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Geography Matters: Reconsidering the Effect of Geography on Development

by

Michael Bleaney and Arcangelo Dimico*

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Abstract

We decisively reject the hypothesis that geographical factors influence long-run only indirectly, through the quality of institutions. The direct influence of geography on per capita incomes is robust to the inclusion of a sub-Saharan Africa dummy and other tests. We obtain our results by replacing the usual instrument (settlers' mortality) by stronger instruments for institutional quality (latitude, the share of the country in the temperate climatic zone). We also show that settlers' mortality suffers from endogeneity with respect to institutional quality for early colonies, because of its dependence on nineteenth-century mortality data.

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Outline

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1) Introduction

There has been much debate in recent years over the historical factors that have determined the vast divergences of per capita income that we observe in the world today. Some have stressed the role of institutions (e.g. Knack and Keefer, 1995; Hall and Jones, 1999), and others the importance of geography (e.g. Diamond, 1997; Olsson and Hibbs, 2005; Sachs, 2003). Easterly and Levine (2003) provide a succinct summary of the opposing positions. Acemoglu *et al.* (2001) [AJR] argue that institutions are the only factor which drives long-run economic growth, and that once institutions are controlled for, geography (represented by latitude) has no significant direct effect on income. They use estimates of European settlers' mortality in a sample of colonies as an instrument for institutional quality, arguing that settlers favoured countries where disease conditions were such that mortality was low, and that consequently in these countries institutions more closely resembled those in Europe. Sachs (2003) and Carstensen and Gundlach (2006) provide counter-evidence that, if the risk of fatal malaria is used as the geographic variable, geographical factors do have a direct effect on per capita income. A rigorous horse-race between the opposing models is undertaken by Rodrik *et al*. (2004) [RST]. Since malaria risk ceases to be significant when a dummy for sub-Saharan Africa is included, they conclude that the direct impact of geography on income is not robust and that "institutions trump geography", as AJR suggest.

It is common ground in this debate that climatic and disease conditions affected institutional quality, and that institutions are highly endogenous to per capita income. Consequently in any empirical test geography has to be represented by a minimum of two variables: one to act as an instrument for institutions, and another that appears as an exogenous variable in the second stage of two-stage least squares estimation.

This paper makes two main contributions. The first is to show that settlers' mortality, the instrument for institutions used by AJR and RST, is endogenous to per capita income for early colonies, for which the mortality data relate to a period long after colonisation, and is also weak in the sense of Stock *et al*. (2002). We then demonstrate, using two alternative instruments that do not suffer from these problems (latitude, share of the country in the temperate climatic zone), that geographical factors (malaria intensity, an index of biodiversity and access to the sea) have a strong direct impact on per capita income after controlling for institutional quality and a sub-Saharan Africa effect.

The rest of the paper is organised as follows. Section 2 summarises the current state of research. In Section 3 we investigate the adequacy of settlers' mortality as an instrument for institutional quality. In Section 4 we present our main results using alternative instruments. Tests of robustness of our results appear in Section 5. Section 6 concludes.

2) The Current State of Research

In this section we estimate models similar to those of RST, who consider three basic determinants of current per capita income: institutional quality, openness to international trade and geography. Their regression equation is of the form:

$$\ln GDPC_i = \beta_1 + \beta_2 \cdot INST_i + \beta_3 \cdot TRADE_i + \beta_4 \cdot GEO_i + \varepsilon_i \qquad (1)$$

where *i* is an index of countries; $GDPC_i$ is per capita income; ε_i is an error term; $INST_i$ is a measure of institutional quality; $TRADE_i$ is a proxy for trade integration; and GEO_i represents geographical factors. To allow for endogeneity, RST use settlers' mortality as an instrument for institutions, and the predicted trade shares of Frankel and Romer (1999) as an instrument for trade integration.

In Table 1 we present models similar to RST, except that we drop the proxy for trade integration because the variable is always insignificant. Consequently, models in Table 1 are similar to Table 7 in RST. Dependent and independent variables for these models are the same as in RST and they are collected from Sachs (2003). GDP per capita in 1995 (PPP adjusted) is the dependent variable. We use the rule of law[1] in 1996 as an indicator of institutional quality. Latitude and the risk of fatal malaria are the geographical variables. The risk of fatal malaria was introduced by Gallup *et al*. (1999), and is calculated as the proportion of the population living in areas of malaria risk multiplied by the proportion of national malaria cases that involve the fatal species (*Plasmodium falciparum*). Since this might be affected by economic and hygienic conditions, like Sachs (2003) we use an index of

[1] "Rule of law combines several indicators that measure the extent to which agents have confidence in and abide by the rules of society. These include perceptions of the incidence of both violent and non-violent crime, the effectiveness and predictability of the judiciary, and the enforceability of contracts" (Kaufmann *et al.*, 2005). Alternative measures of institutional quality cover a smaller sample of countries.

ecological conditions conducive to fatal malaria as an instrument for fatal malaria risk.[2] We use settlers' mortality (derived from AJR and integrated by RST) as an instrument for the rule of law.

