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GDP FORECASTING BY CDR COMPOSITION

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Abstract
It has been established that the parsimonious capitalism, democracy, rule of law (CDR) model is a global time invariant model for the estimation of real gross domestic product adjusted for purchasing power parity (G). This new scientific discovery may be used to estimate G for any year in which a country market capitalization (C), democracy ranking (D), rule of law ranking (R), and the highest and lowest values of Amongst all countries are known. This scientific growth model is used to construct a forecasting model for G from its CDR composition.

Keywords: Gross Domestic Product; Capitalism; Democracy; Rule of Law.

INTRODUCTION

Prior to the Ridley (2017a,b) CDR model the Solow (1956, 1957) growth model was the best estimator of output from which gross domestic product (GDP) could be obtained. That model is based on an adaptation of the Cobb-Douglas model Q=*f*(K,L) in which K is fixed capital and L is lab or. It does not account for entrepreneurial capital and must come up short of explaining the total variation in GDP. Whereas it is presented as an aggregate production function, Ridley and Ngnepieba (2018) show definitively that there is no such thing as an aggregate production function. Also L varies depending on quality due the level of associated skill. That is, it departs from the Ricardo (1817, 1821) definition of homogenous lab or in which each unit must be the same. The Solow model is not global invariant and not time invariant. Therefore, it must be estimated separately for each country and re-estimated for each year. Knowing K and L for any one country does not say anything about *G* in another country or in a different year.
Gartner and Lawson (2003) and Gartner, Holcombe and Lawson (2006) advocate economic freedom as good for economic growth. That research produced the economic freedom of the world (EFW) index. But, the GDP=*f*(EFW) model yields only R^2_{adj} = 52% compared toR^2_{adj} = 83% for the CDR model.
A fundamental principle for time series analysis and forecasting is to recognize that an historical variable that is to be forecast may comprise components that change over time but not all in the same way. For that reason, where possible, the variable should be decomposed into its component variables. Or, its components can be identified together with the relatively weights that they contribute. Each component variable should be forecast separately and subject to the rules that apply to it. The component forecasts can then be integrated by a weighted average to obtain the forecast of the aggregate variable of interest.
This paper explores the possibility of using the CDR growth model to forecast real gross domestic product adjusted for purchasing power parity (*G*).In the CDR model, the components

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of *G*are capitalism measured by total market capitalization (*C*), degree of democracy measured by country democracy ranking (*D*) and degree of rule of law (*R*) measured by the opposite of country ranking in corruption. Rule of law reflects the enforcement of property rights and various laws related to the achievement of justice. The relationship of these components to *G* is global time invariant. Global time invariance permits the estimation of *G* for any year in which country *C*,*D* and *R*, and the highest and lowest values of *G* amongst all countries are known for the forecast year. This can be the basis for the partial construction of a forecast for *G*. Forecasts for *C*, *D* and *R* must be made independently of *G*. Unlike *C*, *D* and *R*, Natural resources (*N*) and latitude equal to the absolute distance from the equator (*d*) are independent of government policy. The appellation CDR derives from the fact that only *C*, *D* and *R* can be shaped by government policy. However, *N* and *d* do contribute to *G*, albeit surprisingly very little. In the interest of forecasting accuracy they can be included in the CDR model. Their inclusion will not affect the property of global time invariance.

THE CDR GROWTH MODEL

Definitions:

Entrepreneurship *is the process of starting a business, typically a start-up company offering an innovative product, process or service.*

Capitalist *is a person who deploys his or her personal capital so as to maximize his or her own benefit and includes all rational people.*

Real gross domestic product adjusted for purchasing power parity (G) *is the net product or value added that equates to standard of living.*

Capitalism (C) *is the mechanism for the collection and assembly of capital, measured by total market capitalization that reflects entrepreneurship capital and capital stock.*

Democracy (D) *is the private work force idea participation and periodic election of public representatives, and catalyst for the process of generating G from C.*

Rule of law (R) *is the reverse of corruption, the protection of shareholder and other property rights, and catalyst for the attraction of C.*

Corruption *is the abuse of entrusted power for private gain and can be classified as grand, petty and political, depending on the amounts of money lost and the sector where it occurs.*

Property (rights) *is a legal expression of an economically meaningful consensus by people about assets, how they should be held, used and exchanged.*

From the appendix the CDR statistical model for GDP is

$$g = \beta_0 + \beta_C C + \beta_D D + \beta_R R + \beta_{CDR} C \cdot D \cdot R + \beta_N N + \varepsilon$$

where all variables are standardized by linear transformation to ensure upper and lower bounds on $0 \leq g,C,D,R,CDR,N \leq 1$. Democracy and corruption are rank ordered, where the highest = 1 and the lowest = the number of countries. Note that *N* can be dropped for policy making; leaving just CDR. Hence the appellation "CDR." Although *N* contributes only 6% to explaining variations in g it is included for the purpose of accuracy in the estimation of GDP.

