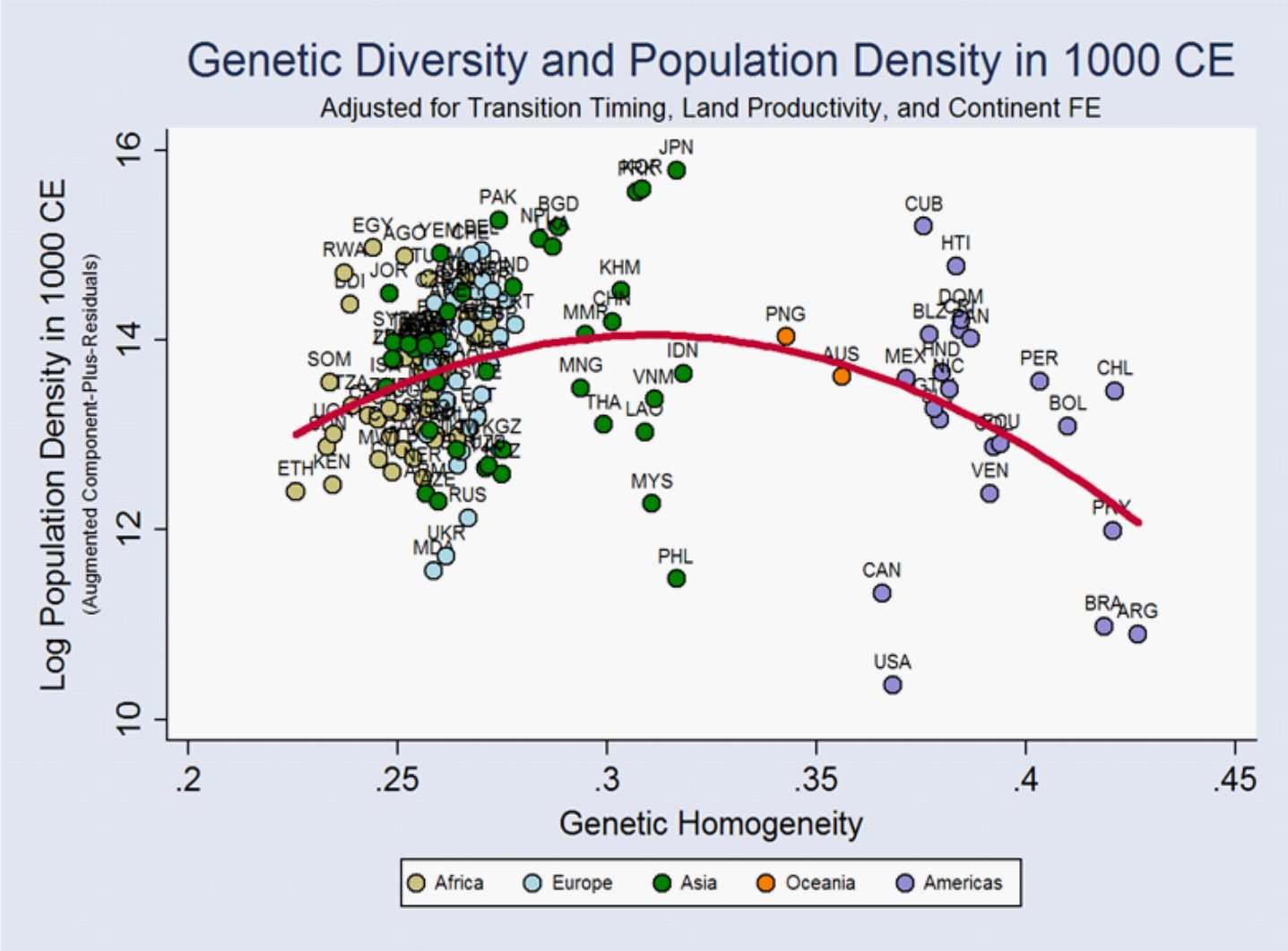
  - 0.09 $\Longrightarrow$ 3-fold increase in population density in 1500
  - 0.01 $\Longrightarrow$ 18% increase in population density in 1500
- 0.01 change from the optimal level of GD
  - $\Longrightarrow$ 1.4% decrease in population density in 1500

Predicted Diversity and Comparative Development in Earlier Periods

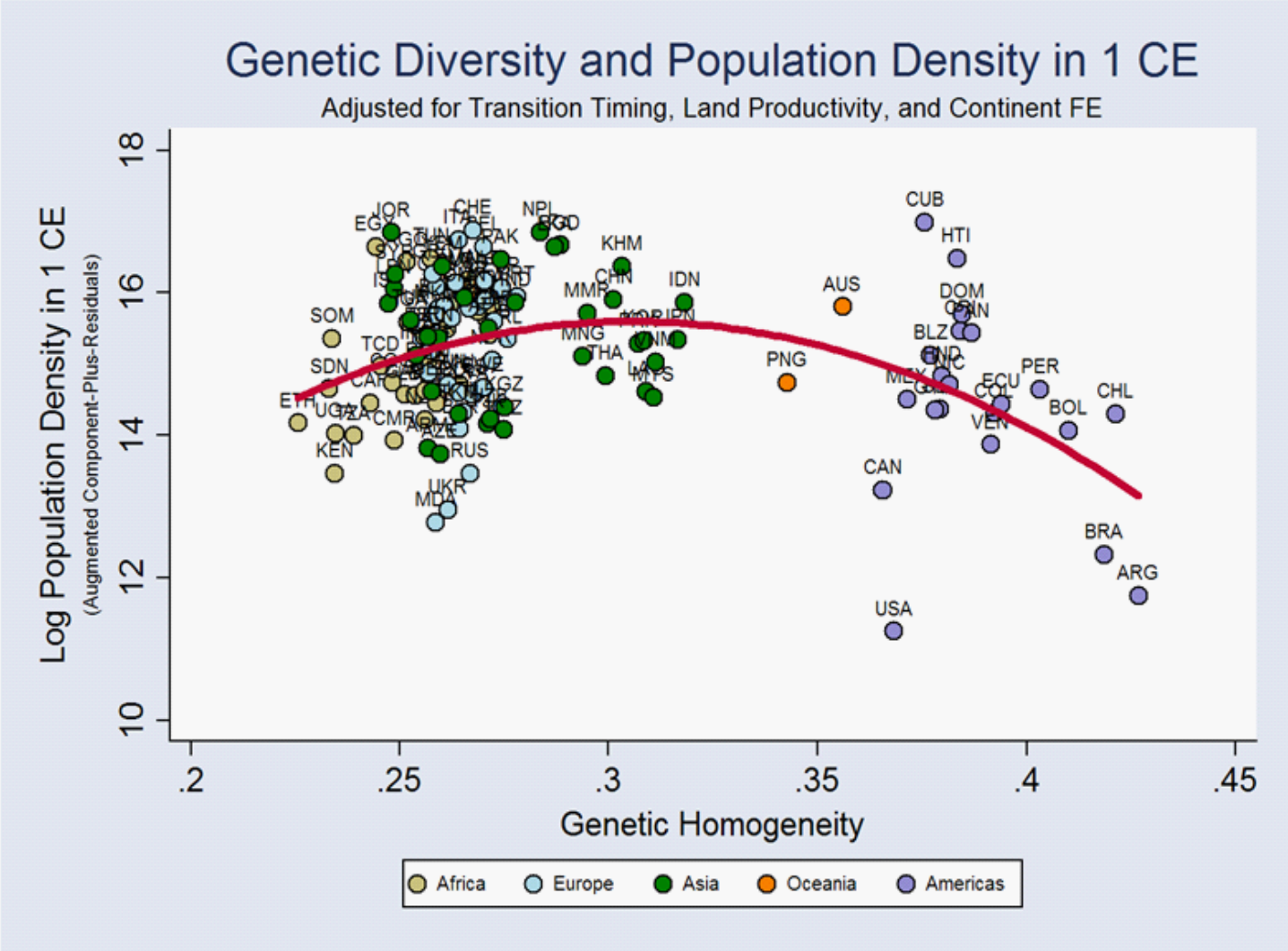
	(1)	(2)	(3)	(4)
	Dependent Variable: Log Population Density			
	1000 CE	1000 CE	1 CE	1 CE
Predicted Diversity	154.91**	201.24**	134.77**	231.69**
	(62.39)	(95.58)	(63.45)	(115.83)
Predicted Diversity Sqr.	-109.81**	-145.89**	-96.25**	-166.86**
	(45.70)	(66.79)	(46.49)	(81.13)
Log Years since NR	1.37***	1.60***	1.66***	2.13***
	(0.15)	(0.27)	(0.21)	(0.44)
Log % of Arable Land	0.37***	0.37***	0.31***	0.35***
	(0.10)	(0.12)	(0.12)	(0.13)
Log Absolute Latitude	-0.38***	-0.37***	-0.12	-0.12
	(0.10)	(0.14)	(0.12)	(0.13)
Log Agri. Suitability	0.21**	0.19*	0.24*	0.21*
	(0.10)	(0.11)	(0.12)	(0.12)
Optimal Diversity	0.705	0.690	0.705	0.694
	(0.108)	(0.293)	(0.188)	(0.194)
Continent Dummies	No	Yes	No	Yes
Observations	140	140	126	126
R-squared	0.61	0.62	0.59	0.61

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

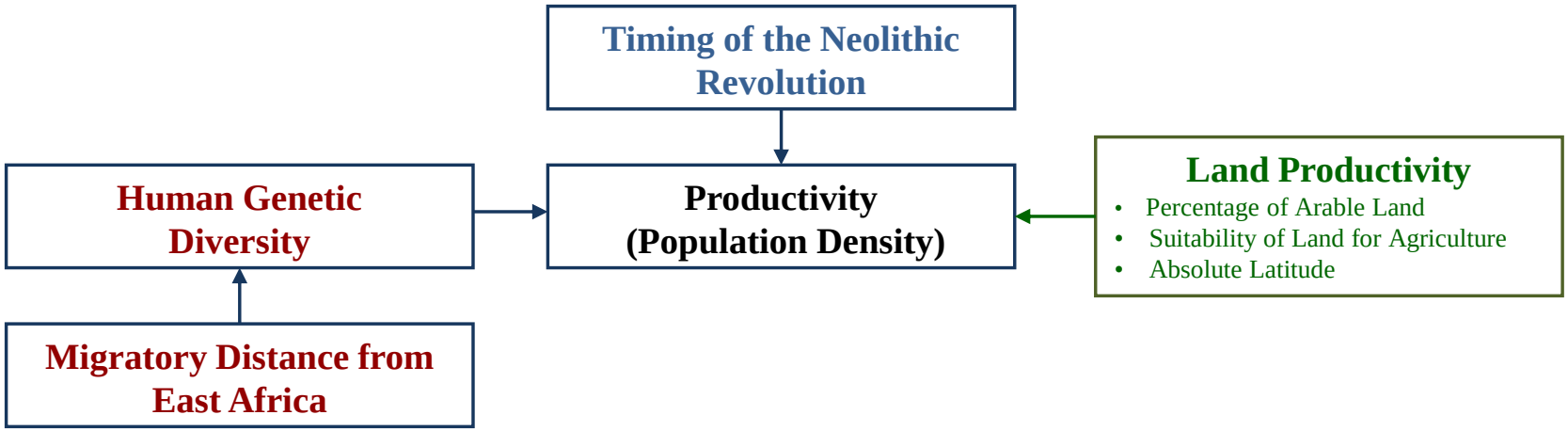
Predicted Diversity and Comparative Development in 1000 CE