Model 1 of Table 1 shows the results of regressing per capita GDP on the rule of law and latitude only, for a sample of ex-colonies. Model 2 adds the malaria variable, and Model 3 adds a sub-Saharan Africa dummy as well. Latitude is always insignificant (as found by AJR); in Model 2 malaria intensity has a significant negative coefficient, but Model 3 shows that it becomes insignificant when a sub-Saharan Africa dummy is included. These results are essentially similar to those reported by RST. In all three models the Cragg-Donald F-statistic is smaller than the Stock and Yogo (2005) critical values, indicating weak relevance of instruments.[3] It is clearly therefore desirable to try to improve on the instruments used in Table 1.

[2] See Sachs (2003) for a fuller explanation of this malaria ecology variable.
[3] Dollar and Kraay (2002) first pointed out the weak identification of models in RST.

Table1: RST Models for a Sample of Ex-Colonies

	Dependent Variable: 1995 per capita GDP (PPP)		
ESTIMATION METHOD: 2SLS	Model 1	Model 2	Model 3
Institutional Quality (Rule of Law)	1.877***	0.904***	0.949***
	(4.56)	(3.82)	(3.56)
Latitude	-0.0260	-0.0140	-0.0145
	(-1.35)	(-1.47)	(-1.53)
Fatal Malaria Risk		-1.164***	-0.877
		(-4.11)	(-1.14)
Sub-Saharan Africa			-0.236
			(-0.48)
Constant	8.879***	8.980***	8.960***
	(22.14)	(39.09)	(36.23)
Cragg-Donald F-Stat.	13.21	7.01	4.45
Stock and Yogo (2005) crit. value (10% IV size)	(16.38)	(7.03)	(7.03)
Endogeneity (p-values)	0.0000	0.1403	0.1350
Conditional LR Test: $\beta = 1.877$ (p-values)	0.9993		
Anderson-Rubin corrected confidence int	[1.292, 3.477]		
Conditional LR corrected confidence int.	[1.292, 3.477]		
Observations	80	76	76
Root MSE	1.017	0.55	0.55
R-squared	0.08	0.71	0.71
Instruments	Settlers' Mortality	Settlers' Mortality + Malaria Ecology	Settlers' Mortality + Malaria Ecology

	FIRST STAGE REGRESSIONS				
	Model 1	Model 2		Model 3	
Dependent Variables:	Rule of Law	Rule of L.	Malaria	Rule of L.	Malaria
Settlers' Mortality	-0.262***	-0.366***	0.113***	-0.354***	0.081**
	(-3.63)	(-4.17)	(3.03)	(-3.96)	(2.57)
Latitude	0.025***	0.025***	-0.008**	0.024***	-0.005*
	(3.25)	(3.33)	(-2.56)	(3.09)	(-1.81)
Malaria Ecology		0.020	0.024***	0.026*	0.008
		(1.65)	(4.58)	(1.80)	(1.65)
Sub-Saharan Africa				-0.175	0.470***
				(-0.76)	(5.71)
Constant	0.581	0.919**	-0.084	0.917**	-0.079
	(1.40)	(2.10)	(-0.45)	(2.09)	(-0.51)
Observations	80	76	76	76	76
Partial R-Squared	0.1464	0.2024	0.4912	0.1816	0.1753
Shea Partial R-Squared	0.1464	0.1632	0.3961	0.1330	0.1271

1) Hansen J- Statistics do not reject the null.
2) Anderson canon corr. LR-Statistics reject the null.
3) Robust *t*-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1
4) Endogeneity is the Durbin-Wu-Hausman test of the significance of the first-stage residuals in the augmented OLS regression.

Table 2: Adding Prehistoric Biogeography

	Dependent Variable: 1995 per capita GDP (PPP)		
ESTIMATION METHOD: 2SLS	Model 1	Model 2	Model 3
Institutional Quality (Rule of Law)	0.962***	1.081***	1.105***
	(3.35)	(2.76)	(2.76)
Fatal Malaria Risk	-1.191***	-0.792	-0.642
	(-4.20)	(-0.89)	(-0.74)
Latitude	-0.0121	-0.0110	
	(-1.26)	(-1.07)	
Sub-Saharan Africa		-0.348	-0.415
		(-0.58)	(-0.70)
Extended Olsson-Hibbs Biogeography	-0.121	-0.229	-0.342
	(-0.73)	(-0.89)	(-1.34)
Constant	9.348***	9.647***	9.788***
	(16.19)	(12.93)	(12.66)
Cragg-Donald F-Stat.	5.11	2.92	2.93
Stock and Yogo (2005) crit. value (10% max IV size)	(7.03)	(7.03)	(7.03)
Endogeneity (p-values)	0.1504	0.1036	0.0990
Root MSE	0.57	0.58	0.59
R-Squared	0.69	0.67	0.66
Observations	76	76	76
Instruments	Settlers' Mort. + Malaria Ecology	Settlers' Mort. + Malaria Ecology	Settlers' Mort. + Malaria Ecology

1) Anderson LR-tests reject the hypothesis of under-identification.
2) Hansen J-Statistics do not reject the hypothesis of over-identification.
3) See notes to Table 1.