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The ordinary least squares (OLS) model for the *i* th country is

$\hat{g}_i = 1.53C_i + 0.14D_i + 0.23R_i - 1.21C_i \cdot D_i \cdot R_i + 0.38N_i$. R^2_{adj}=0.83

(Click here for spreadsheet calculation and data)

Concisely stated, the estimated country CDR index is the vector inner product (dot product) of the global constant [1.53 0.14 0.23 -1.21] and the country [*C D R C·D·R*]. Or, the CDR index = CDRs index + CDR p index. The CDRs sum index = 1.53*C* + 0.14*D* + 0.23*R*. That is, a country CDRs index = 1.53, 0.14 and 0.23 weighted by its country *C, D* and *R* and summed. The CDR p product index = -1.21·*C·D·R*. That is, a country CDR p index is the product of -1.21 and its *C, D* and *R*.

The coefficients are global time invariant. Any country can choose a policy to raise or lower the levels of democracy and/or the levels of rule of law. Achieving such changes may be difficult in practice but it quite possible. Such change was demonstrated by South Korea where the economy went from ashes to enviable in just 50 years. They cannot choose the natural resources. But, the natural resources can change in some systematic way for various reasons. For example seasonality, gradual depletion, etc.

Democracy and rule of law are catalysts. Rule of law attracts capital and democracy creates new pathways that permit the optimal deployment of capital. At the end of the process where capital is converted to g, the catalysts are unchanged by the process. They are the same as they are at the beginning of the process. They are available for reuse as the process continues in subsequent years. Therefore, the catalysts are exogenous variables. Capital comprises exogenous entrepreneurial human capital ideas of imagination and creativity and endogenous capital stock. Capital stock comprises human knowledge and training from prior entrepreneurship, machines, computer, recording devices, etc. Some g from capital stock can be consumed and some can be reinvested. Due to the presence of endogenous capital, the coefficient of capital is subject to bias.

For additional accuracy we can include latitude as follows:

$\hat{g}_i = 2.02C_i + 0.16D_i + 0.10R_i - 1.78C_i \cdot D_i \cdot R_i + 0.38N_i + 0.21d_i$.

|*t*| = (9.52) (2.19) (1.26) (-7.21) (6.67) (5.69) R^2_{adj}=0.89

(Click here for spreadsheet calculation and data)

Ridley and Khan (2018) showed how to use two stage least squares (2SLS) to remove the bias in the estimate. The 2SLS model is better for understanding the economic impact of *C*ong. But, it yields a lowerR^2_{adj}=0.74. Therefore, the OLS model is a more efficient predictor of g. So, the OLS CDR function will be used henceforth.

Consider the variables changing over time *t*,

$\hat{g}_{it} = 2.02C_{it} + 0.16D_{it} + 0.10R_{it} - 1.78C_{it} \cdot D_{it} \cdot R_{it} + 0.38N_{it} + 0.21d_{it}$.

The strategy is to forecast C_{it}, D_{it} and R_{it} from past observation then calculate $\hat{g}_{it}$ from this equation. Note that N_{it} is constant or changes very slowly and d_{it} remains constant. The particular forecasting method is left to the analyst. However, we know from prior research that

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variables such as C_{it} can be cyclical and might best be forecast by spectral analysis. One such method is the Ridley (2003) and Ridley and Ngnepieba (2009) moving window spectral method.

