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TROPICS AND INCOME: A LONGITUDINAL STUDY OF THE U.S. STATES

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A simple regression of personal income per capita for the U.S. states is estimated from cross-section data for the years 1929, 1950, 1970 and 1990 with each state's distance from the equator as the regressor. While proximity to the equator is noted to have a sizable adverse effect on income, elasticity of personal income per capita with respect to "tropicality" shows a steady and somewhat dramatic decline during this 60-year period. The estimates indicate that the disadvantage of tropicality is not immutable, and need not imply a developmental determinism.

I. INTRODUCTION

Following Kamarck's (1976) "provocative" reasoning, Ram (1997) reported from cross-country data a substantial and pervasive effect of "tropicality" on a country's income and many other dimensions of well-being.[1] Based on Kamarck's own explanation and Streeten's observations in the Foreword to Kamarck (1976, pp. ix–xii), Ram, however, also noted that such a locational disadvantage does not necessarily imply a deterministic perspective on national affluence or economic development.[2]

It is of interest to see whether one can find empirical episodes of the disadvantage of tropicality having been mitigated over time.[3] In general, such a mitigation can occur due to (a) reduced dependence on agriculture, (b) increase in income and the associated technological changes that may alleviate the adverse effects of tropicality on human health and productivity, and (c) appropriate public policies that might help toward overcoming the tropical disadvantages. For several reasons, states in the U.S. seem to provide a good example of where to

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[1]Very briefly speaking, Kamarck's (1976) reasoning suggests that the adverse effect of tropics arises largely from (a) erratic patterns of tropical rainfall that can play havoc with agriculture; (b) continuous heat and absence of frost that lead to a wide variety of weeds, insects, fungi, and other microbes that affect both crops and human life; (c) the consequent abundance of various types of enemies of agriculture; (d) tremendous human health hazards and the associated low productivity, and depressed rates of human and nonhuman capital accumulation; (e) poor quality of tropical soils; and (f) difficulty of finding mineral resources.

[2]Kamarck has explained how the situation can be alleviated if public policies take into consideration the disadvantages imposed by tropicality. In his Foreword to Kamarck (1976, pp. ix–xii), Streeten also explains how a reorientation of development policies can help.

[3]The cross-country data used by Ram (1997, 1999) do not indicate that the adverse effect of being located near the tropics is being mitigated over time. On the other hand, a comparison of his estimates (Ram, 1997, p. 1445) for 1960 and 1985 seems to suggest an accentuation in the adverse effect of tropicality on income. A somewhat similar position is indicated by him (Ram, 1999) in relation to a composite measure of the flow of human capital formation. The phenomenon of "global warming" might make the cross-country position even more difficult.

look for such an evidence. First, this is a vast country with a spread of over 2,000 miles between its southern and northern border. Second, it is a populous nation that has experienced a high rate of growth of income during the last several decades.[4] Third, the states are large units, and in most cases resemble countries in terms of area, population and income.

This study, therefore, explores two questions. First, whether, as in the cross-country context, one observes across the U.S. states an income-disadvantage due to being located closer to the equator. Second, whether there is an indication of that disadvantage having been mitigated over the last 50 or 60 years. During the aforesaid period, the country has had a reasonably good growth record, the importance of agriculture has declined, and, besides the ease of technological diffusion and resource-transfers across states, some national policies have been oriented toward alleviating interstate disparities. Therefore, one may expect a decline in the adverse effect of tropics on income and other measures of well-being across the U.S. states.

The estimates of a simple income-function suggest that while tropicality showed a fairly large (adverse) impact in 1929 and even in 1950, its effect has declined steadily and rather dramatically.

II. The Model, The Data, and the Main Results

A simple regression function for personal income per capita at the state level is used, and each state's (average) latitude in degrees is taken as a measure of its tropicality. The specification may be written as:

$$\ln(Y_i) = a + b \ln(\text{DIST}_i) + u_i \tag{1}$$

where Y_i is personal income per capita in state i (during the given year), DIST_i is its latitude in degrees (or its "distance" from the equator), u_i is the stochastic error term, and ln denotes natural logarithm of the variable. It is evident that a larger number for DIST_i indicates a smaller degree of "tropicality," and thus one expects a positive sign on the parameter for the latitude (or the distance) variable.