A further point to note is that latitude is highly significant in the first-stage regressions for the rule of law. This suggests that geographical variables other than settlers' mortality could serve as an instrument for institutional quality. We return to this point in Section 4.

Olsson and Hibbs (2005) offer a second variant of the geographical thesis. They test Diamond's (1997) theory that prehistoric biogeographical conditions continue to affect per capita incomes today, by influencing the timing of the agricultural revolution. According to Diamond's theory, countries that made an early transition to agriculture established a lead in development that they have never entirely lost, contrary to the "reversal of fortune" argument of Acemoglu *et al*. (2002). Olsson and Hibbs (2005) show that a measure of prehistoric biogeography (based on the number of wild grasses and large domesticable animal species) is significantly correlated with current income levels. In Table 2 we add this variable to the Table 1 regressions. Contrary to the Diamond hypothesis, it is never significant and does not even have the predicted sign.

3) The Exogeneity of Settlers' Mortality

Results in Table 1 and Table 2 confirm the institutional thesis of AJR and RST – geography adds nothing to the explanation once institutions are taken into account. However, the validity of this hypothesis depends on the exogeneity of European settlers' mortality. Good data about settlers' mortality at the time of colonisation are almost impossible to find. For this reason AJR use Curtin's (1964, 1989, 1998) nineteenth-century data for the mortality rate of soldiers stationed in various colonies. For most Latin American countries, for which Curtin has no estimates, they use data from Gutierrez (1986), based on the mortality rate of a small sample of bishops. Finally, for some countries (e.g. Australia, Bahamas, Haiti, etc.) they estimate data using figures for neighbouring countries with similar environmental hazards.

Albouy (2006) has pointed out that nineteenth-century mortality data for the USA and Canada (which were colonised well before 1817) may be endogenous to institutional development, because some important infections are more related to hygienic conditions than to climatic ones (e.g. typhoid fevers). Maddison (2003) estimates per capita income in 1820 at $1,257 for the USA and $907 for Canada, compared with $400 in 1600. If this increase in per capita income means that hygienic conditions in 1817 were much better than at the time of the colonisation, Curtin's figures are likely to underestimate the mortality rate of the original settlers, which according to AJR's thesis was crucial to the rate of initial settlement and therefore to the quality of institutions established. Indeed there is historical evidence from early settlements in the USA which clearly implies a higher mortality rate than that given by Curtin.[4] According to these estimates, the mortality in early settlements as at least 35 percent of the initial settlers, and most of these deaths were due to typhoid fevers.[5]

There is independent evidence of a shift over time in the relationship between settlers' mortality and institutional development (Acemoglu *et al.*, 2006; Olsson, 2007). Olsson (2007) finds that settlers' mortality is significantly correlated with institutional development only during the mercantilist era of colonisation (before 1850), and not for countries colonised after 1850 or for Africa (which was mostly colonised late). Acemoglu *et al.*

[4] See Harriot (1588).
[5] See King and Ubelaker (1996), Earle (1992), Walsh (1977) and Curtin (1998).

(2006) report a similar result. These findings essentially seem to suggest that settlers' mortality is more strongly correlated with institutions in countries colonised before the date to which Curtin's mortality data refer, which is consistent with the hypothesis of endogeneity of these estimates.

Table 3 shows that this problem of structural change in the relationship with institutional quality is specific to settlers' mortality (SM). The dependent variable is the rule of law. Models 1 and 2 show that the SM coefficient is significantly less negative for countries colonised after 1850 or for sub-Saharan Africa, as in Olsson (2007). For example, in Model 2 the settlers' mortality coefficient for post-1850 colonisation is less than 40% of its value for pre-1850 colonisation. Models 3 and 4 show that latitude does not suffer from this problem – there is no such structural change in the relationship between latitude and the rule of law.