Predicted Diversity and Comparative Development in 1 CE



The Role of Omitted Variables



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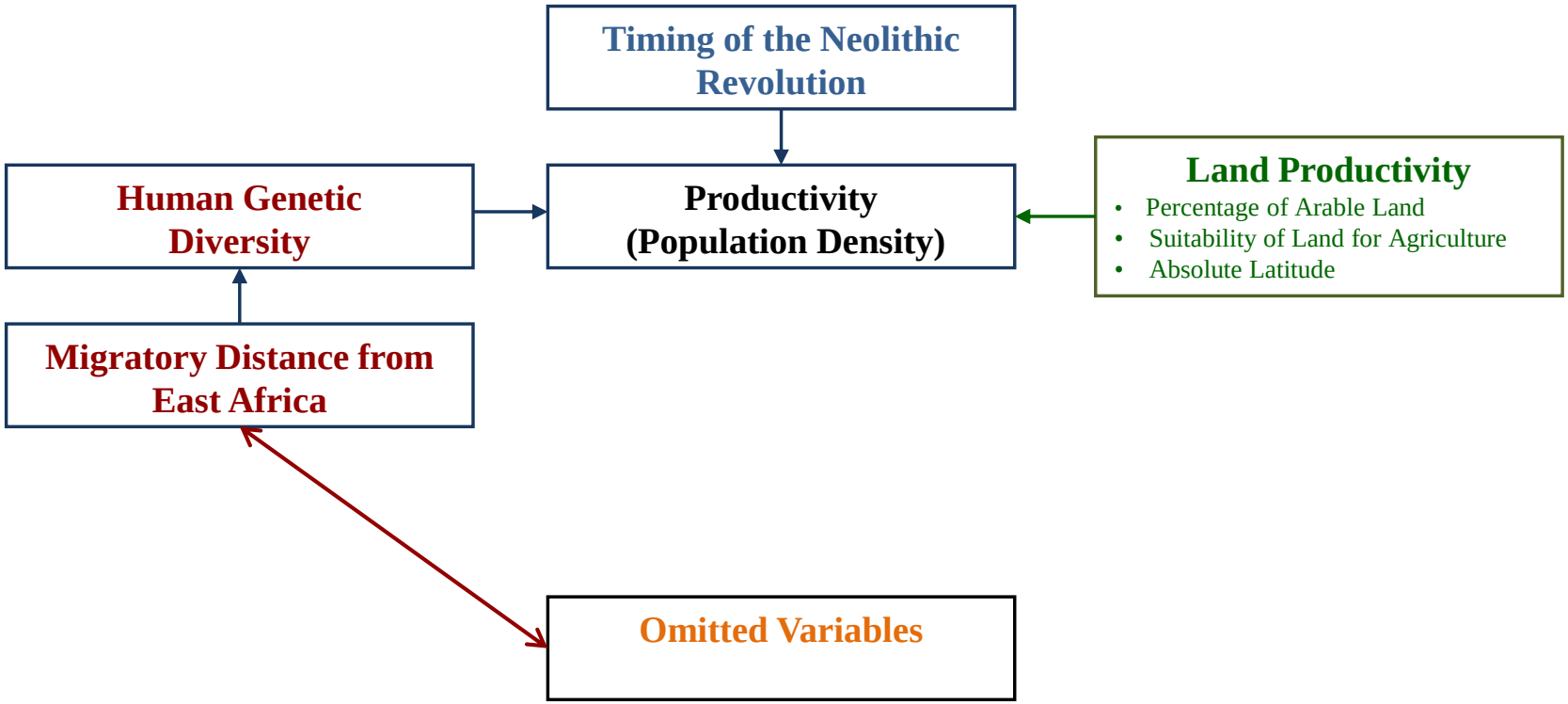

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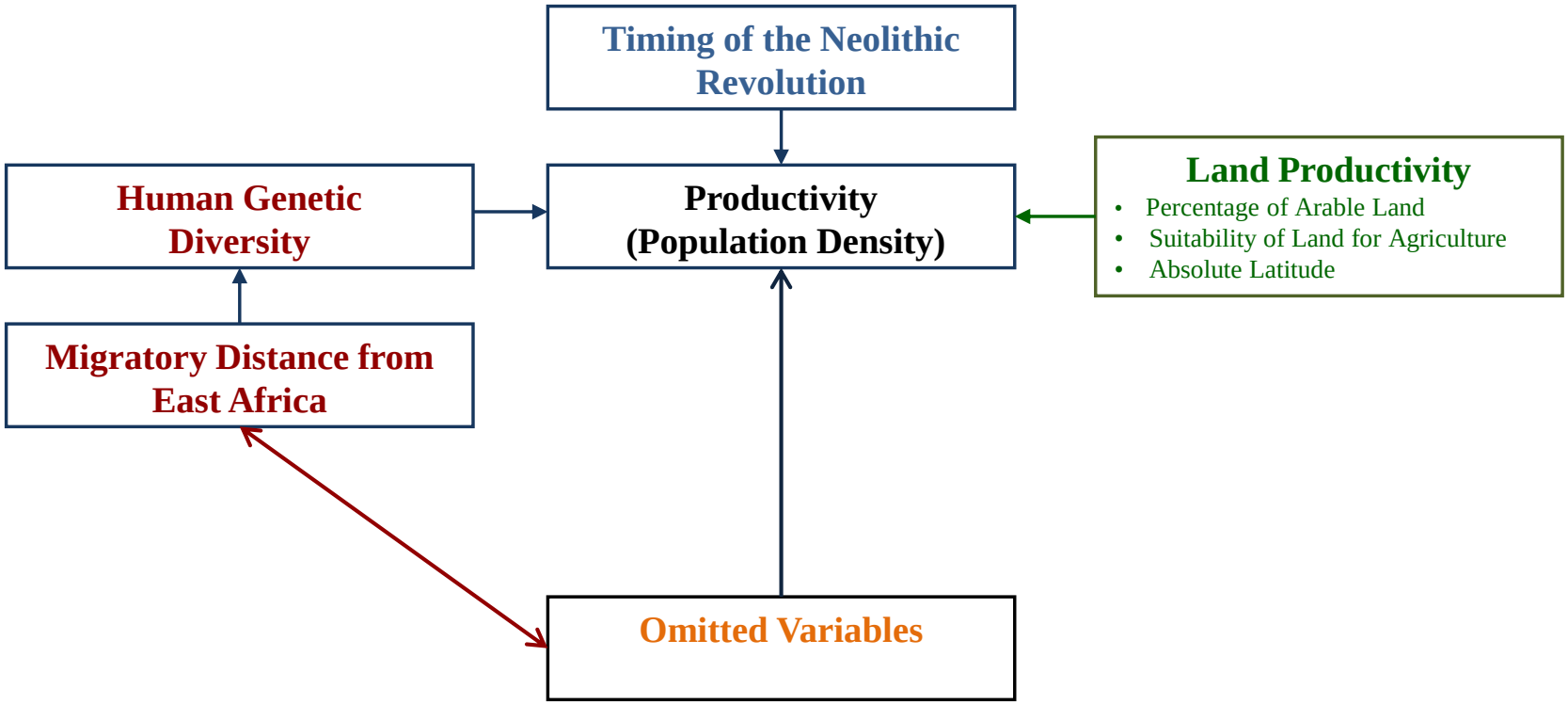
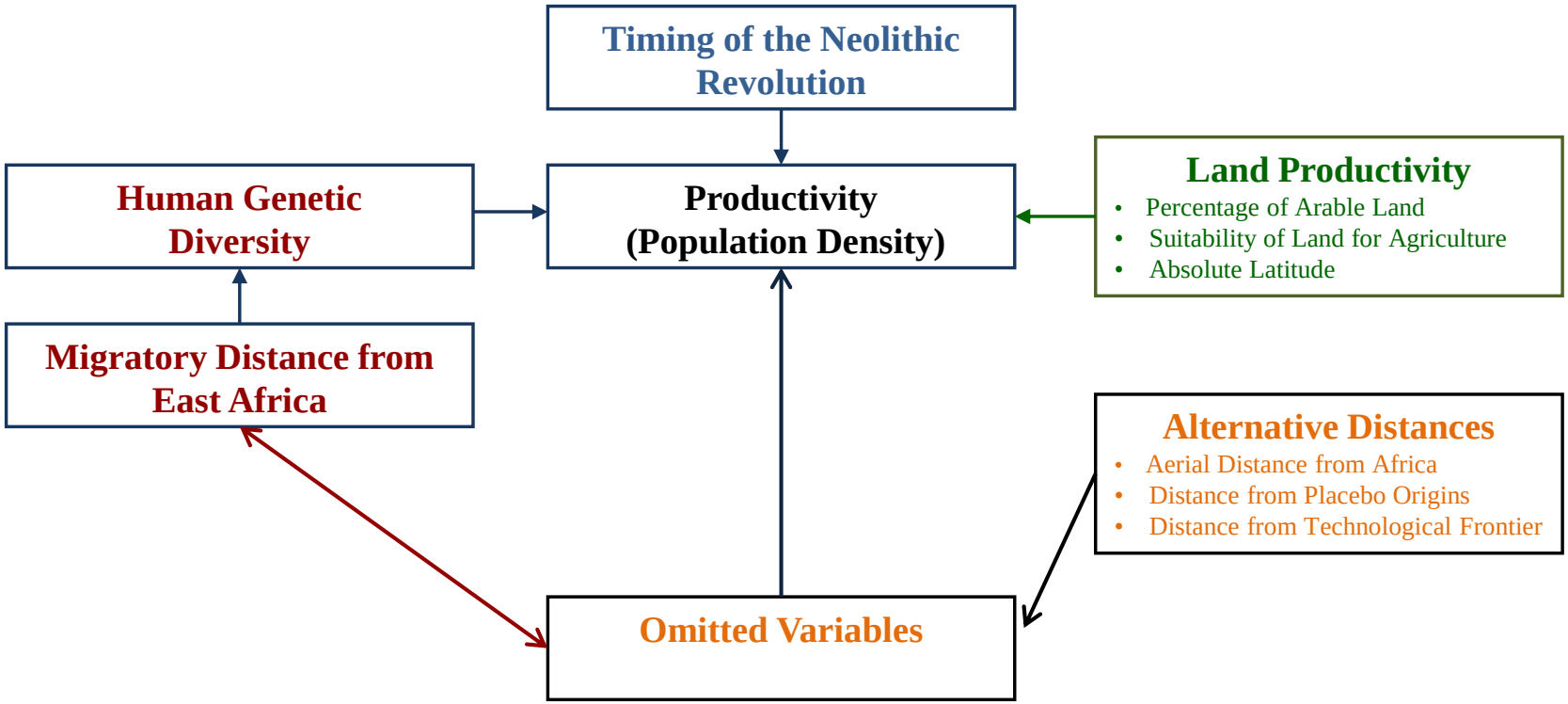


The Role of Omitted Variables – Alternative Distances



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

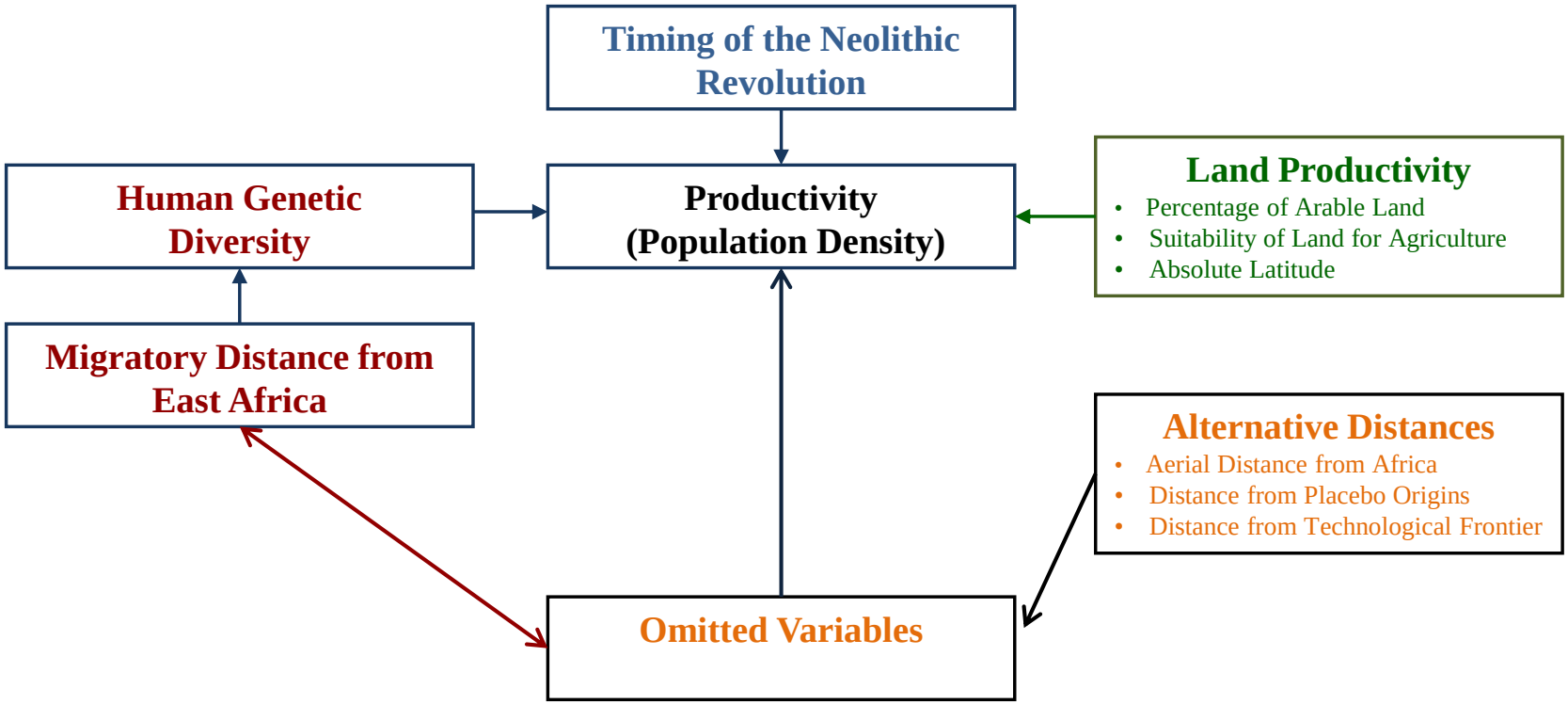
City & Modern Location	Continent	Sociopolitical Entity	Period
Cairo, Egypt	Africa	Mamluk Sultanate	1500 CE
Fez, Morocco	Africa	Marinid Kingdom of Fez	1500 CE
London, UK	Europe	Tudor Dynasty	1500 CE
Paris, France	Europe	Valois-Orléans Dynasty	1500 CE
Constantinople, Turkey	Asia	Ottoman Empire	1500 CE
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

