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A Cross-State US Capitalism-Democracy-Rule of Law Economic Model

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Abstract

The United States (US) capitalism (C), democracy (D), rule of law (R) (CDR) economic model combines the degree of C, D and R associated with a particular state. In prior research, the CDR model was invented and computed for cross-country relationships. This paper computes a CDR model based on published US state C, rankings in D, and rankings in R, taking into account the effect of interactions between C, D and R. The CDR model explains per capita real gross state product (GSP) adjusted for purchasing power parity (GSPppp) with three policy variables namely C, D and R. Geographical latitude (L) is also significant. The model is referred to as the CDR model because C, D and R are policy variables that can be changed by policy makers, while geography is outside the control of policy makers.

Keywords

CDR Index, GSPppp, Capitalism, Democracy, Rule of Law, Entrepreneurship

1. Introduction

The purpose of the CDR cross-country model (Ridley, 2020 and **Appendix B** below) is to understand gross domestic product from levels of capitalism (C), degrees of democracy (D) and degrees of rule of law (R). These are policy variables that government can pursue, and citizens can understand to develop an income maximizing mindset. Together with natural variables natural resources and geographic latitude, the model explains 90% of per capita real gross domestic product (GDP) adjusted for purchasing power parity (GDPppp).

In this paper we will explore the concept in terms of a cross-state CDR model. The CDR model will be used to explain per capita real gross state product (GSP) adjusted for purchasing power parity (GSPppp), in terms of state capital (C), de-

gree of state democracy (D) and degree of state rule of law (R). In the cross-country model, C is total market capitalization. It measures the degree of organization of capital and is the total value of all outstanding stocks on the stock markets. It measures the amount of capital available for investment. It also measures the sum of all future value of stocks, discounted to their present value. In the state model, C is not derived from a stock market, so it is not a measurement of capitalism and is not a policy variable. It is not the same value proposition. However, like in the cross-country model, rule of law attracts capital and protects democracy, which deploys capital optimally to maximize GSPppp. That is, maximize standard of living.

There is no such measure as total market capitalization for US states. Therefore, a proxy variable must be substituted. The proxy must relate to human capital imagination and creativity. The combination of imagination, creativity and innovation is the source of wealth. In this paper, we choose the product of average state scholastic aptitude test (SAT) score and population. So, SAT is the human capital potential, and population is the vessel that contains the volume of that potential. The state with the most capital, has the most people with the highest aptitude. In low CDR states, said aptitude is not promoted and may even be suppressed. In high CDR states, exogenous aptitude is extracted in schools and universities and converted into a measure of academic achievement such as grade point average (GPA), and endogenous stock of knowledge, high skill, machines, programming, recording, teaching material, etc. Said capital stock is deployed optimally to produce goods and services and maximize standard of living. The traditional economic model might choose years of education as the relevant input. However, the quality of education varies from state to state whereas SAT is standardized. Also, in the CDR model, the capital that is of interest is exogenous aptitude and potential to create knowledge that becomes the subject of endogenous stock of knowledge education.

2. Conceptual Background

Prior to the industrial revolution, apart from a few sporadic increases in living standards during the Roman Empire and in China during the Song dynasty, economic growth was negligible. Some 19th century occurrences that set some countries on a path of sustained growth were explained by unified growth theory (Galor, 2011). Pre 1850, increases in population size followed increases in living standards. However, Malthus (1798) attributed that to the standard of living which then fell, after the population increase. But, after 1850 the standard of living rose in England, Western Europe and the USA with similar population growth. The 20th century brought growth in the standard of living that was faster than population growth. This demographic transition contradicted Malthus. There are any number of factors that may have led to the industrial revolution (see Senna, 2013). Whatever the reasons are, the standard of living in the industrial world has risen continuously ever since. It is inescapable that England's invention of Magna Carta and all the countries that adopted it, have better economies than those that

have not (Ridley & Nelson, 2022a). This is consistent with the idea of the importance of institutions such as rule of law and democracy (North, 1991; North & Weingart, 1989). Rupasingha, Goetz & Freshwater (2002) also said that low income developing countries have the potential to grow faster than high income developed countries. But these principles are conditional on good governance and good institutions. They also claim that ethnic diversity is associated with faster rates of economic growth.

Solow (1956) advised that economies tend to converge to a balanced growth path. As the economy moves farther away from the balanced growth path, the marginal return on capital increases. The poorer the economy is, the faster it grows as it moves back towards the growth path, then converges more slowly to a limiting value as capital is accumulated and the marginal return on capital falls. This can take decades. This explanation is appealing, but it is only apparent for countries that were developed and experienced setbacks such as war. For example, Germany after WWII. Other countries seem to have stubborn zero or negative growth. Is their growth path zero or negative? Solow does not explain how developed countries got to be rich. For the reader who is curious about a log linear model Solow approach, the result of fitting a cross-country GDPppp = $\beta_0 C^{\beta_C} D^{\beta_D} R^{\beta_R} \epsilon$, where ϵ is random error, and the $\beta's$ are output elasticities, is the very low value of R^2_{adj} = 0.36. Exogenous catalysts D and R augment C but are not complementary. On the other hand, this paper proposes $GDPpppp = \beta_C C + \beta_D D + \beta_R R + \beta_{CDR} C \cdot D \cdot R + \varepsilon$, where ε is random error, includes an interaction term, and yields very high correlations, irrespective of government spending, natural resources, country size, location, culture, and other commonly held beliefs.

Jones (1995a, 1995b) observed that the share of GDP going to and the share of workers doing research and development increased during the 20th century. Still the long-run growth rate remains the same. It appears that what determines growth rate is the speed of technological progress. And technological progress is correlated with population. Colacito et al. (2019) provides empirical evidence that temperature has significant effects on economic growth in the USA, both at the aggregate level and across a wide cross section of economic sectors.

Yu (2010), Hall, Lacombe & Shaughnessy (2019) and Akai & Sakata (2002) discuss economic growth variations across states within the USA. Yu (2010) obtained high R^2 values, but their data are longitudinal and contain lagged variables. Income in any one year will always be similar to that in the previous year. Hall, Lacombe & Shaughnessy (2019) found an effect on GSP from economic freedoms. It appears reasonable that economic freedoms are effective in the presence of USA rule of law, but not in the absence of rule of law in many other countries elsewhere. Gwartney, Holcombe and Lawson (2006) used the EFW in a cross-country model to obtain R^2_{adj} = 52.5%, considerably lower than the 90% obtained from the CDR cross-country model. Whetting the economic freedoms appetite of the population in corrupt countries only causes them to flee to Western Europe and the USA.

Akai & Sakata (2002) found that fiscal decentralization contributes to economic growth in the USA. The opposite result was found for developing countries. This appears reasonable since decentralization is a positive activity of capitalism and opposite to the centralization activity of communism. Still the R^2 = 40% result is low compared with the CDR model. The negative result for developing countries may be due to the absence of rule of law where decentralization exacerbates corruption and theft.