Table 3: Heterogeneous Effect of Settlers' Mortality on Institutions

	Dependent Variable: Rule of Law			
ESTIMATION METHOD: OLS	Model 1	Model 2	Model 3	Model 4
Settlers' Mortality	-0.451***	-0.615***		
	(-3.84)	(-4.59)		
Sub-Sahara dummy	0.0906	-2.200***	-0.112	-0.396
	(0.41)	(-2.92)	(-0.73)	(-1.36)
Post-1850 dummy[1]	-1.803***	-0.380*	-0.526**	-0.180
	(-2.73)	(-1.84)	(-2.19)	(-1.22)
Settlers' Mort.* post-1850 dummy	0.287**			
	(2.24)			
Settlers' Mort.* Sub-Sahara dummy		0.484***		
		(3.15)		
Latitude			0.0272**	0.0287**
			(2.25)	(2.37)
Latitude * post-1850 dummy			0.0206	
			(1.36)	
Latitude * Sub-Sahara dummy				0.0172
				(1.05)
Constant	1.895***	2.531***	-0.529**	-0.532**
	(3.78)	(4.63)	(-2.29)	(-2.15)
Observations	81	81	105	105
Root MSE	0.726	0.705	0.747	0.75
R-squared	0.34	0.37	0.26	0.26

Robust *t* -statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

To test whether this structural shift in the relationship between settlers' mortality and the rule of law is a result of the endogeneity of the former, we instrument settlers' mortality with an alternative geographical variable (the share of the country in the temperate climatic zone, but we get similar results using latitude).[6] Table 4 shows the results. In each case we show the first-stage regression of SM on the temperate zone share, and then the result of adding the residuals from this first-stage regression to a regression of the rule of law on SM. Significance of the residuals indicates a rejection of the null of exogeneity. For the whole sample, or just for the pre-1817 sub-sample, there is evidence that settlers' mortality is endogenous to institutional quality, but not for the post-1817 sample. This is consistent with the hypothesis that the endogeneity is related to the time elapsed between the date of colonisation and the date to which the mortality data refer.

Table 4. Testing the Exogeneity of Settlers' Mortality

	Entire Sample		Pre-1817		Post-1817	
	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
11111111111Dependent Variable:	Sett. Mort	Rule of L.	Sett. Mort	Rule of L.	Sett. Mort	Rule of L.
Settlers' Mortality		-0.820***		-1.001***		-0.481
		(-7.37)		(-7.19)		(-1.46)
Temperate Zone Share	-2.004***		-1.653***		-1.991***	
	(-6.02)		(-4.90)		(-2.81)	
First-Stage Residuals		0.578***		0.805***		0.264
		(3.95)		(3.90)		(0.72)
Constant	4.903***	3.545***	4.486***	4.181***	5.282***	1.928
	(36.86)	(6.89)	(39.95)	(7.46)	(24.19)	(1.13)
Observations	81	81	42	42	39	39
R-squared	0.230	0.385	0.432	0.471	0.080	0.172
Root MSE	1.045	0.609	0.733	0.674	1.280	0.738

Robust *t* -statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4) Geography Matters: Empirical Evidence

In this section we re-estimate equation (1), again omitting *TRADE* because of its statistical insignificance, with per capita income in 1995 as the dependent variable, the rule of law as a proxy for institutions, and fatal malaria risk, the known species of wild plants and the ratio of a country's coastline to its surface area as proxies for geography. Data on the known species of wild plants are from the World Conservative Monitoring Centre (1992), and

[6] Sachs (2003) was the first to use the share of the country in the temperate climatic zone as an instrument.

coastline length is from the United Nations (Global Environmental Outlook-3)[7]. Most other data are from Sachs (2003).

	Dependent Variable: 1995 per capita GDP (PPP)			
ESTIMATON METHOD: OLS	Model 1	Model 2	Model 3	Model 4
Institutional Quality (Rule of Law)	0.556***	0.558***	0.489***	0.502***
	(7.80)	(7.08)	(5.72)	(5.91)
Fatal Malaria Risk	-1.263***	-1.159***	-1.107***	-0.979***
	(-8.85)	(-7.22)	(-6.97)	(-5.68)
Plant Diversity		0.759***	0.908***	0.855***
		(3.03)	(3.52)	(3.35)
Coastline Length / Surface Area			0.227***	0.215***
			(3.99)	(4.13)
Sub -Saharan Africa				-0.157
				(-1.25)
Constant	8.717***	8.545***	8.425***	8.447***
	(117.6)	(91.61)	(79.04)	(79.37)
Observations	91	88	87	87
Root MSE	0.504	0.488	0.473	0.473
R-squared	0.77	0.77	0.78	0.78

Robust *t*-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5. Preferred Model for Ex-Colonies – OLS Results

We first estimate the model using settlers' mortality as the main instrument for institutions. We then re-estimate the same model, but using the population share within the temperate climate zone (as in Sachs, 2003) as an alternative instrument for institutions[8]. Gallup *et al.* (1999) is the source for data on Köppen-Geiger climate zones. We still confine the sample to ex-colonies, although we show later that we obtain similar results when we extend it to all countries. Table 5 shows OLS estimates for the baseline model. As expected, the rule of law is always highly significant, as are also the three geographic variables (malaria intensity,

[7] Source: United Nations Environmental Programme (www.unep.org/GEO/geo3/)

[8] Sachs (2003) does not provide data on climatic zones for Bahamas, Barbados, Singapore, Madagascar, Fiji and Malta. Because the absence of data for these countries reduces the sample size (compared to other instruments) we use figures from the Sedac-Ciesin (PLACE) to obtain data on the share of the country within climatic zones cf, cs, df and dw for these six countries.

plant diversity, and access to the sea). Model 4 shows that the results are robust to the inclusion of a sub-Saharan Africa dummy.