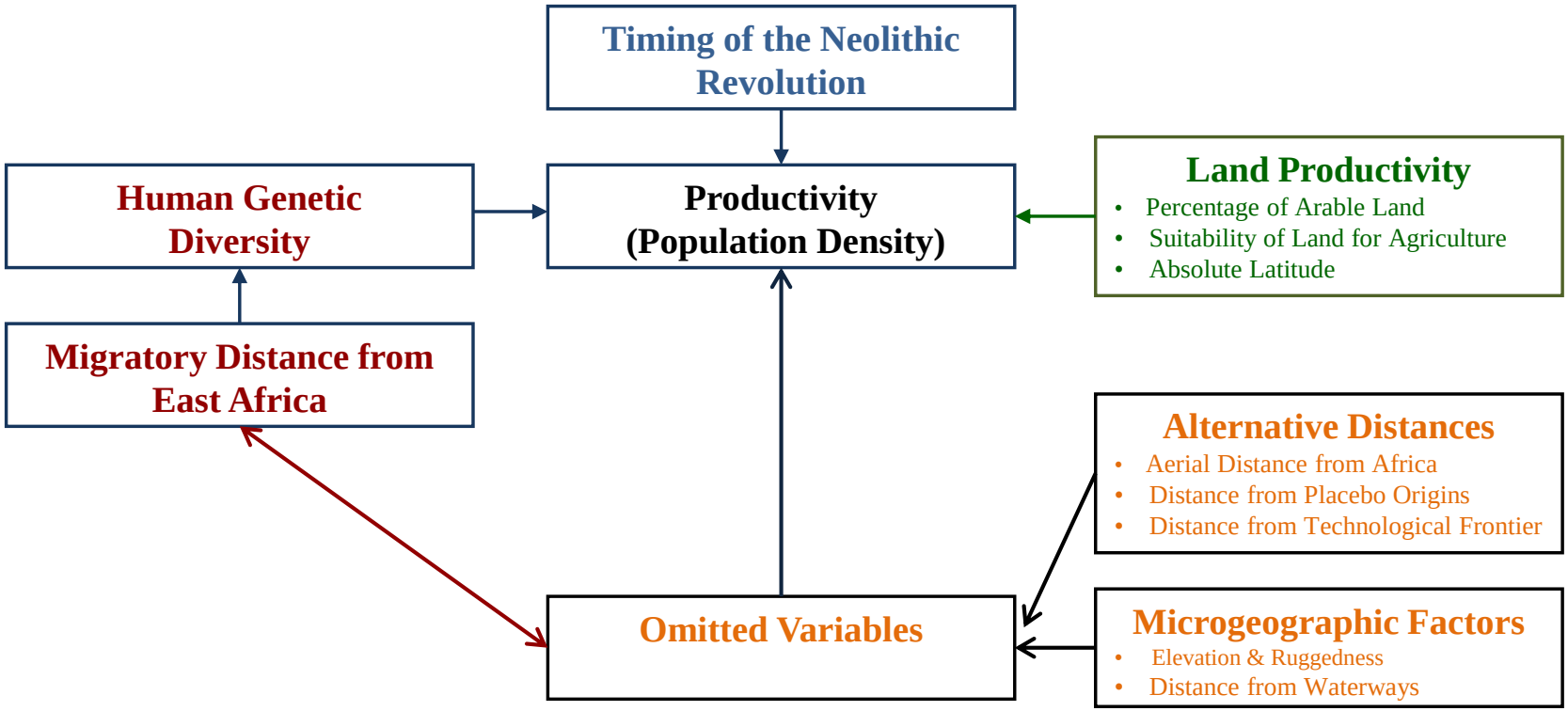
	(1)	(2)	(3)
	Log Population Density 1500 CE	Log Population Density 1000 CE	Log Population Density 1 CE
Predicted Diversity	156.74**	183.77**	215.86**
	(77.98)	(91.20)	(106.50)
Predicted Diversity Sqr.	-114.63**	-134.61**	-157.72**
	(54.67)	(63.65)	(74.82)
Log Years since NR	Yes	Yes	Yes
Land Prod. Controls	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

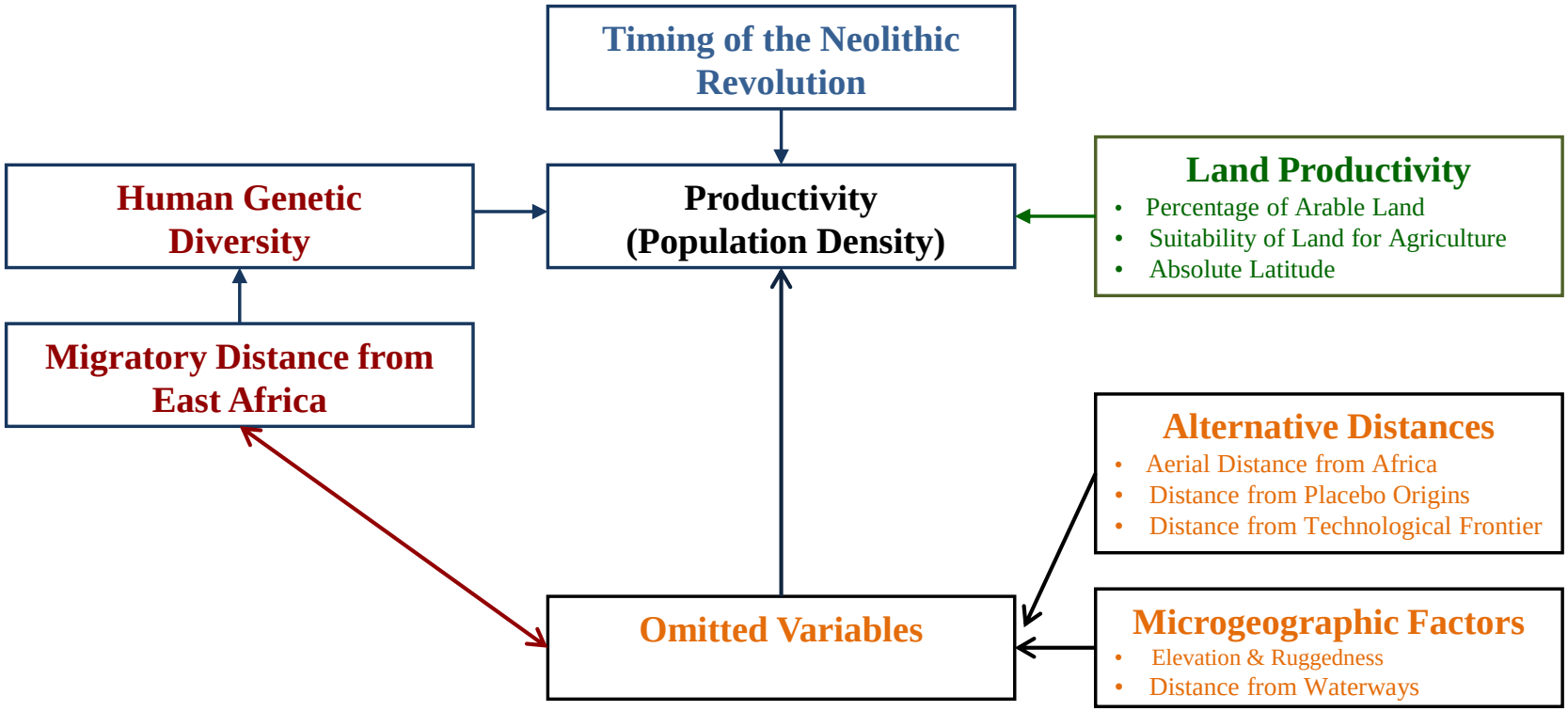


Robustness to Microgeographic Factors

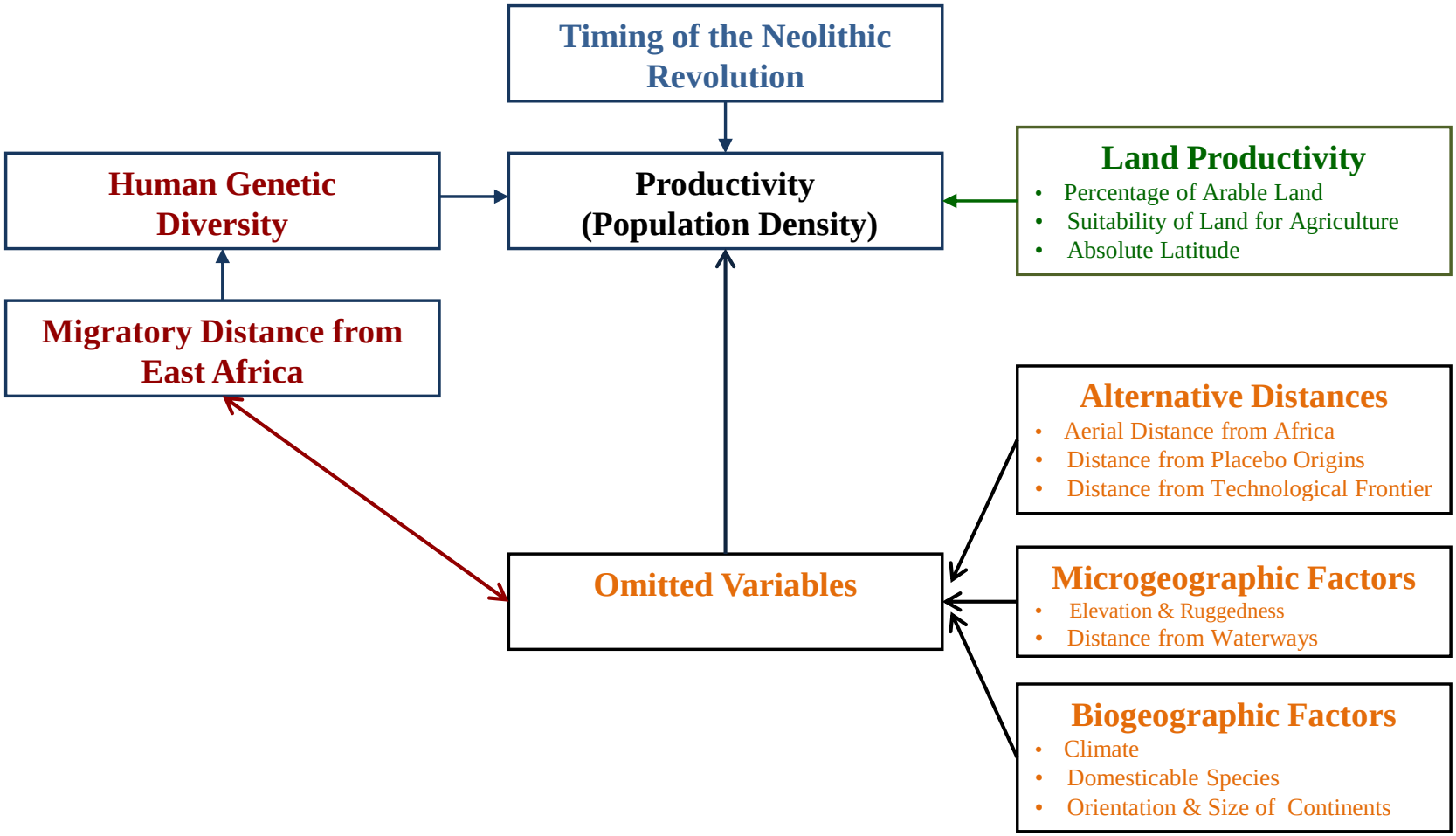
	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log Population Density in 1500				
Predicted Diversity	159.92***	153.20***	157.07**	150.02***	157.06**
	(56.00)	(53.39)	(78.82)	(49.36)	(68.61)
Predicted Diversity Sqr.	-110.39***	-105.33***	-112.78**	-102.76***	-114.99**
	(41.08)	(39.11)	(55.48)	(36.23)	(48.26)
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