It is, of course, obvious that tropicality is not the only determinant of a state's income. In fact, DIST is rarely found in traditional regressions of state income. However, for several reasons, the simple model specified in equation (1) appears reasonable. First, as Kamarck's (1976) reasoning and Ram's (1997, 1999) estimates suggest, tropicality appears to exert an impact on many variables, including labor, capital and schooling, that affect income. Therefore, inclusion of other variables is likely to understate the true effect of tropicality on income. Second, while DIST is a prime example of an econometrically exogenous variable, exogeneity of most other regressors that may be traditionally included in such equations, especially labor, schooling and nonhuman capital, is uncertain, and one may obtain inconsistent estimates if those variables are included. Third, and perhaps most important, White's (1980) joint test for heteroscedasticity and mis-specification does not reject the null hypothesis of homoscedasticity and no-specification-error, and thus the simplicity of the model does not seem to pose a

[4]For example, *Economic Report of the President 1990* (p. 296) shows that real GNP in the U.S. increased nearly sixfold from 1929 to 1989.

significant econometric problem.[5] Fourth, since a major objective of the work is to study changes in the effect of tropicality on income, it should be possible to make a fair judgement on that by considering the estimates from the simple model specified in equation (1). Last, while data on other variables for more recent years should be available, information for early years, particularly for 1929 and 1950, appears scarce.

The earliest year for which reasonable information on personal income per capita is available is 1929. Data for the variable are taken at an interval of approximately 20 years and cover the years 1929, 1950, 1970 and 1990. The numbers for 1929, 1950 and 1970 are based on U.S. Department of Commerce (1989), and those for 1990 are from a September 1993 printout supplied by the U.S. Bureau of Economic Analysis. Data on the latitude are taken from Rand McNally (1995).

The model is specified in logarithms so that the DIST parameter can be interpreted as the elasticity of income with respect to tropicality. Since the elasticity measure is unit-free, it can be compared across years although personal income per capita is in current-price dollars.

The upper panel in Table 1 contains the ordinary least-squares (OLS) estimates of equation (1) for the years 1929, 1950, 1970 and 1990. The sample consists of the 48 contiguous states and the District of Columbia.[6]

The estimates reveal two notable characteristics. First, proximity to the equator, or the degree of tropicality of a state, appears to have had a substantial adverse effect on income. In all cases, the parameter for the DIST variable, which is negatively related with tropicality, is a sizable positive number and is statistically significant. Second, however, there is an indication of a steady decline in the tropicality-disadvantage, or the advantage of being located away from the equator, during this 60-year period. The elasticity of personal income per capita with respect to DIST declined steadily from 1.599 in 1929 by about 75 percent to 0.408 in 1990. This may be fairly perceived as a dramatic decline.[7] The observed pattern can be attributed to several factors. First, the importance of agriculture in the U.S. economy declined sharply over this period. As indicated in the *Economic Report of the President, 1998* (p. 322), the proportion of labor force employed in agriculture fell from about 21.25 percent in 1929 to about 2.56 percent in 1990. Since, as Kamarck (1976) has explained, tropical location has a particularly damaging effect on agriculture, a massive structural transformation away from that sector should reduce the tropical disadvantage. Second, an increase in per capita income and the associated technological changes help in overcoming the disadvantages of a tropical location, especially in regard to health, human-capital formation, and productivity. Third, federal income-support programs and equity-oriented policies tend to mitigate location-related disparities both within and

[5]The test is described by White (1980, pp. 824–25). Corresponding to the estimates in the upper part of Table 1, the chi-square statistics (with 3 degrees of freedom) for the years 1929, 1950, 1970 and 1990 are 0.37, 2.85, 0.43, and 1.05 respectively. The 5 percent critical value is 7.81, and the observed chi-square values are not statistically significant at any meaningful level.

[6]If District of Columbia is excluded, the pattern remains exactly as indicated in Table 1.

[7]There is, of course, a corresponding decline in the explanatory power of this simple regression model.