Table 6 shows the results from two-stage least squares estimation, first instrumenting the rule of law with settlers' mortality (Model 1), then with the temperate zone share (Model 2), and finally also instrumenting fatal malaria risk with malaria ecology (Model 3). These are our main results. In Model 1 the Cragg-Donald F-statistic is much lower than the Stock-Yogo (2005) critical values, denoting a serious problem of weak instruments, which biases standard errors. Nevertheless plant diversity and rule of law are still significant at the 0.01 level, although fatal malaria risk and access to the sea fail to reach the 0.05 significance level.[9]

In Model 2, with the population share within the temperate climate zone as the instrument, the Cragg-Donald F-Statistic is 24.43 and therefore much greater than the Stock-Yogo critical values, and the sample is extended to 87 countries rather than 73. The coefficient on the rule of law is somewhat smaller than in Model 1, although still highly significant. Fatal malaria risk and plant biodiversity are now both significant at the 0.01 level, and access to the sea is significant at the 0.05 level. Thus geographical variables seem to be more important relative to institutional quality when an instrument other than settlers' mortality is used.

Model 3 shows the result of using malaria ecology as an instrument for the risk of fatal malaria, although the exogeneity of fatal malaria risk is not rejected. Coefficients and significance levels are very similar to those in Model 2. Models 2 and 3 show that with climatic zones as an instrument there is strong evidence of a direct effect of geography on income, and in particular geography appears to be much more important relative to institutional quality than with settlers' mortality as an instrument. Since Rodrik *et al*. (2004) argue that geographical variables are not robust to the inclusion of a sub-Saharan Africa dummy in this regression, we test this hypothesis in the following section.

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[9] We use the Moreira and Poi (2001) correction in order to get unbiased significance levels and tests in the presence of weak instruments.

Table 6: Preferred Model for Ex-Colonies - 2SLS Estimates

	Dependent Variable: 1995 per capita GDP (PPP)		
ESTIMATION METHOD: 2SLS	Model 1	Model 2	Model 3
Institutional Quality (Rule of Law)	0.912**	0.756***	0.745***
	(2.40)	(5.48)	(4.99)
Fatal Malaria Risk	-0.687*	-0.869***	-0.893***
	(-1.85)	(-4.43)	(-3.99)
Plant Diversity	1.189**	1.090***	1.070***
	(2.63)	(3.99)	(3.69)
Coastline length/Surface Area	0.0568	0.144**	0.144**
	(0.31)	(2.11)	(2.12)
Constant	8.354***	8.380***	8.391***
	(56.84)	(76.74)	(63.45)
Cragg-Donald F-Stat.	5.45	24.43	9.32
Stock and Yogo (2005) critical value (10% max IV size)	(16.38)	(16.38)	(7.03)
Endogeneity (p-values)	0.1745	0.0896	0.2341
Conditional LR Test: $\beta = 0.912$ (p-values)	0.9999		
Anderson-Rubin corrected confidence int.	[0.3718, 2.396]		
Conditional LR corrected confidence int.	[0.3718, 2.396]		
Observations	73	87	87
Root MSE	0.553	0.49	0.49
R-Squared	0.70	0.75	0.75
Instruments	Settlers' Mortality	Temp. Zone Share	Temp. Zone Share + Malaria Ecology

1) Robust *t*-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1
2) Endogeneity is the Durbin-Wu-Hausman test of the significance of the first-stage residuals in the augmented OLS regression.

5) Robustness Check

In this section we check the robustness of our results in three ways: (1) by using latitude rather than the share of the country in the temperate zone as an instrument; (2) by introducing additional control variables into the regression; and (3) by extending the sample to all countries, and not just ex-colonies.

Table 7 shows the results of using latitude as an instrument, with malaria intensity treated first as exogenous and then endogenous. Latitude is not quite as strong an instrument as climatic zones, but still much stronger than settlers' mortality. The results very much confirm those in Table 6, using climatic zones.

In Table 8 we re-estimate Model 2 of Table 6 adding in succession: (1) a dummy for sub-Saharan Africa; (2) a dummy for being an oil producer; and (3) a measure of ethnic fractionalization. The geography variables lose little significance, and in particular both malaria risk and plant diversity remain significant at the 0.01 level when a sub-Saharan Africa dummy is included, in sharp contrast to the RST regression shown in Table 1.