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

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

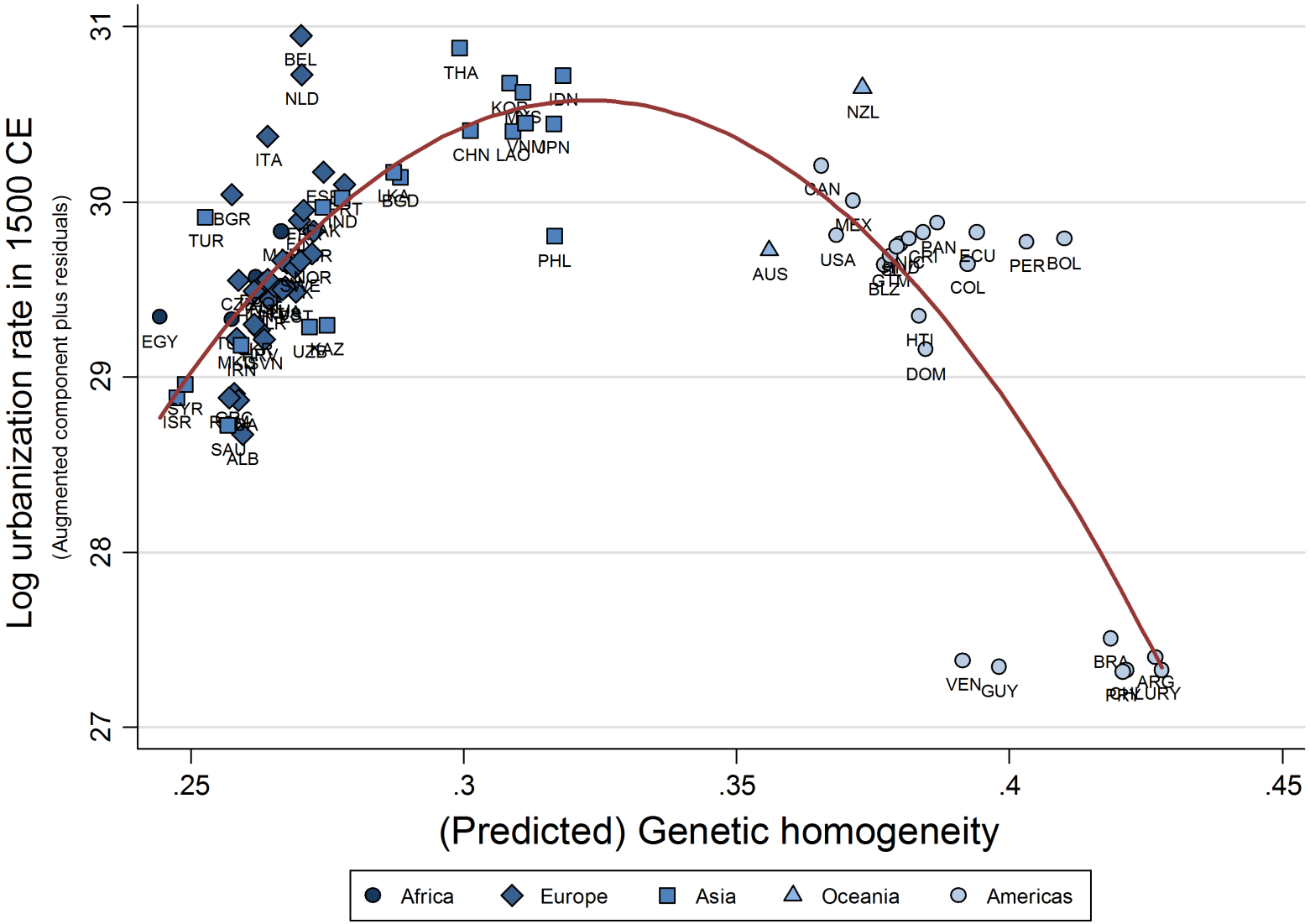
Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

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



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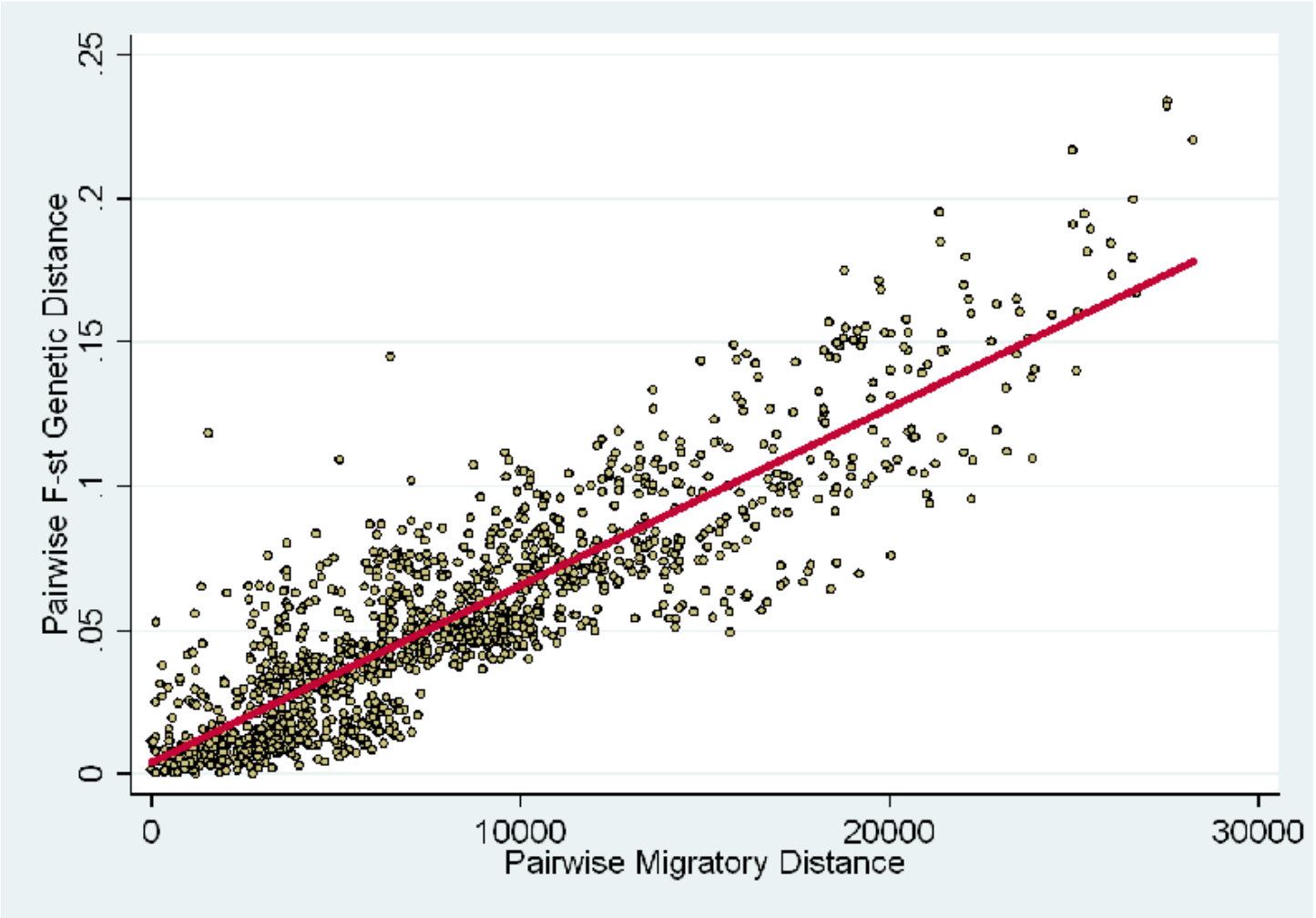
  - Genetic distance between all pairs of ancestral populations of each country
    - Projected based on migratory distance between these ancestral populations

Projection of Pairwise Genetic Distances



Empirical Model III

- Testing the hypothesis using contemporary genetic diversity

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  - 145-country sample

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- Empirical specification

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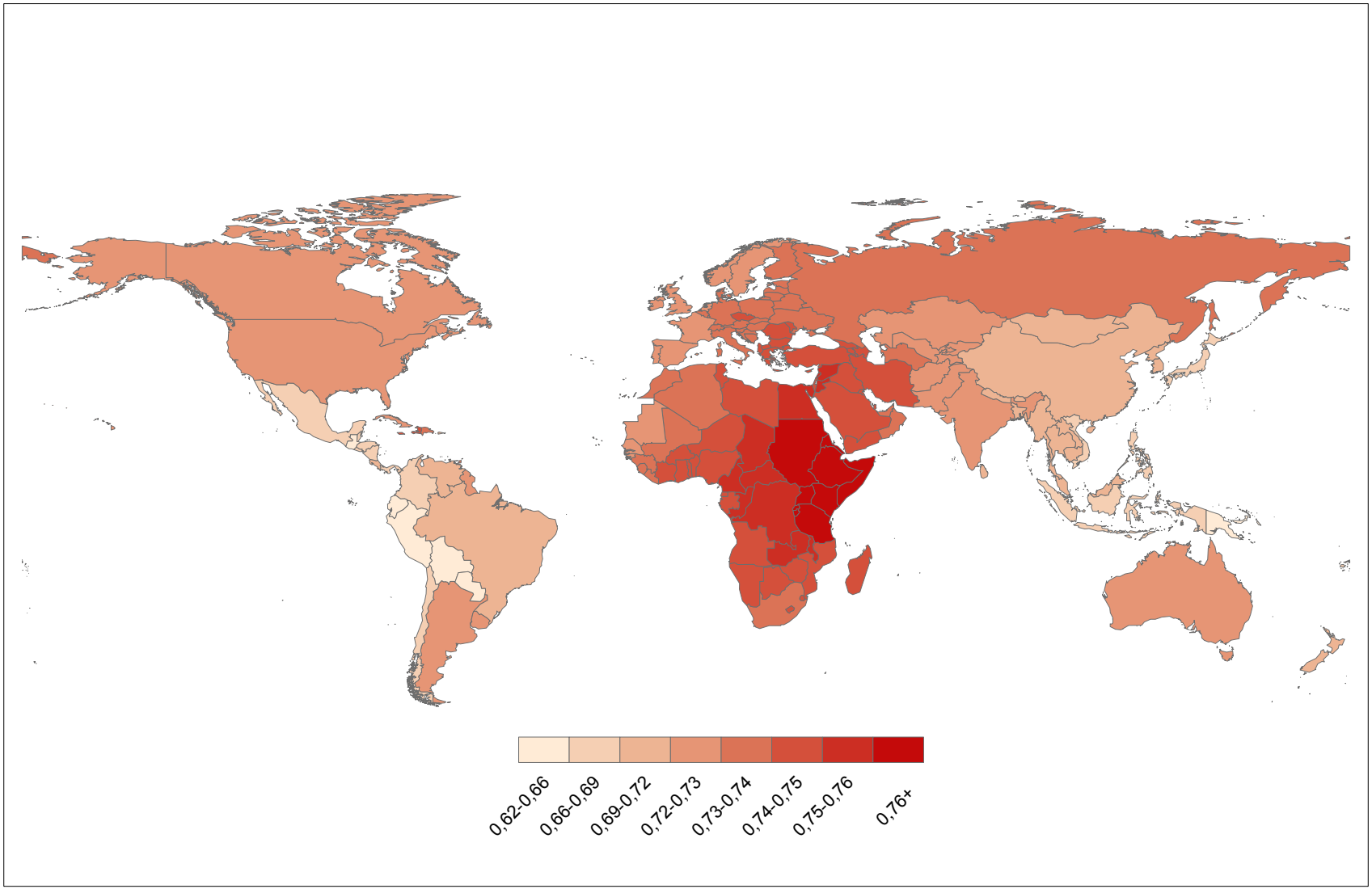
  - $\Lambda_i \equiv$ vector of institutional and cultural controls for country i
  - $\Gamma_i \equiv$ vector of additional geographical controls for country i
  - $\eta_i \equiv$ error term for country i