Mankiw, Romer & Weil (1992) gives an augmented Solow model that includes accumulation of human as well as physical capital that better describes cross-country data. But the elasticities would all have to be equal for it to be a legitimate aggregate model. Furthermore, the log linear Solow type model explains only about 36% of GDPppp. Islam (1995) added a panel analysis to growth modeling in which the independent variables were lagged dependent variables. Income from year to year is almost the same everywhere so such a model will have an artificially high R^2. Ridley (2020) also estimated a CDR panel regression but there were no lagged variables. The model coefficients remained practically unchanged and R^2 = 90% persisted, reinforcing the global time invariance of the CDR model. Caselli, Esquivel & Lefort (1996) apply a generalized method of moments estimator to eliminate problems of correlated individual effects and endogenous explanatory variables in cross-country models. They did not report the impact on model R^2 to compare. Still, they suggested future research that applies new and better methods to cross-regional data. This paper applies the CDR model to US cross-state data. Sala-i-Martin, Doppelhofer & Miller (2004) introduced Bayesian averaging of classical estimates (BACE), to determine the "importance" of variables in cross country growth regressions. They also did not report the impact on model R^2 to facilitate comparison.

There is no history of cross-state US CDR models that can be reviewed. The Solow (1956, 1957) aggregate (national) growth model was proved mathematically by Ridley & Ngnepieba (2018) to be a fallacy of composition (Cohen & Harcourt, 2003) to think that we can simply jump from Cobb & Douglas (1928) microeconomic production function conceptions to an understanding of aggregate production by society as a whole. Cobb-Douglas applies to a single machine. The only way that the Solow model could work as an aggregate model is if the elasticities were equal for every Cobb-Douglas machine function in the national sum. Furthermore, the Solow model explains only 36% of GDP. Acemoglu, Johnson & Robinson (2005), Acemoglu & Robinson (2012) and Acemoglu, Naidu, Restrepro & Robinson (2014) expounded on the importance of institutions and both cross-country and cross-state CDR models are comprised of variables that represent institutions.

3. Hypothesis

H_0: The cross-state US CDR model is not a good predictor of GSPppp.

H_1: The cross-state US CDR model is a good predictor of GSPppp.

4. Method

The CDR model is a statistical model in which GSP is regressed on C, D, R and L. Ordinarily, the regression coefficients in a g = *f*(C,D,R,L) economic model would simply be weights and g would be a weighted average of C, D, R and L. However, the weights would be impossible to interpret in any meaningful way. The model would not provide a reference from which G can be estimated outside of the data sample. That is, a model that is estimated in any one year would not apply to subsequent years. This problem is overcome by creating a constant global index from the combination of the model parameters and weights C, D, R and L. That is, a CDR index. To do this, we standardize the variables such that they are always on or between 0 and 1, as defined below, and the model parameters become scale factors. The standardized variables are obtained from the following reversible transformations.

4.1. Transformations

g = (GSPppp − lowest GSPppp)/(highest GSPppp − lowest GSPppp)

GSPppp = Per capita real gross state product adjusted for purchasing power parity (change in per capita wealth = GSPppp less consumption, depreciation and obsolescence)

C (State Capital) = (state capital − lowest state capital)/(highest state capital − lowest state capital)

D (Democracy) = (lowest democracy rank − democracy rank)/(lowest democracy rank − highest democracy rank)

R (Rule of law) = (lowest rule of law rank − rule of law rank)/(lowest rule of law rank − highest rule of law rank)

L (Latitude) = (latitude − lowest latitude)/(highest latitude − lowest latitude)

These transformations standardize the variables and ensure upper and lower bounds on $0 \le g, C, D, R, CDR \le 1$.

These transformations will not affect the level of significance of the variables.

Data for these standardized variables are listed in Table A1. Democracy and rule of law are rank ordered, where the highest = 1 and the lowest = the number of states.

4.2. Model Specification

$$g = \beta_0 + \beta_C C + \beta_D D + \beta_R R + \beta_{CDR} C \cdot D \cdot R + \beta_L L + \varepsilon_{CDRL}$$

where the β's are regression coefficients, $C \cdot D \cdot R$ is an interactive term, and ε_{CDRL} is random, normally distributed error with a mean of zero and constant standard deviation, not explained by C, D, R, $C \cdot D \cdot R$, L.

4.3. Prediction of GSPppp

State standard of living can be estimated from the CDR index inverse transformed as follows: $\widehat{\text{GSPppp}}$ = g · (highest GSPppp − lowest GSPppp) + lowest GSPppp.

5. Data

The terms capital, democracy and rule of law are often confused. In this research we are interested in capital, democracy and rule of law based on epistemological, metaphysical, and axiological insights (Randrup, Druckemiller, & Briggs, 2016), so for clarity of purpose we begin with the following definitions. The data are almost never available for the same year, but they change so slowly that selecting from different years, as available, is satisfactory. The data for this study are given in Table A1 and Table A2 in **Appendix A**.

5.1. Exogenous and Endogenous Variables

There is a lack of consensus in the literature with respect to which variables are exogenous and which are endogenous. In this paper capital, democracy, rule of law, and latitude are all exogenous. To see why this is so, consider for example a production system. At the beginning of the production cycle, raw material is used such that at the end of the cycle there is less raw material than at the beginning. Profits from the sale of products made from raw material will be used to purchase more raw material. Therefore, raw material is endogenous. Similarly, capital stock of knowledge and machines used in production are also endogenous. Knowledge becomes obsolete and machines depreciate and become obsolete, and in that sense are used up, albeit slowly. Human capital ideas of imagination and creativity originate externally from the production system and are therefore exogeneous. Although it may be arguably true that the SAT element of capital (SATxPopulation) may benefit from the profits of production which would make SAT endogenous, we are only interested in the potential for ideas which are random and independent of profit and is therefore exogenous. This is the capital that is used in the cross-state US CDR model, as there are no available data for cross-state total capitalization that includes endogenous capital. During the production cycle, democracy, rule of law and latitude remain constant. They do not get used up. They are entirely unaffected by the production system and the sale of products derived therefrom. Therefore, they are all exogenous.

5.2. Capital

Definition. *Capital is intangible exogenous potential for human imagination and creativity and the source of wealth.* In this research capital is estimated from the product of average SAT score and population. It is exogenous since it does not include endogenous capital stock of machines.

5.3. Democracy

Definition. *Democracy is an intangible exogenous catalyst* (term coined by Berzelius, 1835) *that creates new pathways for the optimal deployment of capital*. Democracy is a measure of participatory governance and management. As a psychological matter, one person one vote democracy is a right that inspires the best in human participation and relentless determination to succeed. The lowliest citizen

voter is as powerful as the billionaire. As an intellectual matter, democracy incorporates the knowledge of all interested parties. Democracy is a mechanism for exploring a wider and larger set of options and forming consensus through discussing and weighting. If it is presumed that nobody else knows better what is good for an individual as that individual, then democracy is a nonmathematical process that will arrive at the optimal national consensus. In this research we use the FairVote archive democracy index that measures a state's average ranking in key categories: average margin of victory (measuring overall competitiveness), landslide index (measuring the number of somewhat competitive races), seats-to-votes distortion (measuring how well the intent of voters was reflected by the results), and representation index (weighted double, as it measures both voter participation and the percentage of effective votes that elect someone). Democracy is exogenous.