TABLE 1

EFFECT OF TROPICALITY ON PERSONAL INCOME AND GROSS STATE PRODUCT PER CAPITA ACROSS THE U.S. STATES: A LONGITUDINAL PERSPECTIVE

Year	Constant Term	Coefficient of DIST	$\bar{R}^2$	N
Personal Income Per Capita				
1929	0.490	1.599*	0.23	49
	(0.33)	(3.93)		
1950	3.402*	1.044*	0.26	49
	(3.73)	(4.21)		
1970	6.394*	0.500*	0.11	49
	(9.33)	(2.68)		
1990	8.273*	0.408*	0.07	49
	(11.85)	(2.15)		
Gross State Product Per Capita				
1963	5.745*	0.612*	0.11	49
	(6.74)	(2.64)		
1990	8.993*	0.263	0.01	49
	(9.41)	(1.01)		

Note: The simple regression model is $\ln(Y_i) = a + b \ln(\text{DIST}_i) + u_i$, where Y_i is personal income or GSP per capita of state i in current-price dollars. DIST_i is the state's latitude in degrees, and u_i is the stochastic term. The symbol "ln" denotes natural logarithm of the variable. The t-statistics are in parentheses below the parameter estimates, and an asterisk indicates the estimate is statistically "significant" at least at the 5 percent level. The sample consists of the 48 contiguous states and the District of Columbia. Please also see footnotes 6 and 9.

across states. Fourth, free flow of human (and physical) capital across the country tends to attenuate the disadvantages of tropical location.

While personal income per capita is a good measure of well-being, it includes not merely returns to labor and capital, but also transfer payments. Considering the production-related nature of the tropical disadvantage, it seems useful to study also the impact of tropicality on gross state product (GSP) per capita. Usable data on GSP are available from 1963, and lower part of Table 1 reports estimates of equation (1) with the left-hand variable being GSP per capita instead of personal income per capita.[8] It is evident that the elasticity of GSP per capita with respect to the distance-variable declined by about 57 percent from 1963 to 1990, and the effect of the variable is not seen to be statistically significant at any meaningful level in 1990. The scenarios indicated by regressions of personal income and GSP per capita are thus the same.[9]

The U.S. states provide a good example of the point that the economic disadvantage of tropical proximity is not immutable. Considerable caution is, however, appropriate in treating the case of U.S. states as being directly relevant to the less-developed countries (LDCs). First, as Table 1 indicates, it took a fairly long

[8]Data on GSP are taken from two printouts of the U.S. Bureau of Economic Analysis.

[9]As a methodological point, t-statistics based on ordinary (OLS) standard errors are reported in Table 1 because, as already noted, White's (1980) test indicates lack of heteroscedasticity and specification error. However, use of White's heteroscedasticity-consistent standard errors yields exactly the same pattern as shown in Table 1. Details of heteroscedasticity-consistent standard errors are available from the author.

period of some 40 to 50 years for the disadvantage to decline substantially in the U.S. states. Second, as already noted, the U.S. economy experienced a massive structural transformation away from agriculture during the period, which was also characterized by rapid growth in income and a fairly remarkable technological progress. Perhaps more important, the U.S. states constitute a much more homogeneous and integrated set of political units than the LDCs.[10] For example, resource transfers across the U.S. states are quite easy, and interstate technological diffusion is also straightforward. Moreover, the U.S. states have been characterized by similar macroeconomic and structural policy settings, including those relating to education and training, product and financial markets, and infrastructure. Therefore, resolution of the problems of tropical location faced by the LDCs may be neither automatic nor inevitable over a reasonable period. However, Kamarck (1976), and Streeten's Foreword in that work, have discussed the national and international policy approaches that can be of major help toward mitigation of the economic disadvantage of tropical location experienced by many LDCs.

III. Concluding Observations

This work studies intertemporal changes in the effect of tropicality on income and output across the U.S. states. Besides an examination of the nexus between tropicality and income and output in this vast country, the main motivation is to see if the disadvantage of being located near the equator was reduced significantly over time as the importance of agriculture declined greatly and as public policies and improvements in income and technology are likely to have mitigated the adverse effects of tropicality on human health, capital formation, and productivity. Using data for the 60-year period 1929–90 and a simple model, we observe a steady and somewhat dramatic decline in the adverse effect of tropicality. The elasticity of personal income per capita of a state with respect to its distance from the equator declined by about 75 percent during the period. Estimation of an equation for gross state product per capita for 1963 and 1990 indicates a similar scenario. The main lesson is that tropical location does seem to imply a substantial disadvantage, but the adverse effect of tropicality is not immutable. At the same time, however, its attenuation may neither be automatic nor inevitable. While the example of the U.S. states is not directly applicable to the LDCs, Kamarck (1976) and Streeten's Foreword in that work have discussed how appropriate national policies and international effort can be of major help toward mitigation of the problems faced by many LDCs due to their proximity to the tropics.

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[10]This point owes much to the observations by a perceptive referee.

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