Genetic Diversity across Countries in 2000



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

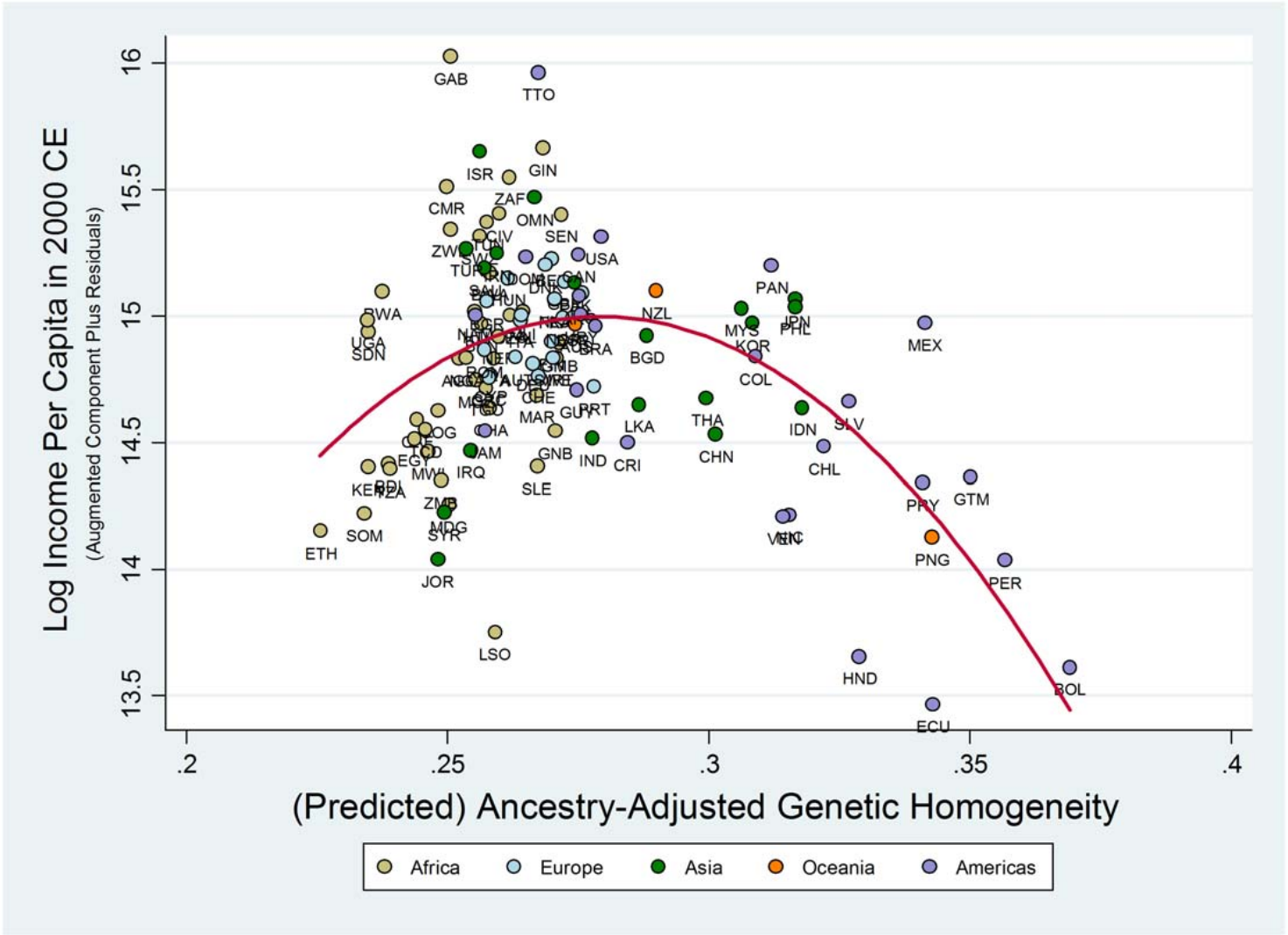
Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

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 of Contracting Malaria				-0.502	-0.723**
				(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
R-squared	0.74	0.84	0.85	0.90	0.93

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

Genetic Diversity and Comparative Development in 2000



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- Decreasing GD of Ethiopia (0.77), the most heterogeneous country, by:
  - 0.05 $\Longrightarrow$ 1.7-fold increase in income per capita in 2000
    - From 2% to 4% of that of the US

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    - From 9% to 40% of that of the US
  - 0.01 $\Longrightarrow$ 39% increase income per capita in 2000
- Decreasing GD of Ethiopia (0.77), the most heterogeneous country, by:
  - 0.05 $\Longrightarrow$ 1.7-fold increase in income per capita in 2000
    - From 2% to 4% of that of the US
  - 0.01 $\Longrightarrow$ 21% increase in income per capita in 2000

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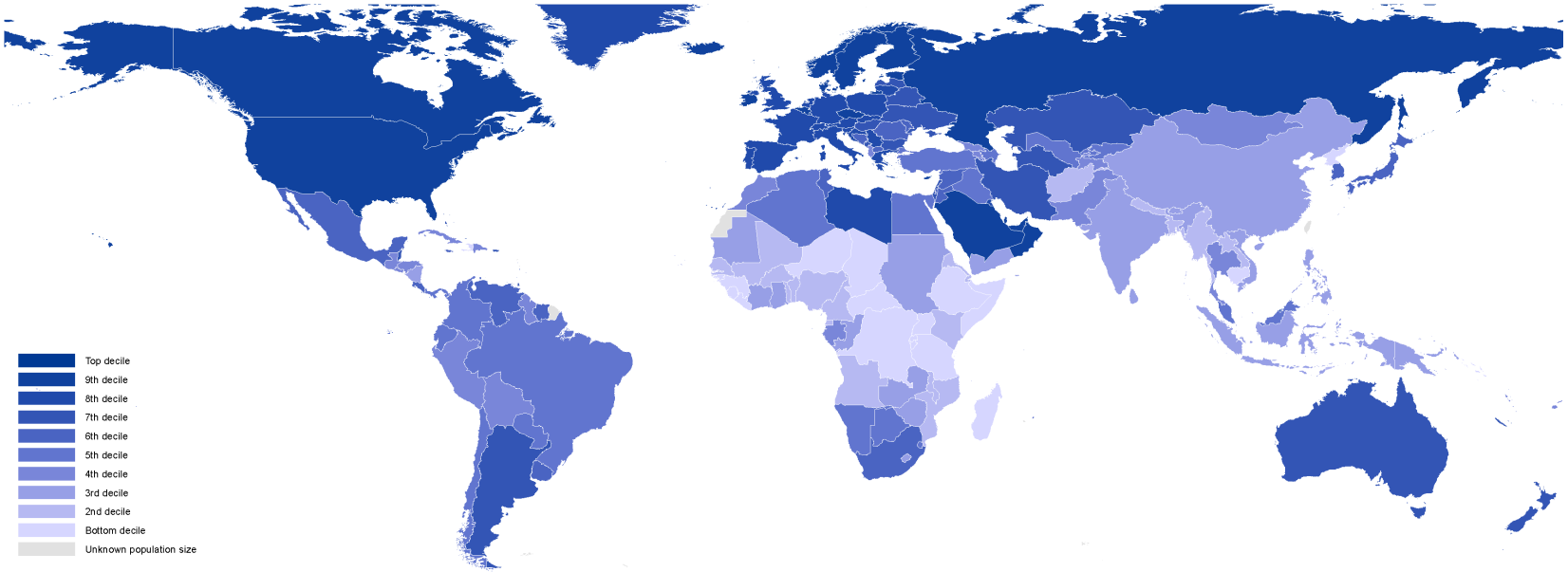
  - 0.01 $\Longrightarrow$ 39% increase income per capita in 2000
- Decreasing GD of Ethiopia (0.77), the most heterogeneous country, by:
  - 0.05 $\Longrightarrow$ 1.7-fold increase in income per capita in 2000
    - From 2% to 4% of that of the US
  - 0.01 $\Longrightarrow$ 21% increase in income per capita in 2000
- 0.01 change from the optimal level of GD
  - $\Longrightarrow$ 1.9% decrease in income per capita in 2000

Addressing Endogenous Post-1500 Migrations

	(1) Full Sample	(2) Non OECD	(3) w/o Neo Europes	(4) w/o Latin America	(5) w/o Sub Sahara	(6) >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 of Malaria	-0.502	-0.605	-0.591	-0.308	-0.425	-0.153
	(0.351)	(0.381)	(0.370)	(0.486)	(0.581)	(0.434)
% Population Living in Tropical Zones	-0.319	-0.196	-0.302	-0.520**	-0.528	-0.339
	(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

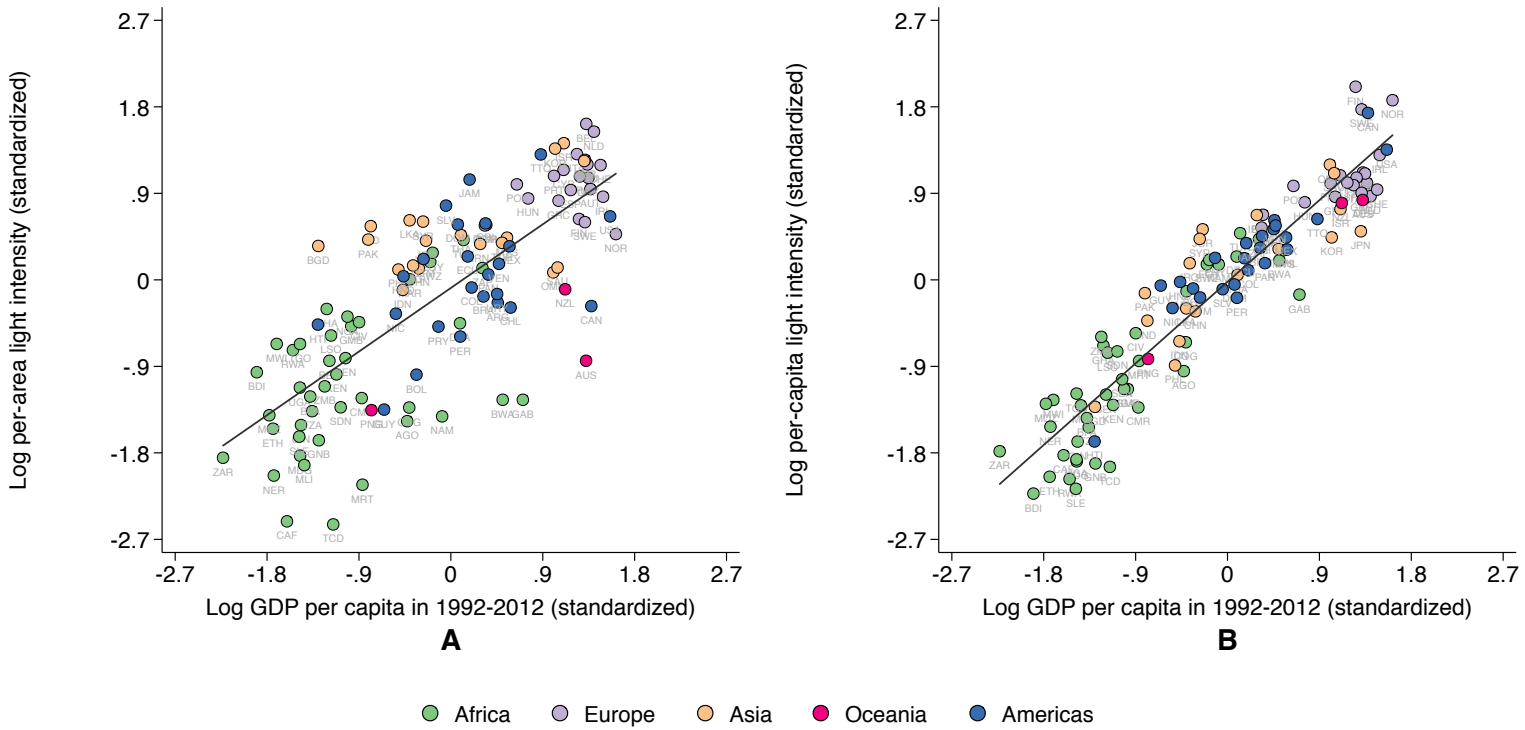
Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Nightlight Per Capita Observed by Satellites: 1992-2012



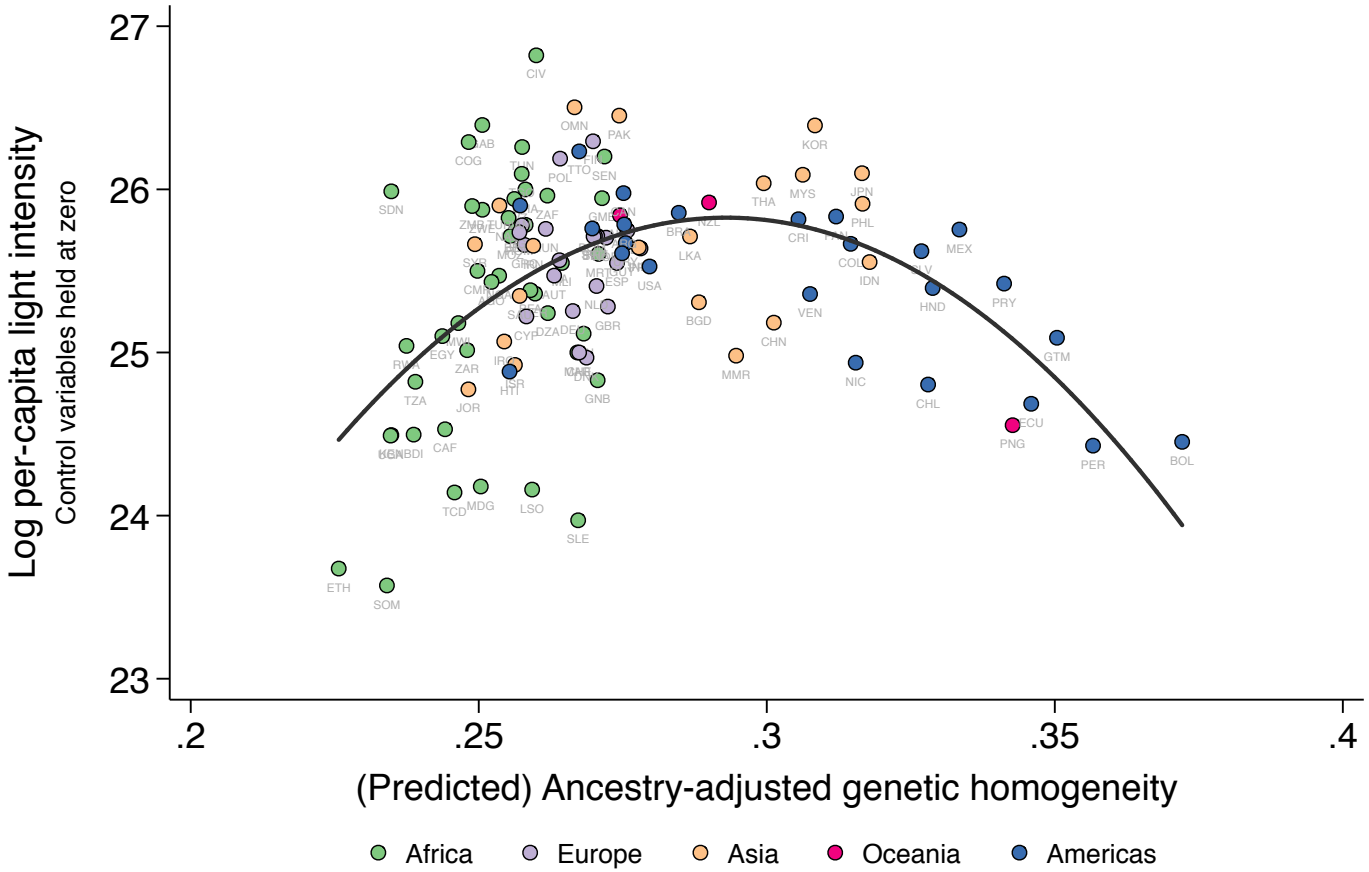
Source: Ashraf-Galor-Klemp (2014)