Table 7. Using Latitude as an Instrument for Institutions

Dependent Variable: 1995 per capita GDP (PPP)		
ESTIMATION METHOD: 2SLS	Model 1	Model 2
Institutional Quality (Rule of Law)	0.650***	0.652***
	(3.68)	(3.84)
Fatal Malaria Risk	-0.963***	-0.959***
	(-5.17)	(-4.63)
Plant Diversity	1.018***	1.021***
	(3.73)	(3.61)
Coastline Length/Surface Area	0.177**	0.177**
	(2.47)	(2.53)
Constant	8.398***	8.396***
	(80.50)	(65.69)
Cragg-Donald F-Stat.	17.46	7.03
Stock and Yogo critical values.	(16.38)	(7.03)
Endogeneity (p-values)	0.3687	0.6328
Observations	87	87
Root MSE	0.47	0.47
R-squared	0.77	0.77
Instruments	Latitude	Latitude + Malaria Ecology

Table 8: Robustness Check – Additional Controls

Dependent Variable: 1995 per capita GDP (PPP)			
ESTIMATION METHOD: 2SLS	Model 1	Model 2	Model 3
Institutional Quality (Rule of Law)	0.796***	0.707***	0.729***
	(5.79)	(5.20)	(4.98)
Fatal Malaria Risk	-0.657***	-0.823***	-0.897***
	(-2.87)	(-4.27)	(-3.98)
Plant Diversity	1.022***	0.663**	1.037***
	(3.83)	(1.99)	(3.74)
Coastline length/Surface Area	0.120*	0.203***	0.147**
	(1.92)	(2.96)	(2.20)
Sub-Saharan Africa	-0.240*		
	(-1.72)		
Oil Producers		0.425**	
		(2.45)	
Ethnic Fractionalization			-0.102
			(-0.44)
Constant	8.409***	8.284***	0.729***
	(77.34)	(77.05)	(4.98)
Cragg-Donald F-Stat.	22.62	25.00	23.33
Stock and Yogo (2005) critical value (10% max IV size)	(16.38)	(16.38)	(16.38)
Endogeneity (p-values)	0.0600	0.0556	0.1348
Root MSE	0.49	0.46	0.49
R-Squared	0.75	0.77	0.76
Observations	87	84	84
Instruments	Temperate Zone Share	Temperate Zone Share	Temperate Zone Share

1) Significance Levels in parentheses*** p<0.01, ** p<0.05, * p<0.1
2) Endogeneity is the Durbin-Wu-Hausman test of the significance of the first-stage residuals in the OLS regression.

In Table 9 we test whether the results still hold when we include European countries. In this case the exogeneity of both the rule of law and malaria risk is rejected. As a consequence, we use instruments for both of the variables.

Model 1 in Table 9 is the equivalent of Model 2 in Table 6. The Cragg-Donald statistic shows that latitude is a strong instrument, and results are very similar to those for the temperate zone share, although access to the sea loses significance. When a sub-Saharan Africa dummy is added (Model 2), the instruments cease to be strong, and malaria risk loses significance, although plant biodiversity does not. In Model 3 we show the results with alternative instruments, using prehistoric biodiversity (which has a correlation of 0.62 with the rule of law) and the proportion of the country within the tropics[10] (which has a correlation of 0.73 with malaria risk). In this case the Cragg-Donald F-statistic is 10.95 and therefore comfortably greater than 7.03, which is the threshold suggested by Stock and Yogo for the relevance of instruments. In this model, the rule of law and fatal malaria risk are both significant at the 1% level, while plant biodiversity and access to the sea are both significant at the 5% level. The dummy for Sub-Saharan Africa is not significant. Plant diversity has a rather smaller coefficient than in the equivalent regression for ex-colonies only (Table 8, Model 1), but malaria risk and access to the sea both have somewhat larger coefficients (in absolute value).

In summary, none of these checks indicate that our finding of a direct impact of geography on per capita incomes lacks robustness.

Table 9: Robustness Check – Sample Extended to All Countries

Dependent Variable: 1995 per capita GDP (PPP)			
ESTIMATION METHOD: 2SLS	Model 1	Model 2	Model 3
Rule of Law	0.829***	0.934***	0.714***
	(5.47)	(4.83)	(6.10)
Fatal Malaria Risk	-0.923***	-0.438	-0.874***
	(-3.50)	(-0.84)	(-2.68)
Plant Diversity	0.825**	0.917**	0.623**
	(2.29)	(2.49)	(1.99)
Coastline Length/Surface Area	0.0994*	0.0739	0.134**
	(1.65)	(1.20)	(2.14)
Sub-Saharan Africa		-0.353	-0.224
		(-1.23)	(-1.27)
Constant	8.493***	8.422***	8.562***
	(56.99)	(48.80)	(68.81)
Cragg-Donald F-Stat.	9.52	4.64	10.95
Stock and Yogo (2005) critical value (10% max IV size)	(7.03)	(7.03)	(7.03)
Endogeneity (p-values)	0.0558	0.0680	0.4630
Observations	124	124	125
Root MSE	0.50	0.51	0.48
R-squared	0.79	0.78	0.81
Instruments	Temp. Zone Sh. + Malaria Ecology	Temp. Zone Sh. + Malaria Ecology	Tropical Area + OH Biogeography
Sample	All Countries	All Countries	All Countries