5.4. Rule of Law

Definition. *Rule of law is the reverse of corruption, the protection of shareholder and other property rights, enforcement of contracts, and an intangible exogenous catalyst for stability and the attraction of capital*. Property is a legal expression of an economically meaningful consensus by people about assets, how they should be held, used and exchanged. In this research we use the National Center for Access to Justice (NCAJ) Index. The Justice Index illuminates the degree to which each US state has adopted selected best policies for ensuring access to justice for all people. In six component indexes—Attorney Access Index, Self-Representation Access Index, Language Access Index, Disability Access Index, Fines and Fees Index, and Consumer Debt Litigation Index—NCAJ has identified laws and practices that entitle people to rely on the legal system for justice and has also scored and ranked the states based on research that shows the degree to which the states have adopted those laws and practices. The objective is to increase public understanding of the policies that matter to fairness, and to create a platform that encourages adoption of these best policies in every state. Rule of law is exogenous.

5.5. CDR Interaction

An interaction term in regression analysis represents the combined effect of two or more independent variables on the dependent variable. It allows examination of how the relationship between the target and an independent variable change depending on the value of another independent variable. The CDR model contains an interaction variable to represent the possibility for C, D & R to effect change in each other. R attracts capital (obtained from the capitalist organization (C) of capital) and protects D which deploys C optimally. R is important because people like to know the rules of the game that they choose to play. But the level of R that is achieved changes on account of the process of D, and people like to participate in the process of D, and the process of C as it relates to the organization of capital.

6. Findings and Discussion

The results of the regression analysis are given in Table 1. The cross-state CDR model is consistent with the cross-country model. In both models, the coefficients for C, D and R are all positive and the coefficient for C·D·R is negative. Natural resources data are not available, so no comparison is possible. The coefficient for Latitude is positive. Longitude was not statistically significant and was omitted from the model.

Table 1. Ordinary least squares (OLS) regression results.

Coefficient	Estimate	$\lvert t \rvert$	Partial R^2_{adj} for different independent variables included in the regression model			F Statistic
			Variable	R^2_{adj}		$F_{5,44}$
β_0	0.5586	6.06	All	0.778	0.778	
β_C	0.1305	1.38	C	0.019		
β_D	0.0489	0.75	D	0.200	0.758	35
β_R	0.1174	2.09	R	0.024		
β_{CDR}	−0.6732	−9.13	C·D·R	0.515		
β_L	0.2862	2.24	L	0.020	0.020	

The cross-state model R^2 = 0.8 and R^2_{adj} = 0.778, or approximately 0.8. The R^2_{adj} for the cross-country model is 0.9. The lower R^2_{adj} for the cross-state model could be for any number of reasons. We assume that the primary reasons are the absence of natural resources, and the approximation of total capitalization. The coefficients of R, $C \cdot D \cdot R$ and L are significant at the 5% level. This typically is what economists consider statistically significant. The coefficients of C and D are not statistically highly significant but are important for general understanding of the model. The model retains the general characteristics of the CDR model and for the first time, places the cross-state macroeconomics on a sound scientific footing.

In the cross-country model capitalism contributes 60% to GDPppp. Capital included both exogenous and endogenous capital. In the cross-state model capital contributes 1.9%. We are unable to capture the effect of organizing this capital into capitalism. It is exogenous and does not include endogenous capital stock of raw materials, machines, knowledge, recordings, computers, etc. The SAT measures academic participation of children, not the wisdom of adults. This accounts for the lower percentage of contribution. Nevertheless, human capital of imagination and creativity is the source of wealth and is critical to economic development. The product of SAT and population appears to capture this capital. As an aside, state budget and state spending were tried as the surrogates for capital and R^2_{adj} was approximately 0.4 and 0.5 respectively, much lower than 0.8 for SATxPopulation. The greatest single (non-interactive) partial contribution to GSP is democracy (20%). Rule of law contributes 2.4%. It is important to understand

that rule of law protects democracy and attracts capital. So, the functionality of rule of law is paramount. We now know from Ridley and Nelson (2022a) that while cooperation is an obstacle to rule of law, collaboration is required to permit rule of law. So, the point of beginning is collaboration. The absence of rule of law, especially the presence of corruption, repels capital and minimizes economic growth. Geographic latitude contributes 2.24%. Geography is obviously important. It can be absolutely restrictive to certain activities and crops. And it might have contributed more in former times. But with the advent of modern communications and transportation, obstacles related to geography are easily overcome simply by division of production, and trade, not unlike that suggested by Smith (1776). All of these intangible variables are responsible for the production of gross state product of tangible goods and services.

The regression model tells us how much variation in GSP is explained by the variations in C, D, R and L. Although all variations in these variables are important to characterize the cross-state model, we are unable to determine the variation in total capitalization (since those data are not available). But there is a sizable effect of variation in democracy across states. This could be due to variation in collaboration skills in different communities. Ridley & Nelson (2022b) explain how a negative epigenetic transgenerational psycho sequela can be inherited by members of some US subpopulations as a result of historical environmental stresses such as forced labor, excessive discrimination and exposure to dangerous chemicals. Even when the stresses are removed, formerly oppressed communities can continue to suffer the same genetic maladies. Collaboration skills may have been lost. The ability to participate fully in democracy may have been affected similarly. (Ridley, 2022, 2023) show how collaboration trumps IQ for the prediction of GDPppp. Rosier, Llaugel & Ridley (2024) explain how US corporations use job design to train employees to collaborate, thereby greatly increasing corporate profit. Ridley, Lee & Nelson (2023) and Lee & Ridley (2024) explain how Singapore uses mandatory school sports and music education to raise national collaboration skill, rule of law and ultimately GDPppp to a level 50% higher than the US. The US should consider a similar strategy as part of reparations for its formerly oppressed communities. See Ridley & Korovyakovskaya (2025) for a full discussion.

As part of the exploration effort to find a model that fits the data well, a logarithmic model was considered. Logarithms were taken of all variables and the model re-estimated (see **Appendix D**). The logarithmic transformation yields elasticities for parameters so comparisons can be made with some traditional economic models. However, the ability to explain the variation in GSPppp and ultimately the predictive ability of the logarithmic model is significantly reduced. The logarithmic model R^2_{adj} = 0.44, very much lower than (approximately 0.8) that for the proposed CDR model. Therefore, logarithms were not considered further. Rupasingha, Goetz & Freshwater (2002) investigated a variety of social and institutional factors as determinants of economic growth. The highest R^2_{adj} obtained

there was 27.7%. The CDR model explains 80%.