Income Per Capita and Nightlight Observed by Satellites: 1992-2012



Source: Ashraf-Galor-Klemp (2014)

Genetic Diversity and Nightlight Observed by Satellites: 1992-2012



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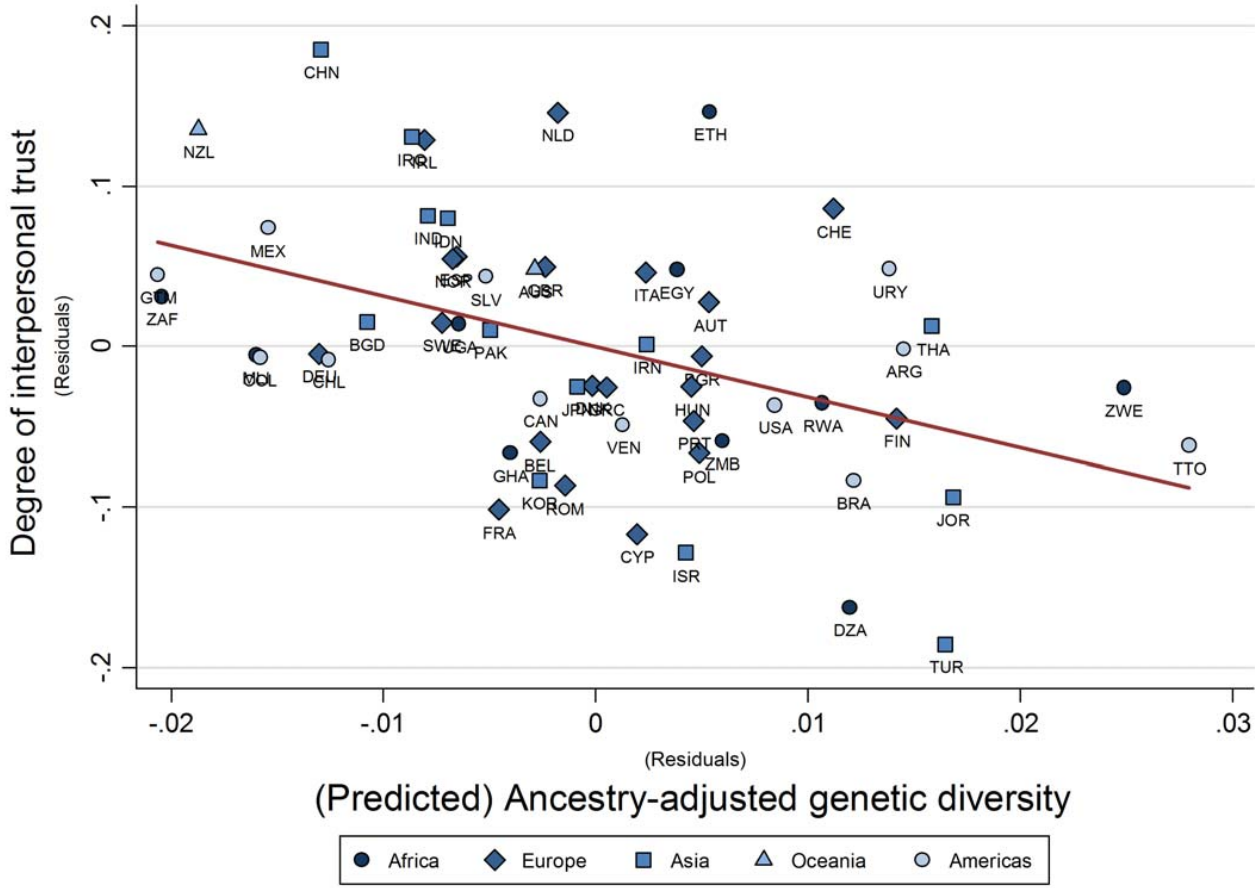
  - $\Longrightarrow$ Inefficiency in the operation of the economy relative to its PPF

Genetic Diversity and Trust over the Period 1981-2008



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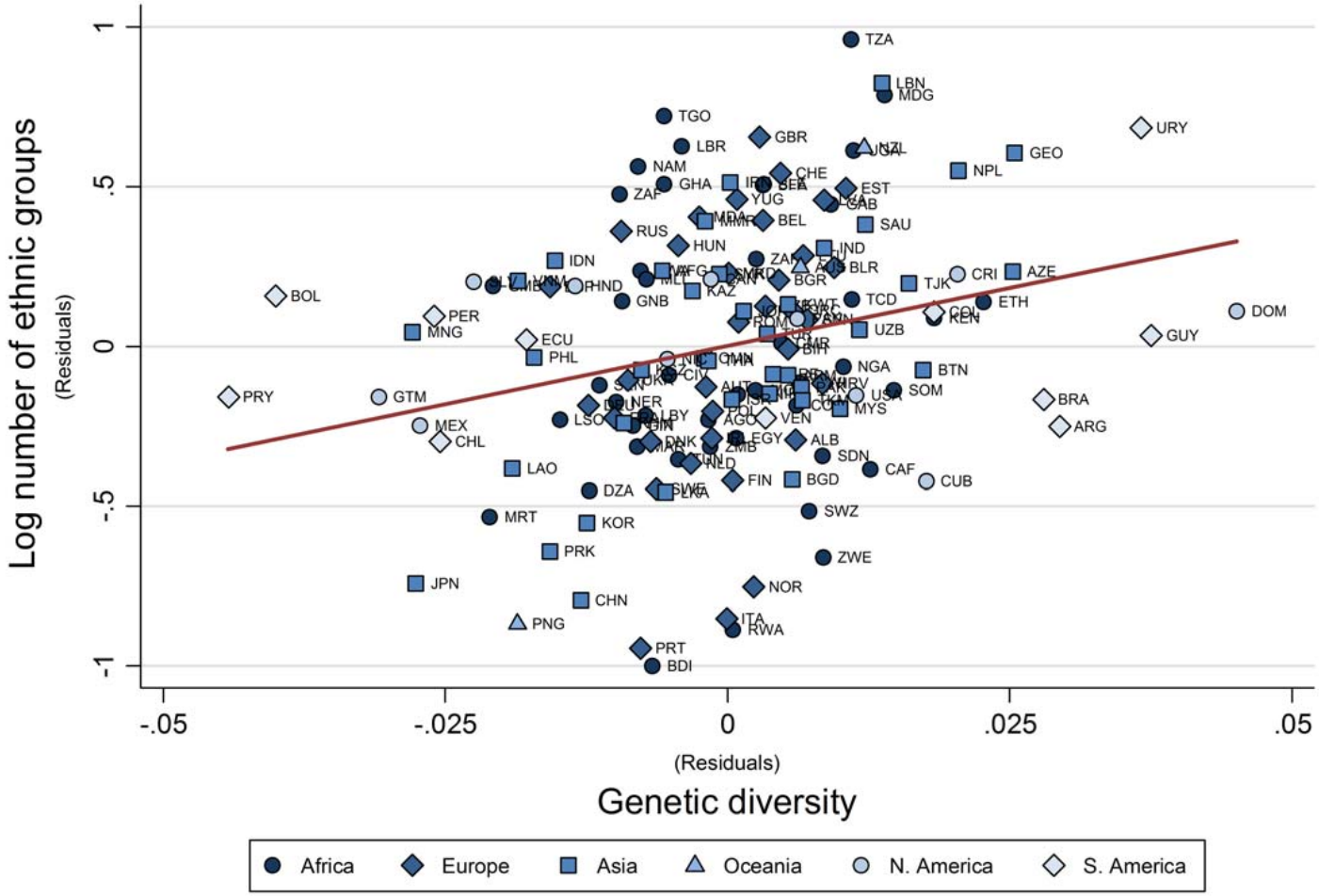
- Genetic diversity contributed to the contemporary level of ethnolinguistic heterogeneity

Genetic Diversity and the Number of Ethnic Groups



coefficient = 7.29, standard error = 2.02, t-statistic = 3.60, partial R2 = 0.07

Genetic Diversity and Various Measures of Ethnolinguistic Heterogeneity

	(1) OLS EG	(2) 2SLS EG	(3) 2SLS EF-F	(4) 2SLS EF-A	(5) 2SLS ELF-D	(6) 2SLS POL-D	(7) 2SLS POL-ER	(8) 2SLS POL-RQ
Genetic diversity	**7.294*** (2.213)**	**11.680*** (4.234)**	**8.196*** (2.242)**	**4.288** (1.905)**	**3.293** (1.663)**	**5.648** (2.842)**	**1.110** (0.560)**	**1.576*** (0.566)**
Years since Neolithic	-0.043 (0.033)	-0.064* (0.034)	-0.020 (0.018)	-0.010 (0.018)	-0.011 (0.014)	-0.014 (0.025)	-0.008* (0.005)	-0.009* (0.005)
Settlement duration	0.045** (0.022)	0.038* (0.021)	0.008 (0.013)	0.011 (0.011)	0.006 (0.006)	0.010 (0.010)	0.001 (0.002)	-0.001 (0.003)
Duration as colony	0.031 (0.026)	0.033 (0.024)	0.032*** (0.011)	0.012 (0.014)	0.019** (0.009)	0.034** (0.016)	0.005 (0.004)	0.007 (0.005)
Absolute latitude	-0.007 (0.013)	-0.005 (0.012)	-0.003 (0.005)	-0.002 (0.005)	0.005 (0.004)	0.009 (0.007)	0.002 (0.001)	0.002 (0.001)
Mean land quality	-0.668** (0.255)	-0.631*** (0.228)	-0.218* (0.121)	-0.313*** (0.099)	-0.087 (0.087)	-0.155 (0.157)	-0.021 (0.038)	-0.074** (0.037)
Variation in land quality	1.072** (0.503)	1.014** (0.465)	0.066 (0.260)	-0.089 (0.220)	-0.160 (0.196)	-0.233 (0.351)	-0.042 (0.069)	-0.039 (0.080)
Mean elevation	-0.160 (0.137)	-0.204 (0.134)	-0.168** (0.081)	-0.083 (0.066)	-0.076 (0.059)	-0.110 (0.100)	-0.010 (0.019)	0.026 (0.018)
Variation in elevation	-0.060 (0.385)	0.188 (0.429)	0.551** (0.255)	0.397* (0.220)	0.544*** (0.188)	0.908*** (0.306)	0.213*** (0.072)	0.100 (0.065)
Dispersion in elevation	0.087 (0.088)	0.050 (0.089)	-0.040 (0.052)	-0.036 (0.047)	-0.088** (0.035)	-0.149** (0.059)	-0.042*** (0.015)	-0.020 (0.015)
Observations	143	143	143	143	143	143	129	129
Adjusted R^2	0.38							

Instrumental Variable: Migratory distance from East Africa
Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Genetic Diversity and Conflict: Channels

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Genetic Diversity and Civil Conflict