Significance Levels in parentheses *** p<0.01, ** p<0.05, * p<0.1
Endogeneity is the Durbin-Wu-Hausman test of the significance of the first-stage residuals in the OLS regression.

[10] Data on the share of the country within the tropics are collected from Gallup et al. (1999), and integrated with data from the Sedac-Ciesin (PLACE). Gallup et al. (1999) define as geographical tropics the area between the Tropic of Cancer (23.45 N latitude) and the Tropic of Capricorn (23.45 S latitude).

6) Conclusions

Is the impact of geography on long-run development purely indirect, through its effect on the quality of institutions, as recent research has suggested, or is it more direct? The finding that its impact is only indirect, or that “institutions trump geography” in the words of Rodrik *et al*. (2004), depends heavily on the adequacy of settlers’ mortality as an instrument for institutions. We have shown that settlers’ mortality, as well as being a weak instrument, appears to be endogenous to institutional quality, probably because of the effect of the latter on hygienic conditions and the time elapsed between the date of colonisation and the date to which mortality data refer.

The share of the country in the temperate climatic zone does not have the endogeneity or structural instability problems of settlers’ mortality. Using fatal malaria risk, the diversity of plant species and access to the sea as geographical variables, and with the temperate zone share as the instrument for institutional quality, we have shown that geography has a significant direct impact on long-run development. Our findings are robust to the inclusion of dummies for sub-Saharan Africa or oil production, to the extension of the sample from ex-colonies to all countries, and to the replacement of climatic zones by latitude as an instrument.

Sources of Data

Variable	***Source***
Settlers' Mortality (Rodrik et al. 2004 estimates)	Sachs (2003)
1995 GDP p. capita (used in Rodrik et al. 2004)	Sachs (2003)
Rule of Law (in 1996)	Sachs (2003)
Latitude	Sachs (2003)
Fatal Malaria Risk (Malaria Falciparum)	Sachs (2003)
Malaria Ecology	Sachs (2003)
Population Within Temperate Climatic Zone	Sachs (2003) + Sedac-Ciesin
Share of the Country Within the Tropics	Sachs (2003) + Sedac-Ciesin
Web-address:http://www.earth.columbia.edu/articles/view/1040	
Plant Diversity	World Conservative Monitoring Centre
Web-address:http://sedac.ciesin.columbia.edu/ddc/baseline/index.html	
Years of Colonisation	World Statesmen.org
Web-address:www.worldstatesmen.org	
Oil Producers	International Energy Agency
Web-address: www.esds.mcc.ac.uk/wds_iea/	
Prehistoric Bio-geographical Conditions	Olsson and Hibbs (2005)
Web-address: www.douglas-hibbs.com	
Coastline Length	United Nations Environmental Programme (GEO-3)
Web-address: www.unep.org/GEO/geo3/	
Köppen-Geiger climate zones	Gallup et al. (1999)
Web-address: www.cid.harvard.edu/ciddata/ciddata/html	
Ethnic Fractionalization	Fearon and Laitin (2003)
Web-address: www.stanford.edu/~jfearon/	

References

Acemoglu, Daron, Simon Johnson, and James A. Robinson, "The Colonial Origins of Comparative Development: An Empirical Investigation," *American Economic Review,* December 2001, 91 (5), 1369-1401.

__, __ , and __, "Reversal Of Fortune: Geography And Institutions In The Making of The Modern World Income Distribution," *The Quarterly Journal of Economics*, November 2002, 117 (4), 1231- 1294.

__, __ , and __, "Reply to the Revised (May 2006) version of David Albouy's The Colonial Origins of Comparative Development: An Investigation of the Settler Mortality Data," *MIT Working Paper*, September 2006.

Albouy, David, "The Colonial Origins of Comparative Development: An Investigation of the Settler Mortality Data," *Center for International and Development Economics Research, Working Paper Series 1055,* Institute for Business and Economic Research, UC Berkeley, September 2006.

Carstensen, Kai and Eric Gundlach, "The Primacy of Institutions Reconsidered: Direct Effects of Malaria Prevalence," *The World Bank Economic Review,* September 2006, 20(3), 309-339.

Curtin, Philip, "*The Image of Africa,*" Madison, WI: University of Wisconsin Press, 1964.