In passing we mention a phenomenon that is never considered in explaining the political choices that Americans make. One of the obstacles to communications along potential pathways is legitimate logical and binary thinking, and group thinking. Music can connect that which people have in common. Music and sports can facilitate political and other problem solving by cutting through polarization and binary logic. People who might otherwise not think to associate might come together through music and sports. Consider also, the discovery by Hibbing, Smith and Alford (2014) that there are genes that make people predisposed to liberalism and other genes that make people predisposed to conservatism. In the advanced democracy of the USA, it is quite astonishing to find that these characteristics appear nearly equally bifurcated in the population. Due to the remarkably peaceful political party and presidential transitions, it is reasonable to assume that democracy is responsible for the meaningful deployment of liberal and conservative traits. And that both traits are required for the economic growth that we observe. In contrast, the absence of democracy could permit one of these two traits to dominate the economy. Such an outcome could be a reduction in diversity and the lack of economic growth that persists in poor countries.

Also varying substantially across states is the effect of geographic latitude. As latitude varies so does climate and altitude. The US terrain varies substantially from the lowlands of Florida to the highlands of Alaska. However, latitude is a natural variable that is fixed outside the control of government policy. An alternative to latitude might well be temperature. Colacito, Hoffmann, & Phan (2019) provides empirical evidence that temperature affects economic growth negatively in the United States. Since temperature and latitude are negatively correlated, as expected, this current paper provides evidence that latitude has a positive effect on GSP. In the interest of exploration for the best variable, latitude was replaced by temperature in the model (see **Appendix D**). The result was R^2 = 0.78. This is the same as that for the CDR model that uses latitude. However, one major difference between latitude and temperature is that whereas latitude is a fixed time invariant variable of geography, temperature could vary albeit over centuries in time. Latitude was chosen for compatibility and comparison with the published cross-country CDR model.

Another variable that has been reported in the published literature is ethnolinguistic fractionalization. This variable was obtained from Lu (2024) and included in the model. However, it had no impact on R^2_{adj} (see **Appendix D**). The t statistic was near zero. This implies that race and ethnicity are irrelevant to GSP. Ethnolinguistic fractionalization is also a natural variable that is fixed outside the control of government policy. Although some ethnic communities in the US have suffered historical deprivation of education and earn less than is fair from a human justice point of view, the good fit of the CDR cross-state economic model to the data, suggests that they earn what is equatable for their average level of education. That is, they are economically placed in jobs that they are currently suited

for. The economic model does not know who is who, only their contribution to GSP. Human justice will be fulfilled when they acquire education that is comparable to their fellow citizens of equal aptitude. Olson (1982) warns against artificial attempts at attaining equity when equality of outcomes is best.

The fitted OLS model is

$$\hat{g} = 0.5586 + 0.1305C + 0.0489D + 0.1174R - 0.6732C \cdot D \cdot R + 0.2862L, R^2_{adj} = 0.8$$

$$|t| = (1.38) \quad (0.75) \quad (2.09) \quad (9.13) \quad (2.24)$$

$$\text{Partial correlation} = 1.9\% \quad 20.0\% \quad 2.4\% \quad 51.5\% \quad 2.0\%$$

State standard of living can be estimated from the CDR index for any combination of C, D, R, L and inverse transformation as follows:

$$\widehat{\text{GSPppp}} = \text{g}\cdot(\text{highest GSPppp} - \text{lowest GSPppp}) + \text{lowest GSPppp}.$$

From Table A1 highest GSPppp = 107450.43 and lowest GSPppp = 34890.25.

$$\widehat{\text{GSPppp}} = (0.5586 + 0.1305C + 0.0489D + 0.1174R - 0.6732C \cdot D \cdot R + 0.2862L) \times (107450.43 - 34890.25) + 34890.25.$$

The cross-state US CDR model fitted F statistic = $F_{5,50\text{-}5\text{-}1} = F_{5,44} = 35 >$ the theoretical $F_{0.05,v1,v2} = 2.4$. Therefore, at a level of significance of 5%, we reject H_0 and accept the hypothesis H_1, and concluded that the cross-state US CDR model is a good predictor of GSPppp.

The fitted values $\widehat{\text{GSPppp}}$ are plotted in Figure 1. The values are best described as lying on a straight line. Alaska (AK) is far right because of the influence of extreme latitude. A histogram of the fitted values is plotted in Figure 2. The residuals from the CDR model are plotted in Figure 3. They appear to be randomly distributed with no patterns. A histogram of the residuals from the CDR model is plotted in Figure 4. They appear to be symmetrical and normally distributed. The normal probability plot in Figure 5 is an approximately straight line suggesting a normal distribution. A series of statistical tests to determine the aptness of the model is given in **Appendix C**.

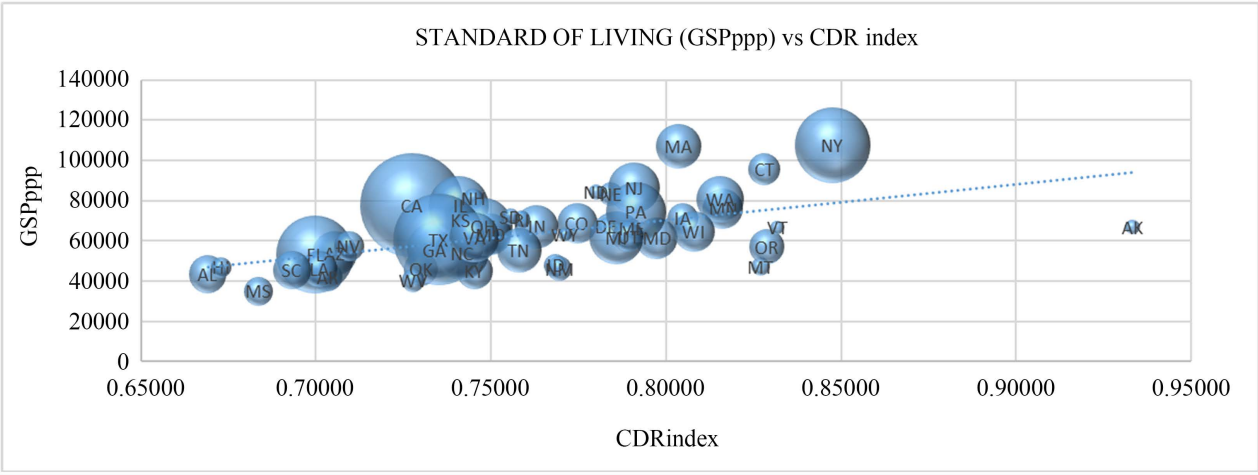

Figure 1. US cross-state standard of living (GSPppp) vs CDRindex.