	(1) 2SLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
	Number of new civil conflict onsets per year, 1960–2008 (PRIO25)						
Genetic diversity (ancestry adjusted)	**0.256*** (0.082)**	**0.599*** (0.231)**	**0.737*** (0.267)**	**0.723*** (0.268)**	**0.740*** (0.261)**	**0.744*** (0.270)**	**0.805*** (0.275)**
Ethnic fractionalization				0.007 (0.011)		-0.002 (0.012)	-0.002 (0.013)
Ethnolinguistic polarization					0.017 (0.012)	0.018 (0.013)	0.019 (0.013)
Absolute latitude		-0.529** (0.243)	-0.508* (0.267)	-0.444 (0.314)	-0.527** (0.265)	-0.547* (0.316)	-0.116 (0.296)
Range of elevation		0.010** (0.004)	0.010** (0.004)	0.009** (0.004)	0.009** (0.004)	0.009** (0.004)	0.005 (0.004)
Range of land suitability		0.017 (0.012)	0.014 (0.012)	0.013 (0.012)	0.017 (0.013)	0.018 (0.013)	0.015 (0.014)
Executive constraints, 1960–2008 average			0.005* (0.003)	0.005 (0.003)	0.005* (0.003)	0.006 (0.003)	0.008** (0.004)
Fraction of years under democracy, 1960–2008			-0.018 (0.018)	-0.017 (0.018)	-0.018 (0.018)	-0.019 (0.018)	-0.017 (0.017)
Fraction of years under autocracy, 1960–2008			-0.005 (0.016)	-0.005 (0.015)	-0.004 (0.016)	-0.004 (0.015)	-0.007 (0.015)
Value of oil production per capita, 1960–2008 average							0.002* (0.001)
Log population, 1960–2008 average							0.003 (0.003)
Log GDP per capita, 1960–2008 average							-0.016*** (0.004)
Effect of increasing genetic diversity from the 10^{th} to the 90^{th} percentile	0.017*** (0.005)	0.039*** (0.015)	0.048*** (0.017)	0.047*** (0.017)	0.048*** (0.017)	0.048*** (0.018)	0.052*** (0.018)
Other baseline geographical controls		x	x	x	x	x	x
Continent dummies		x	x	x	x	x	x
Legal origin and colony dummies			x	x	x	x	x
Observations	143	143	143	143	143	143	143

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  - $\Longrightarrow$ Diversity fosters innovations, shifting the PPF outward

The Benefits of Diversity – Evidence

	(1)	(2)	(3)	(4)
	Patent Applications 1980-2000		Scientific Articles 1980-2000	
Predicted Diversity (Ancestry Adjusted)	0.851**	0.673**	2.290***	1.816***
	(0.343)	(0.312)	(0.576)	(0.541)
Log Years since NR (Ancestry Adjusted)	-0.021	-0.007	-0.091*	-0.076
	(0.041)	(0.042)	(0.048)	(0.048)
Log % of Arable Land	-0.003	-0.000	0.009	0.007
	(0.013)	(0.013)	(0.016)	(0.015)
Log Absolute Latitude	0.010	0.017	0.045*	0.055**
	(0.015)	(0.013)	(0.024)	(0.023)
Social Infrastructure	0.241***	0.177**	0.685***	0.548***
	(0.078)	(0.072)	(0.117)	(0.127)
Ethnic Fractionalization	0.003	-0.008	0.095	0.073
	(0.059)	(0.060)	(0.096)	(0.096)
% of Population of European Descent	0.029	-0.042	0.042	-0.040
	(0.067)	(0.062)	(0.090)	(0.081)
% of Population at Risk of Contracting Malaria	0.031	0.035	0.102*	0.131***
	(0.049)	(0.043)	(0.055)	(0.048)
Terrain Ruggedness	-0.086	-0.060	-0.349*	-0.269
	(0.098)	(0.095)	(0.177)	(0.169)
% of Population Living in Tropical Zones	-0.021	0.004	0.018	0.049
	(0.036)	(0.031)	(0.058)	(0.055)
Mean Distance to Nearest Waterway	-0.037	-0.031	0.105***	0.118***
	(0.044)	(0.044)	(0.038)	(0.035)
Years of Schooling		0.020***		0.032***
		(0.007)		(0.008)
Observations	77	77	93	93
R-squared	0.74	0.77	0.80	0.82

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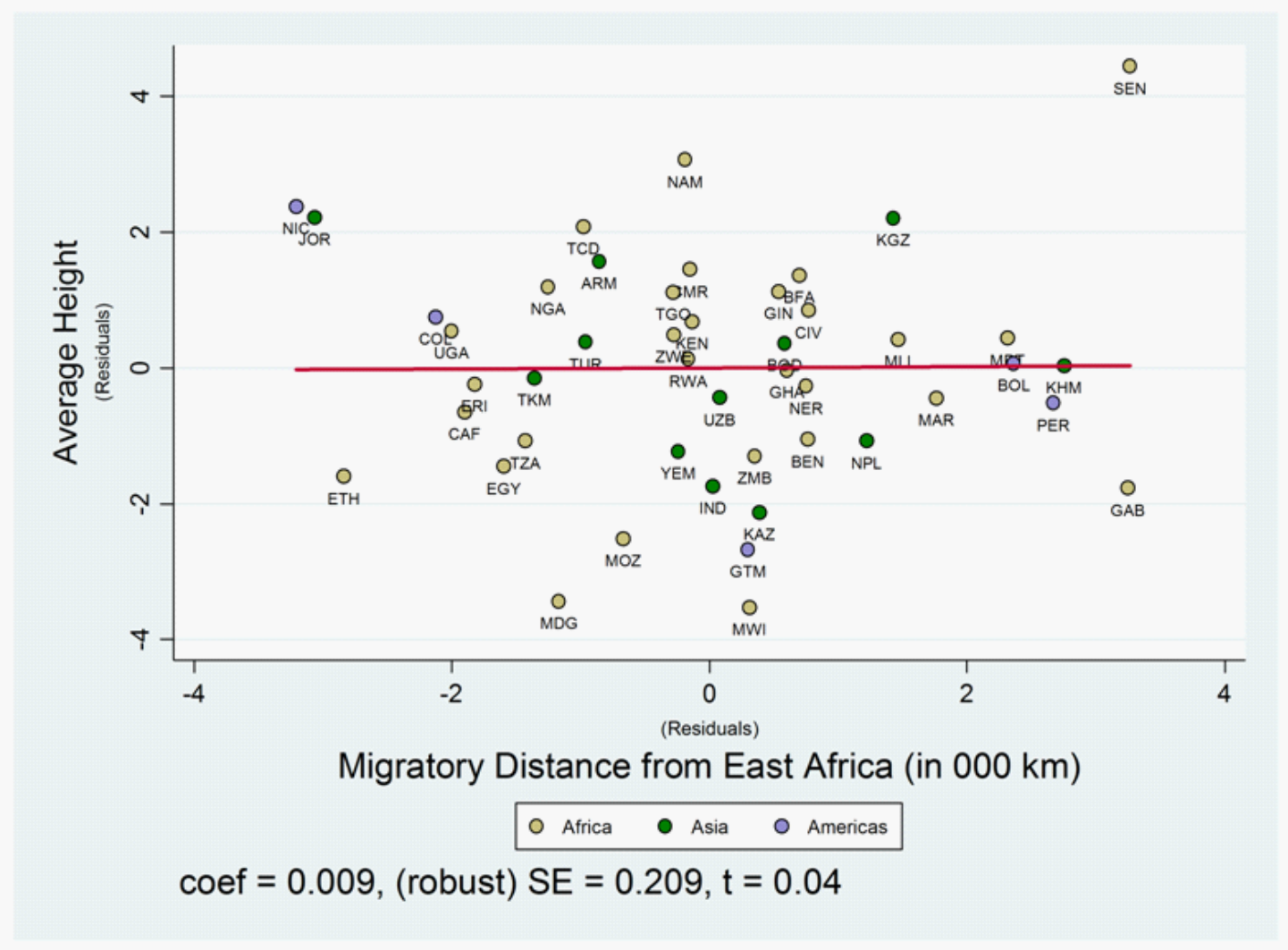
Migratory Distance from East Africa and Height



Accounting for distance from the equator.

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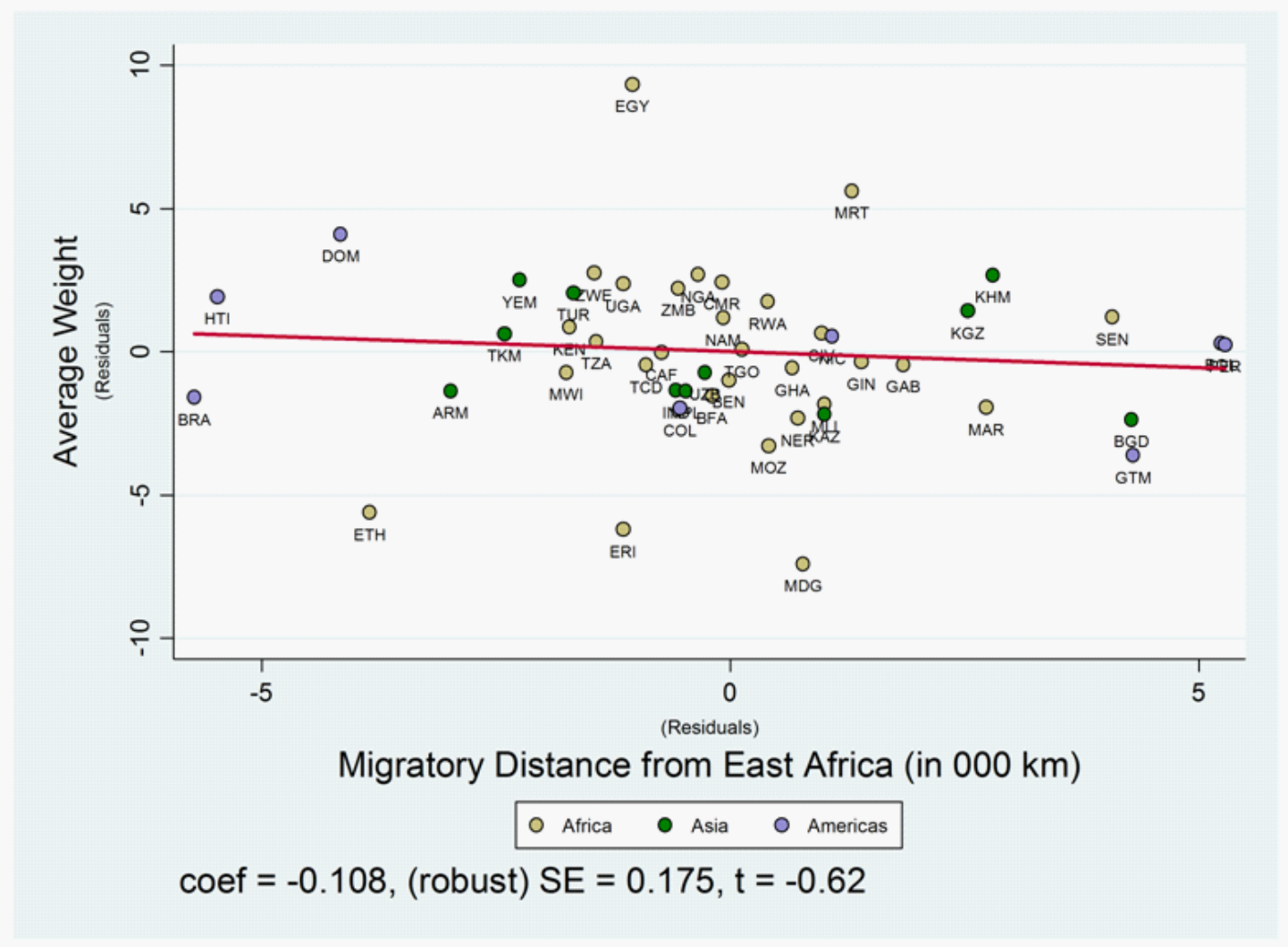