__ , "Medical Knowledge and Urban Planning in Tropical Africa," *The American Historical Review* , June 1985, vol. 90(3), 594-613.

__, "*Death by Migration: Europe's Encounter with Tropical World in the Nineteenth-Century,*" New York: Cambridge University Press 1989.

__, "*Disease and Empire: the Health of European Troops in the Conquest of Africa,*" New York: Cambridge University Press 1998.

Diamond, Jared, “*Guns, Germs and Steel: The Fates of Human Societies,*" Norton, 1997

Dollar, David and Aart Kraay, “Institutions, Trade, and Growth: Revisiting the Evidence,” *World Bank, Policy Research Working Paper Series*, nr. 3004.

Easterly, William and Ross Levine, “Tropics, Germs and Crops: How Endowments Influence Economic Development,” *Journal of Monetary Economics*, Elsevier, January 2003, 50(1), 3-39.

Fearon, James D. and David D. Laitin, “Ethnicity, Insurgency, and Civil War," *The American Political Science Review*, 2003, 97 (1), 75-90.

Gallup, John Luke, Jeffrey D. Sachs, and Andrew Mellinger, “Geography and Economic Development," *CID Working Papers 1*, March 1999, Center for International Development at Harvard University

Gutierrez, Hector, “La Mortalité des Evêques Latino-Americains aux XVIIe et XVIIIe Siècles,” *Annales de Demographie Historique*, 1986, 29-39.

Hall, Robert E. and Charles I. Jones, “Why Do Some Countries Produce So Much More Output per Workers than Others?" *Quarterly Journal of Economics*, 114(1). 83-116.

Harriot, Thomas, “*A Briefe and True Report of the New Found Land of Virginia,"* 1588 Electronic Edition (ww.docsouth.unc.edu/nc/hariot/hariot.html)

International Energy Agency, “IEA Oil Information,” *ESDS International*, University of Manchester.

Kaufmann, Daniel, Aart Kraay, and Massimo Mastruzzi, “Governance Matters IV: Governance Indicators for 1996-2004," *Policy Research Working Paper Series 3630*, the World Bank June 2005.

King, Julia A. and Douglas H. Ubelaker, "*Living and Dying on the 17th Century Patuxent Frontier,"* The Maryland Historical Trust Press Crownsville, MD, 1996.

Knack, Stephen and Keefer Philip, "Institutions and Economic Performance: Cross-Country Test Using Alternatives Measures." *Economics and Politics*, November 1995, 7(3), pp. 207-27

Maddison, Angus, "The World Economy: a Millennial Perspective (OECD Development Centre, 2001. 383 pp. 29)," *Financial History Review*, December 2003, 10 (02), 274 - 276.

North, Douglass C. "Institutions," *Journal of Economic Perspectives,* Winter 1991, 5 (1), 97-112.

Olsson, Ola, "On the Institutional Legacy of Mercantilist and Imperialist Colonialism," *Working Papers in Economics 247*, March 2007, Goteborg University, Department of Economics.

__ and Douglas Jr. Hibbs, "Biogeography and long-run economic development," *European Economic Review*, May 2005, 49 (4), 909-938.

Rodrik, Dani, Francesco Trebbi, and Arvind Subramanian, "Institutions Rule: The Primacy of Institutions over Integration and Geography in Economic Development," *Journal of Economic Growth*, June 2004, 9(2), 131-65.

Sachs, Jeffrey D., "Institutions Don't Rule: Direct Effects of Geography on Per Capita Income," *NBER Working Paper 9490*, February 2003, National Bureau of Economic Research Inc.

Shea, John, "Instrument Relevance in Multivariate Linear Models: A Simple Measure," *NBER Technical Working Paper no. 0193*, National Bureau of Economic Research, March 1996.

Stock, James H. and Motohiro Yogo, "*Testing for Weak Instruments in Linear IV Regression*" in D.W.K. Andrews and J.H. Stock, eds. Honor of Thomas Rothenberg. Cambridge: Cambridge University Press, 2005, 80-108.

Stock, James H, Jonathan H Wright, and Motohiro Yogo, "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments," *Journal of Business & Economic Statistics,* October 2002, 20 (4), 518-29.

United Nations, "United Nations Environment Programme: Global Environment Outlook-3 Data Compendium" *UNEP*, www.unep.org/GEO/geo3.

Walsh, Lorena, "Servitude and Opportunity in Charles County, Maryland 1658-1705," In Aubrey C. Land, Lois Green Carr and Edward C. Papenfuse, eds., *Law, Society, and Politics in Early Maryland*. 1977, 111-133. Baltimore, Johns Hopkins University Press.

World Conservation Monitoring Centre, "*Global Biodiversity Status of the Earths Living Resources*," London: Chapman and Hall, 1992