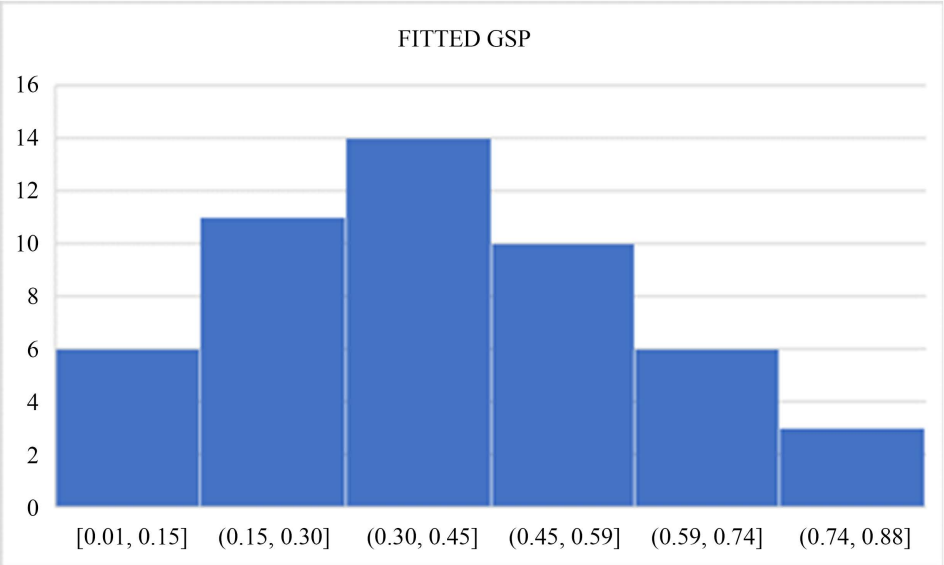

Figure 2. Histogram of fitted GSP.

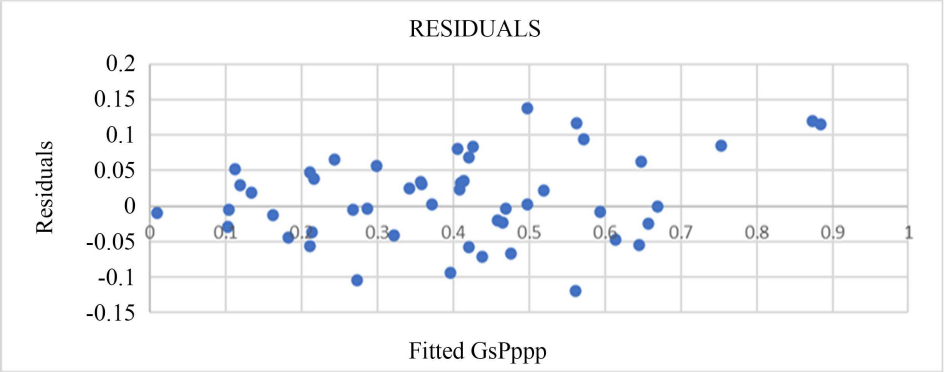

Figure 3. Residuals vs fitted GSPppp.

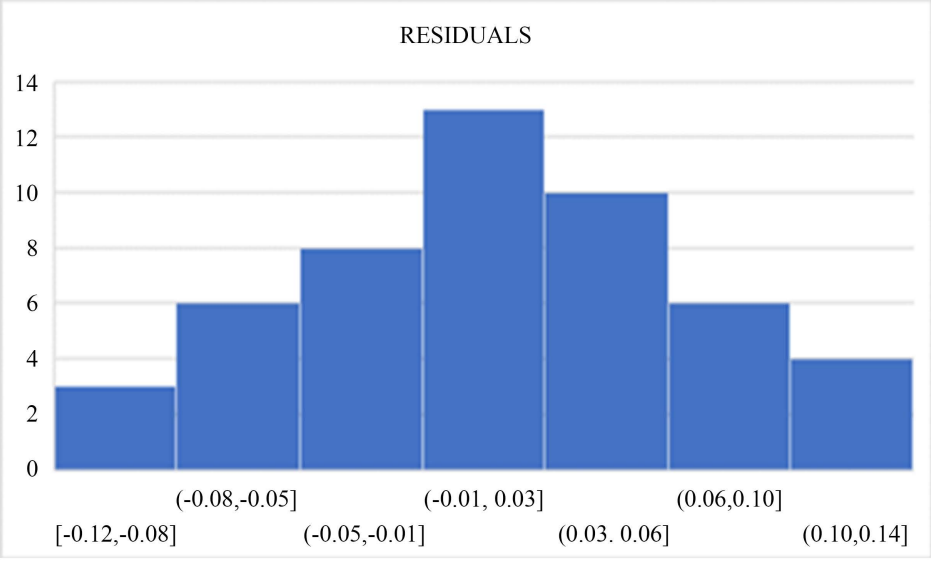

Figure 4. Histogram of residuals.

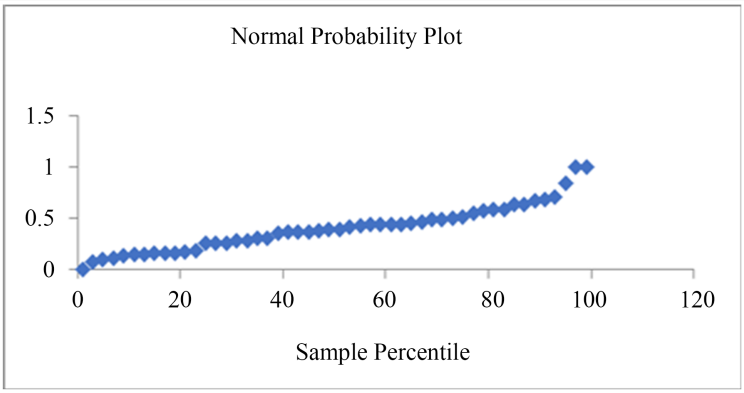

Figure 5. Normal probability plot.

7. Policy Implication and Recommendation

From the regression analysis, the greatest single partial contribution to GSP is democracy at 20.0%. This suggests that the effect of democracy matters greatly. The US enjoys a high world democracy ranking and high GDPppp. And there are countries that also have high democracy rankings and high GDPppp. This implies that states with relatively low democracy ranking should have their level of democracy improved. The US has a well-defined system of democracy nationally and there is fairly uniform application of the rule of law. But there may be pockets of corruption such that democracy may not benefit from the full protection of the rule of law (contribution 2.4%), or at least not as well as in other states. The contribution from the CDR interaction is 51.5%. A negative CDR coefficient represents distortions. These distortions occur when there is too much democracy and too much rule of law. Excessive democracy is the result of unnecessary discussions that delay investments and opportunities. US corporations and institutions should limit advice and discussion inputs to the various classes of experts to save time in decision making. Excess rule of law is the result of over regulation that obscures opportunities. US corporations and institutions should limit regulations and laws to those which are necessary and eliminate law making for the sake of making laws. Laws should be enforced rather than making new laws for political gamesmanship. The contribution from latitude is 2.0%. Latitude is a natural variable. It is not a policy variable.

8. Conclusion

The cross-state CDR economic growth model fits state data well and explains GSP. It is comparable to and generally consistent with the cross-country CDR economic growth model. The model coefficients are somewhat different as expected, but remarkably, the coefficient signs are the same. The different sizes of the coefficients are due to the use of a surrogate for state capital in the cross-state model and the absence of data for natural resources. The inability to obtain a measure of capitalism and natural resources is an inherent limitation of the cross-state model. The cross-state CDR can be used to accurately estimate state income. It is the first eco-

nomic model to place macro growth economics on sound scientific ground. GSPppp is a function of C, D, R, and L. But it is called the CDR model because C, D and R are policy variables that can be determined by government policy, and L is fixed, not determined by government. In summary, collaboration permits rule of law, rule of law attracts capital and protects democracy, democracy deploys capital optimally to create GSP of products and services. That is, collaboration is the point of beginning. Singapore used mandatory school sports and music education to raise the collaboration skill of its children to number one in the world. Therefore, recommendations for future research include mandatory sports and music education, and gene therapy reparations to improve collaboration skills that may have been lost due to historic environmental stresses such as forced labor, excessive discrimination and exposure to dangerous chemicals. Recovery of collaboration skill may bode well for GSP.