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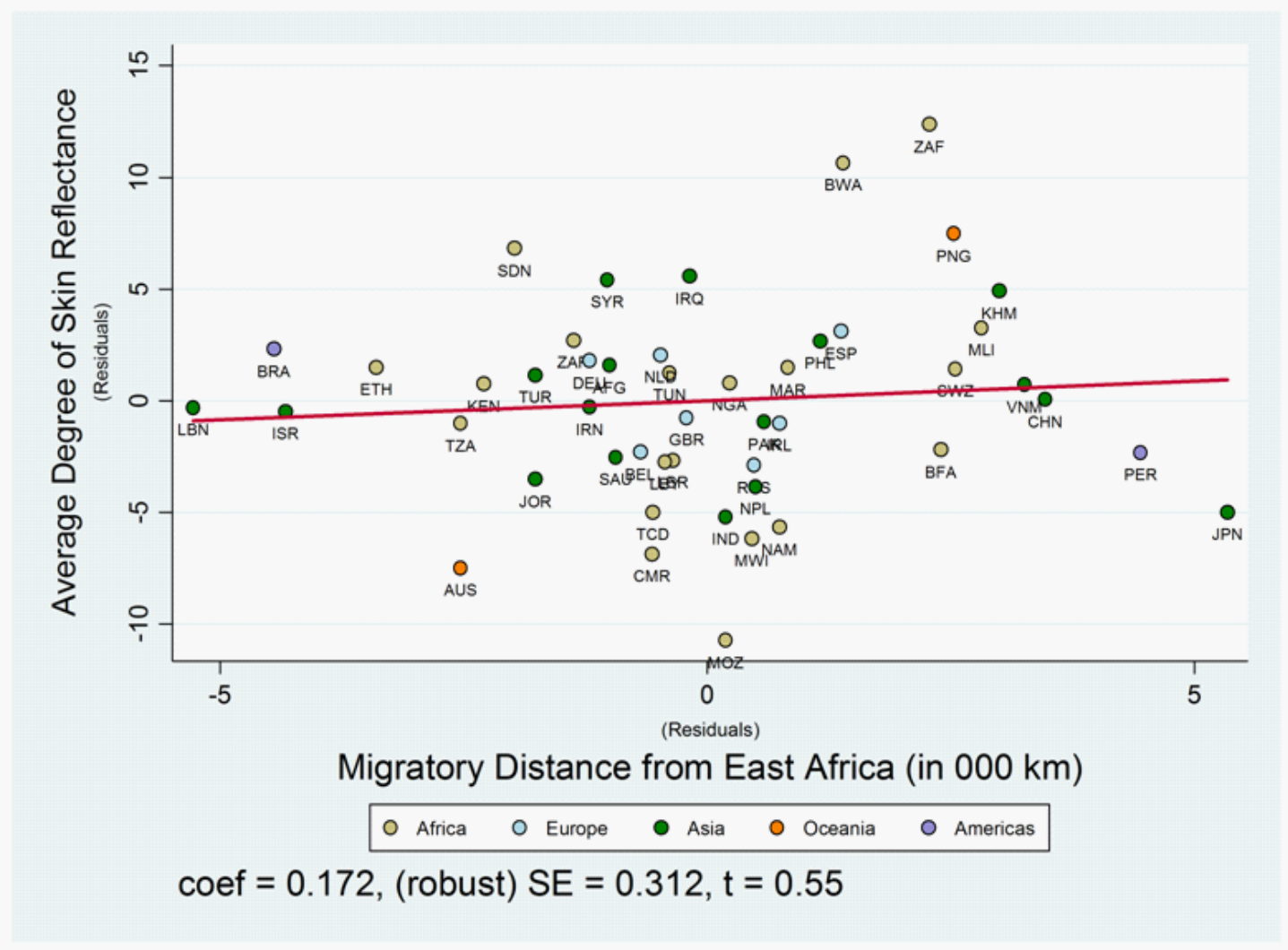
Migratory Distance from East Africa and Skin Reflectance



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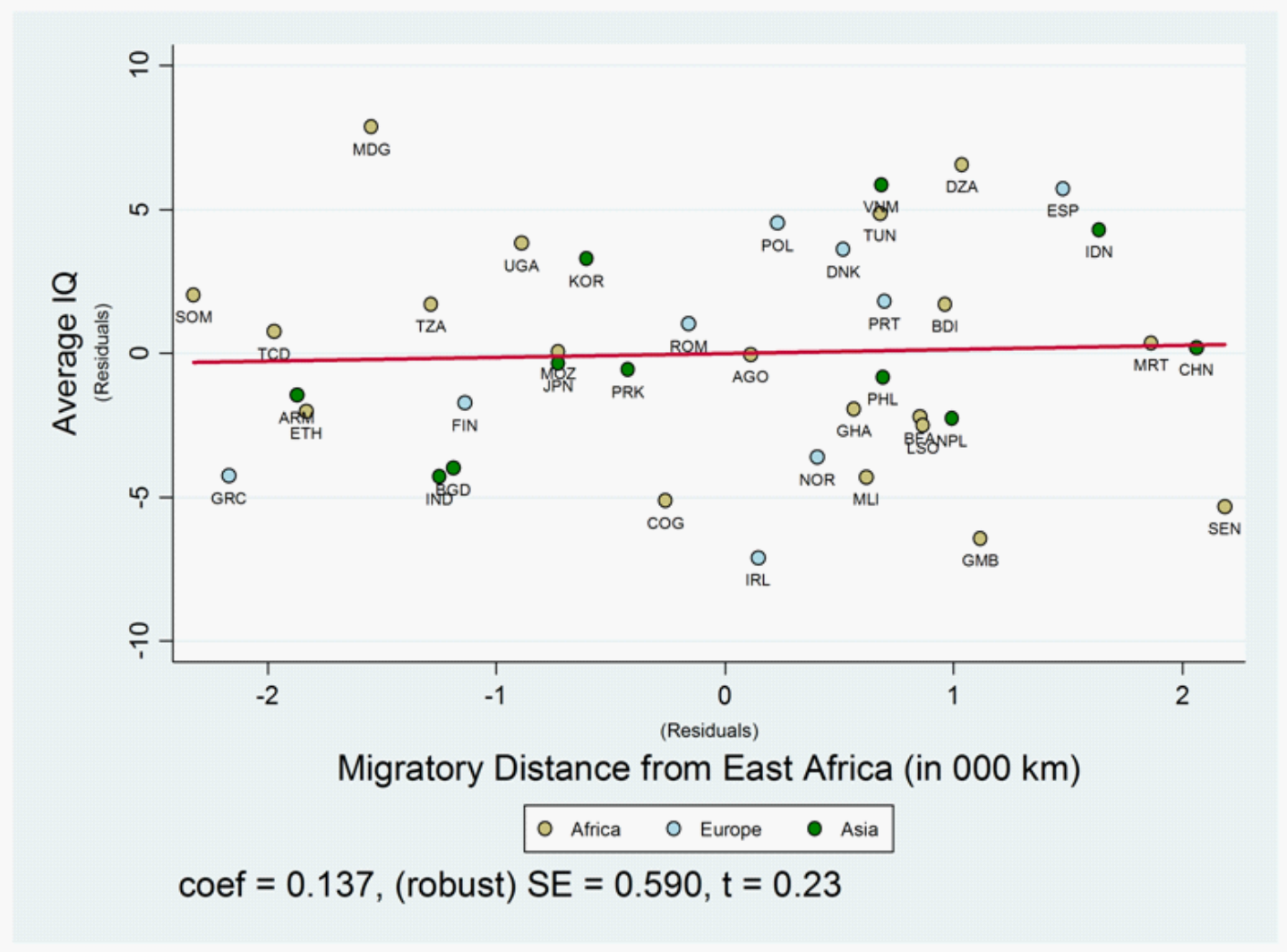
Migratory Distance from East Africa and IQ



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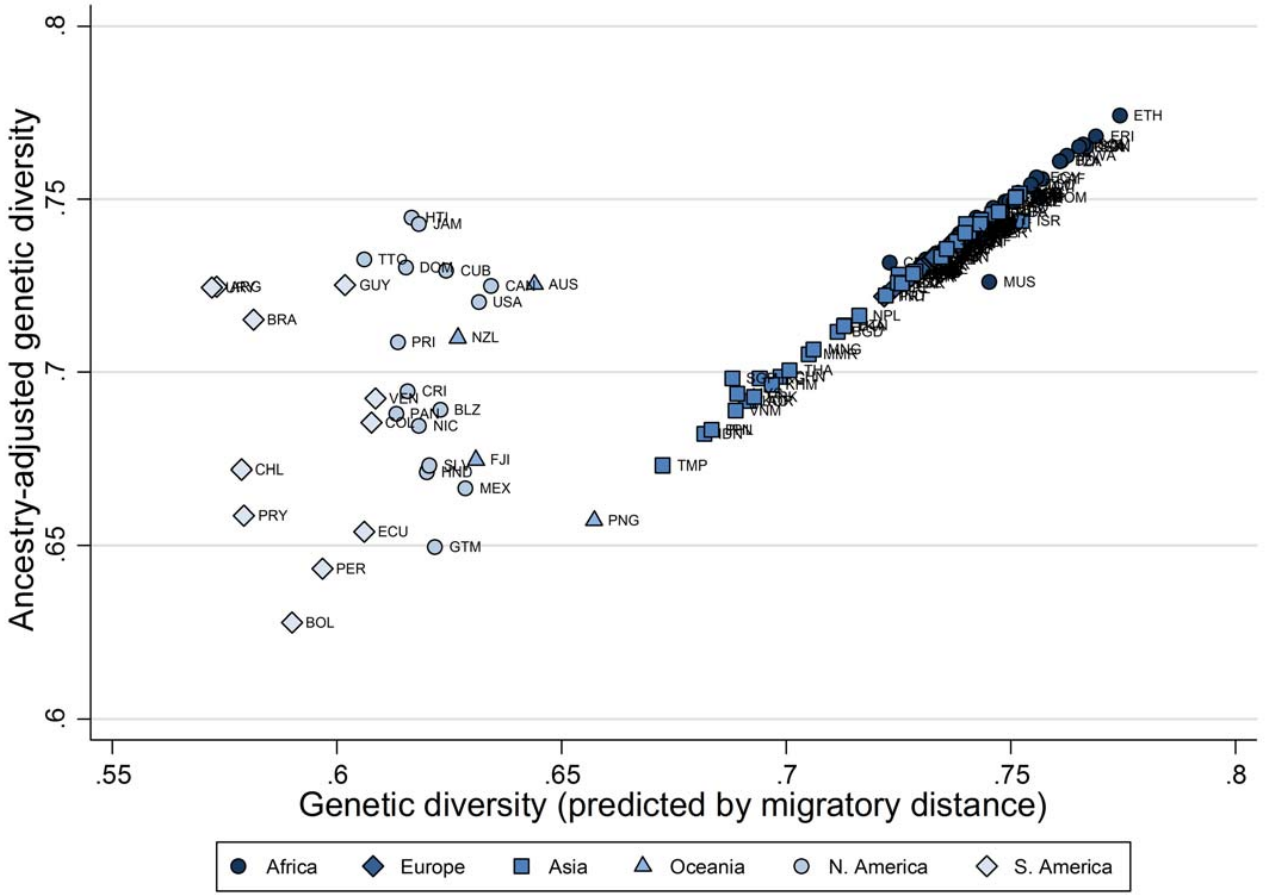
The Impact of Post-1500 Migrations on Genetic Diversity



Theoretical Foundations of the Hump-Shaped Effect of Diversity

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

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Theoretical Foundations of the Hump-Shaped Effect of Diversity

- Diversity and TFP growth

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

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

Theoretical Foundations of the Hump-Shaped Effect of Diversity

- Diversity and TFP growth

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

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

- For instance:

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

Theoretical Foundations of the Hump-Shaped Effect of Diversity

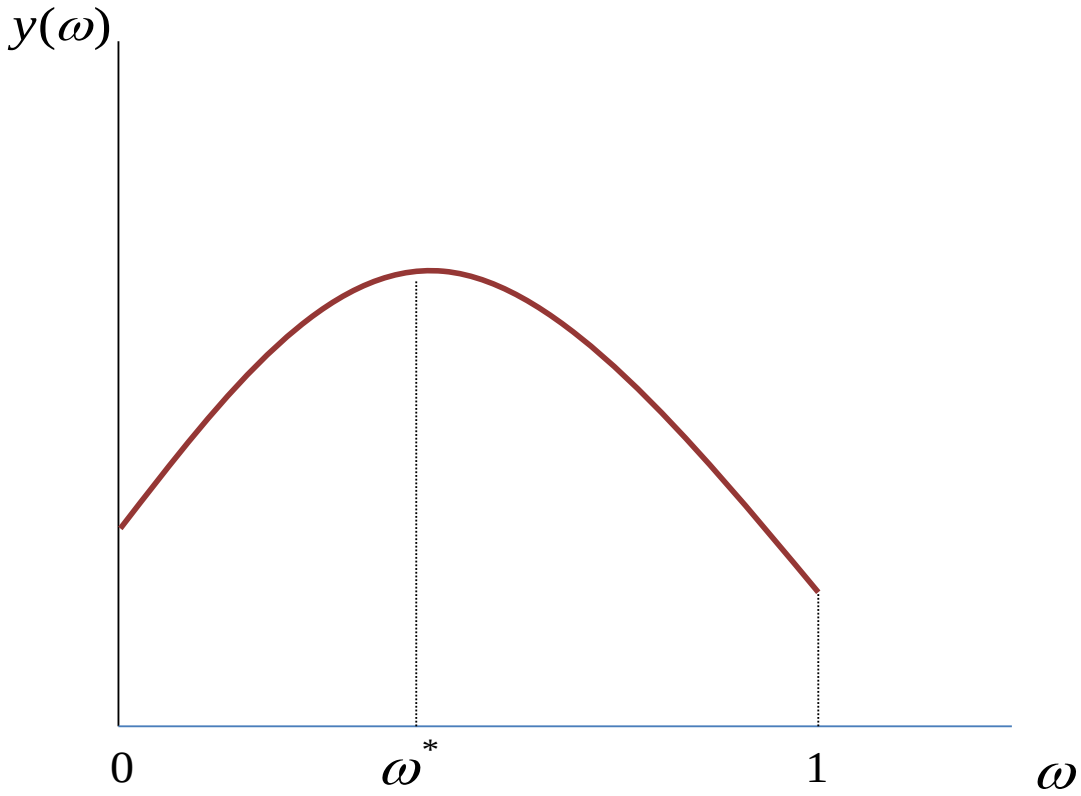
- Properties of $y(\omega)$

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

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

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

The Optimal Level of Genetic Diversity



An Rise in the Optimal Diversity – Faster Technological Progress