Declaration of Data Availability

All data used in this study are given in the paper.

Declaration of Ethics

The author declares that no animals were used in this research.

Conflicts of Interest

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no competing interests to declare that are relevant to the content of this article.
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
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Appendix A

Table A1. Data for the cross-state CDR model.

STATE	GSPppp $	C	D	R	Latitude	Longitude	Temperature degF
Alabama	43248.6501	5833187919	41	49	32.806671	−86.79113	62.8
Alaska	66931.2393	793529062	21	24	61.370716	−152.404419	26.6
Arizona	53644.9414	8460226866	27	44	33.729759	−111.431221	60.3
Arkansas	42018.8817	3589736608	42	35	34.969704	−92.373123	60.4
California	77691.5369	41736895509	35	4	36.116203	−119.681564	59.4
Colorado	68654.4193	5750619144	3	17	39.059811	−105.311104	45.1
Connecticut	95758.8657	3631185608	15	3	41.597782	−72.755371	49
Delaware	67427.1091	948370184	24	21	39.318523	−75.507141	55.3
Florida	53379.7136	20805888642	43	33	27.766279	−81.686783	70.7
Georgia	55473.3776	11290351032	35	18	33.040619	−83.643074	63.5
Hawaii	46784.7883	1621171894	45	5	21.094318	−157.498337	70
Idaho	47792.8495	1783932820	33	40	44.240459	−114.478828	44.4
Illinois	77347.4166	12428132760	11	8	40.349457	−88.986137	51.8
Indiana	66967.0550	6588747688	26	29	39.849426	−86.258278	51.7
Iowa	71111.1000	3853965752	5	20	42.011539	−93.210526	47.8
Kansas	70252.4219	3657660600	10	42	38.5266	−96.726486	54.3
Kentucky	44929.8460	5443049888	24	31	37.66814	−84.670067	55.6
Louisiana	45965.5086	5561361858	49	26	31.169546	−91.867805	66.4
Maine	66201.2688	1471347720	22	36	44.693947	−69.381927	41
Maryland	61257.6150	6226641792	22	1	39.063946	−76.802101	54.2
Massachusetts	106965.2622	7817267704	18	2	42.230171	−71.530106	47.9
Michigan	61523.9048	9744779077	13	16	43.326618	−84.536095	44.4
Minnesota	76088.7290	6853499294	1	7	45.694454	−93.900192	41.2
Mississippi	34890.2500	3506154336	47	38	32.741646	−89.678696	63.4
Missouri	63280.6995	7330501383	8	41	38.456085	−92.288368	54.5
Montana	47141.5647	1293480425	14	28	46.921925	−110.454353	42.7
Nebraska	83198.2986	2455803008	8	30	41.12537	−98.268082	48.8
Nevada	57335.2003	3619979924	37	48	38.313515	−117.055374	49.9
New Hampshire	80978.4128	1425742515	34	47	43.452492	−71.563896	43.8
New Jersey	86390.5340	9902067604	30	9	40.298904	−74.521011	52.7
New Mexico	46122.3684	1907887322	17	14	34.840515	−106.248482	53.4
New York	107450.4251	20989097711	44	6	42.165726	−74.948051	45.4
North Carolina	53870.7541	11765190276	38	27	35.630066	−79.806419	59
North Dakota	84283.0072	1002693978	29	46	47.528912	−99.784012	40.4
Ohio	66975.8623	12318623712	7	23	40.388783	−82.764915	50.7
Oklahoma	45779.1599	3773263409	47	25	35.565342	−96.928917	59.6
Oregon	56847.7690	4766913000	16	11	44.572021	−122.070938	48.4
Pennsylvania	74222.0650	4567761968	6	19	40.590752	−77.209755	48.8

Continued

Rhode Island	70370.1048	1051289082	30	34	41.680893	−71.51178	50.1
South Carolina	45645.1350	5261740900	39	43	33.856892	−80.945007	62.4
South Dakota	71879.7992	1071093736	19	50	44.299782	−99.438828	45.2
Tennessee	55328.8048	8230810440	27	10	35.747845	−86.692345	57.6
Texas	60614.2778	29482303890	50	45	31.054487	−97.563461	64.8
Utah	62041.1716	4053532224	46	15	40.150032	−111.862434	48.6
Vermont	66668.8984	706741623	2	22	44.045876	−72.710686	42.9
Virginia	61522.7158	9606740409	30	32	37.769337	−78.169968	55.1
Washington	80779.4660	8329408761	4	13	47.400902	−121.490494	48.3
West Virginia	40155.3108	1655599868	40	37	38.491226	−80.954453	51.8
Wisconsin	64615.2405	7284635448	12	12	44.268543	−89.616508	43.1
Wyoming	63126.4489	692221200	20	39	42.755966	−107.30249	42

Source: Democracy rank https://archive.fairvote.org/?page=2117 List of Latitudes and Longitudes for Every State (inkplant.com). Temperature. World population review (2024): Average Temperatures by State 2024.

Table A2. Gross State Product, Consumer price index, SAT, population.

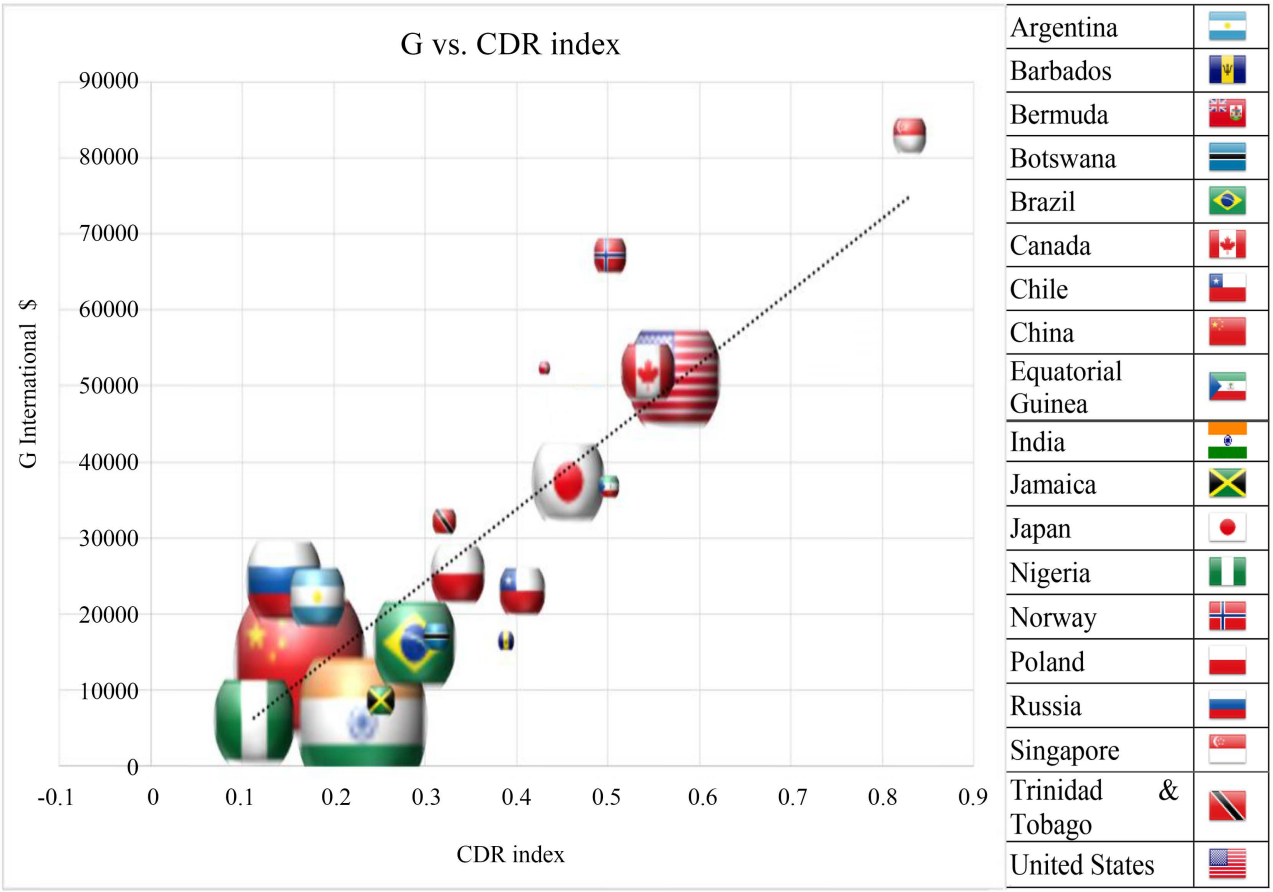
STATE	Abbreviation	Real GSP $M	Real GSP per capita $	Consumer price index	SAT	Population	Rule of law index
Alabama	AL	241,753	48116.95	3.4	1161	5,024,279	18.98
Alaska	AK	53,006	72275.23	3.3	1082	733,391	34.01
Arizona	AZ	414,273	57928.11	3.3	1183	7,151,502	23.07
Arkansas	AR	140,785	46748.76	3.4	1192	3,011,524	28.87
California	CA	3,233,151	83894.66	3.3	1083	38,538,223	61.6
Colorado	CO	428,040	74135.99	3.3	996	5,773,714	41.69
Connecticut	CT	282,478	78336.77	2.5	1007	3,605,944	62.52
Delaware	DE	74,263	75017.07	3.4	958	989,948	38.39
Florida	FL	1,279,119	59388.42	3.4	966	21,538,187	29.35
Georgia	GA	661,115	61717.76	3.4	1054	10,711,908	41.03
Hawaii	HI	86,888	59705.72	3.9	1114	1,455,271	61.41
Idaho	ID	94,914	51608.77	3.3	970	1,839,106	25.65
Illinois	IL	875,569	68337.05	2.7	970	12,812,508	56.03
Indiana	IN	401,472	59165.92	2.7	971	6,785,528	30.91
Iowa	IA	200,442	62827.22	2.7	1208	3,190,369	38.68
Kansas	KS	182,350	62068.57	2.7	1245	2,937,880	23.87
Kentucky	KY	225,235	49987.39	3.4	1208	4,505,836	30.71
Louisiana	LA	238,196	51139.64	3.4	1194	4,657,757	32.11
Maine	ME	73,781	54156.80	2.5	1080	1,362,359	28.77
Maryland	MD	420,997	68153.11	3.4	1008	6,177,224	64.68
Massachusetts	MA	615,148	87504.30	2.5	1112	7,029,917	63.71
Michigan	MI	547,772	54356.85	2.7	967	10,077,331	42.93

Continued

Minnesota	MN	383,619	67224.99	2.7	1201	5,706,494	57.26
Mississippi	MS	114,950	38817.69	3.4	1184	2,961,279	27.53
Missouri	MO	344,115	55908.99	2.7	1191	6,154,913	24.33
Montana	MT	55,193	50905.49	3.3	1193	1,084,225	31.29
Nebraska	NE	144,183	73506.35	2.7	1252	1,961,504	30.83
Nevada	NV	192,216	61913.01	3.3	1166	3,104,614	20.44
New Hampshire	NH	91,255	66245.43	2.5	1035	1,377,529	21.45
New Jersey	NJ	656,480	70672.88	2.5	1066	9,288,994	53.91
New Mexico	NM	105,463	49804.91	3.3	901	2,117,522	46.83
New York	NY	1,775,714	87901.20	2.5	1039	20,201,249	57.5
North Carolina	NC	625,682	59934.74	3.4	1127	10,439,388	31.94
North Dakota	ND	58,015	74464.70	2.7	1287	779,094	22.76
Ohio	OH	698,217	59173.70	2.7	1044	11,799,448	36.41
Oklahoma	OK	201,659	50932.31	3.4	953	3,959,353	32.27
Oregon	OR	260,111	61386.66	3.3	1125	4,237,256	49.74
Pennsylvania	PA	789,502	60718.31	2.5	1078	13,002,700	40.98
Rhode Island	RI	63,173	57567.17	2.5	958	1,097,379	29.16
South Carolina	SC	259,930	50783.20	3.4	1028	5,118,425	23.69
South Dakota	SD	56,309	63506.37	2.7	1208	886,667	11.36
Tennessee	TN	425,410	61556.92	3.4	1191	6,910,840	49.78
Texas	TX	2,032,933	67437.35	3.4	978	30,145,505	22.86
Utah	UT	219,181	66994.72	3.3	1239	3,271,616	45.06
Vermont	VT	35,073	54539.35	2.5	1099	643,077	36.87
Virginia	VA	590,802	68448.05	3.4	1113	8,631,393	30.3
Washington	WA	672,125	87229.14	3.3	1081	7,705,281	47.75
West Virginia	WV	80,135	44675.41	3.4	923	1,793,716	28.43
Wisconsin	WI	336,461	57088.07	2.7	1236	5,893,718	49.52
Wyoming	WY	39,322	68166.65	3.3	1200	576,851	25.72

Source: Real GSP 2023. BEA 2017 Chain: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.bea.gov/sites/default/files/2024-06/stgdppi1q24.pdf. Consumer price index SAT https://blog.prepscholar.com/average-sat-scores-by-state-most-recent Population (year 2020) https://simple.wikipedia.org/wiki/List_of_U.S._states_by_population Rule of Law index (2016) https://ncaj.org/state-rankings/justice-index.

Appendix B: Cross-Country CDR Economic Growth Model



Year 2014 *G* vs CDR Index for 79 countries (line). Bubble size (21 countries) is the square root of population. This model was re-estimated for years 1995 to 2016 with similar results. For additional comments on the countries listed see Ridley (2020).

$\hat{g} = 1.53C + 0.14D + 0.23R - 1.21CDR + 0.38N \quad R^2 = 0.9$

G = $\hat{g}$ (GDPppp highest − GDPppp lowest) +GDPppp lowest).

Appendix C: Aptness of the CDR Model

The following are tests to verify the aptness of the cross-state CDR model.

Ramsey (1969, 1974) RESET test for linearity misspecification error.

Consider the following hypotheses

H_0: The CDR model is linear

H_1: The CDR model is nonlinear

When the CDR model is modified to include the squares of the fitted values ($\hat{g}^2$) the result is:

$$\hat{g} = 1.11C + 0.14D + 0.20R - 0.91C \cdot D \cdot R + 0.32N + 0.26\hat{g}^2$$

$$|t| = (1.78)\ (1.63)\ \ (2.11)\ \ (1.83)\ \ \ \ \ (2.98)\ \ \ (0.72)\ \ R^2 = 0.84844.$$

The number of parameters estimated $p = 6$.

$$t_{\alpha,n-p-1} = t_{0.05,50-6-1} = t_{0.05,43} = 2.0$$

The coefficient of $\hat{g}^2$ is 0.26 with $t = 0.72$.

$t = 0.72 < t_{0.05,43} = 2.0$ implies that at a 5% level of significance, we fail to reject Ho and accept that the linear specification is appropriate for the CDR model.

Jarque and Bera (1980, 1987) test for normality of residuals.

Consider the following hypotheses.

H_0: Residuals from the CDR model are normally distributed

H_1: Residuals from the CDR model are not normally distributed

The number of parameters estimated $p = 2$.

The number of observations n = 50.

Skewness S = 0.302

Kurtosis K = 3.194

$$\text{JB} = \frac{n}{6}\left(S^2 + \frac{1}{4}(K-3)^2\right) = \frac{50}{6}\left(0.302^2 + \frac{1}{4}(3.194-3)^2\right) = 0.84$$

$$\chi^2_{\alpha,p} = \chi^2_{0.01,2} = 9.21$$

JB = 0.84 < $\chi^2_{0.01,48}$ = 9.21 implies that at 1% level of significance, we fail to reject Ho and accept that the residuals from the CDR model are normally distributed.

See also the histogram in **Figure 4**.

Breusch and Pagan (1979) test for homoscedasticity of the residuals.

Consider the following hypotheses

H_0: The residuals from the CDR model are homoscedastic

H_1: The residuals from the CDR model are heteroscedastic

Regressing the variance of residuals on the independent variables,

$$\hat{\varepsilon}^2 = 0.0 - 0.0013C - 0.0005D - 0.0013R + 0.00599C \cdot D \cdot R + 0.0L$$

$$|t| = (1.57)\ (0.78)\ \ \ (0.61)\ \ \ (1.64)\ \ \ (0.95)\ \ \ \ \ \ \ (0.85)\ \ R^2 = 0.093.$$

The number of parameters estimated $p = 5$.

The number of observations n = 50.

F test:

$$\mathrm{F} = \frac{R^2/p}{\left(1-R^2\right)/\left(n-p-1\right)} = \frac{0.093/5}{\left(1-0.093\right)/\left(50-5-1\right)} = \frac{0.0186}{0.206} = 0.09$$

$$F_{\alpha,p,n-p-1} = F_{0.01,5,50-5-1} = F_{0.01,5,44} = 3.29$$

$\mathrm{F} = 0.09 < F_{0.01,5,744} = 3.29$ implies that at 1% level of significance, we fail to reject Ho and accept that the residuals of the CDR model are homoscedastic.

Chi Square Lagrange Multiplier (LM) test:

$$\mathrm{LM} = \mathrm{n}\, R^2 = 50 \cdot 0.09 = 4.5$$

$$\chi^2_{\alpha,p} = \chi^2_{0.01,6} = 16.81$$

$\mathrm{LM} = 4.5 < \chi^2_{0.01,6} = 16.81$ implies that at 1 % level of significance, we fail to reject Ho and accept that the residuals of the CDR model are homoscedastic.

White (1980) test for homoscedasticity of the residuals.

Consider the following hypotheses

H_0: The residuals from the CDR model are homoscedastic

H_1: The residuals from the CDR model are heteroscedastic

Regressing the variance of residuals on the independent variables,

$$\hat{\varepsilon}^2 = 0.0013 - 0.0006\hat{g} + 0.0129\hat{g}^2$$

$$|t| = \left(0.601\right) \quad \left(0.056\right) \quad \left(1.111\right) \qquad R^2 = 0.228.$$

The number of parameters estimated $p = 2$.

The number of observations n = 50.

F test:

$$\mathrm{F} = \frac{R^2/p}{\left(1-R^2\right)/\left(n-p-1\right)} = \frac{0.228/2}{\left(1-0.228\right)/\left(50-5-1\right)} = \frac{0.114}{\left(0.175\right)} = 0.65$$

$$F_{\alpha,p,n-p-1} = F_{0.01,1,50-2-1} = F_{0.01,1,47} = 7.3$$

$\mathrm{F} = 0.65 < F_{0.01,1,47} = 7.3$ implies that at 1% level of significance, we fail to reject Ho and accept that the residuals of the CDR model are homoscedastic.

Chi Square Lagrange Multiplier (LM) test:

$$\mathrm{LM} = \mathrm{n}\, R^2 = 50 \cdot 0.09 = 4.5$$

$$\chi^2_{\alpha,p} = \chi^2_{0.01,6} = 16.81$$

$\mathrm{LM} = 4.5 < \chi^2_{0.01,2} = 9.21$ implies that at 0.01% level of significance, we fail to reject Ho and accept that the residuals of the CDR model are homoscedastic.

See also the plot of residuals vs. fitted values of g in **Figure 3**.

Appendix D: Alternate Model Specifications

The fitted OLS model with temperature (T) substituted for latitude (L) is

$$\hat{g}=0.8432+0.1634C+0.0294D+0.1152R-0.6592C\cdot D\cdot R-0.2730T,\ R^2_{adj}=0.8$$
$$|t|= \quad (1.74) \quad (0.46) \quad (2.10) \quad (9.04) \quad (2.67)$$

The fitted OLS model with ethnolinguistic fractionalization (EF) included is

$$\hat{g}=0.5635+0.1319C+0.0439D+0.1192R-0.6728C\cdot D\cdot R+0.2872L-0096EF,\ R^2_{adj}=0.8$$
$$|t|= \quad (1.36) \quad (0.64) \quad (1.93) \quad (8.98) \quad (2.13) \quad (0.06)$$

The fitted OLS model with all variables replaced by logarithms is

$$\hat{g}=2.5586+0.0893C+0.1830D+0.1591R-0.0188C\cdot D\cdot R+0.7775L,\ R^2_{adj}=0.44$$
$$|t|= \quad (2.38) \quad (1.36) \quad (1.03) \quad (1.66) \quad (3.93)$$