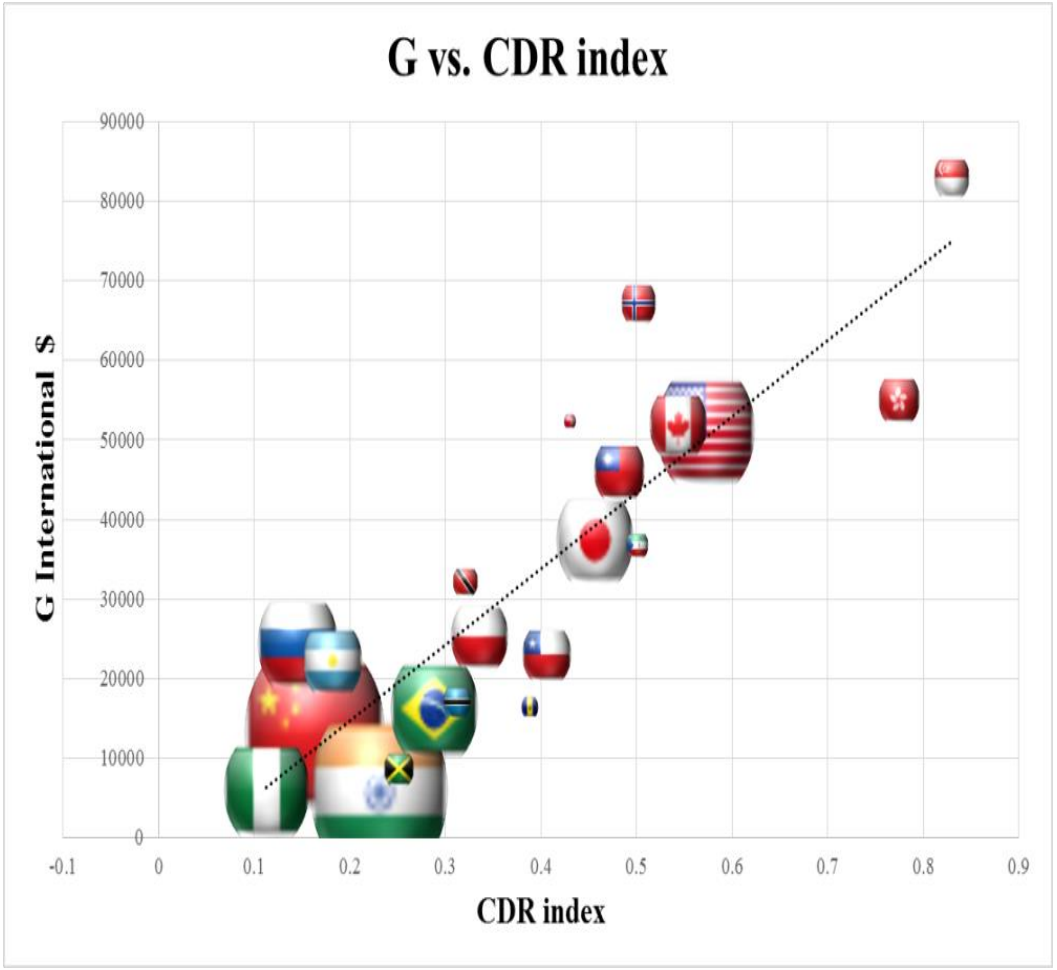
CONCLUSIONS

This paper discusses forecasting *C*, *D* and *R* and using their and *N* and *d* relationship to g to predict GDP. Suggestions for future research may be to develop better data collection mechanisms for *C*, *D* and *R* to enable better forecasting models for *C*, *D* and *R*. Further decomposition of the components *C*, *D* and *R* into sub components might also be investigated.

APPENDICES

For convenience, the following appendices are reconstructed here from prior CDR publications.

Appendix A: The Global Invariant CDR model



Argentina	
Barbados	
Bermuda	
Botswana	
Brazil	
Canada	
Chile	
China	
Equatorial Guinea	
Hong Kong	
India	
Jamaica	
Japan	
Nigeria	
Norway	
Poland	
Russia	
Singapore	
Taiwan	
Trinidad & Tobago	
United States	

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Figure 1. 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 (2017a, 2017b).

Standardized g model

The ordinary least squares *g* model is specified as follows:

$g = \beta_0 + \beta_C C + \beta_D D + \beta_R R + \beta_{CDR} C \cdot D \cdot R + \beta_N N + \varepsilon$

where, the intercept β_0 and the coefficients β_C,β_D, β_R, β_{CDR},β_N are all dimensionless,

ε is arandom, normally distributed error with a mean of zero and constant standard deviation,

and where all model variables are standardized as follows:

$g = \frac{G - \text{lowest } G}{\text{highest } G - \text{lowest } G}$

G = per capita real gross domestic product per capita (PPP)

C(Capitalism) $= \frac{\text{per capita capitalization} - \text{lowest per capita capitalization}}{\text{highest per capita capitalization} - \text{lowest per capita capitalization}}$

D(Democracy) $= \frac{\text{lowest democracy rank} - \text{democracy rank}}{\text{lowest democracy rank} - \text{highest democracy rank}}$

R(Rule of law) $= \frac{\text{lowest corruption rank} - \text{corruption rank}}{\text{lowest corruption rank} - \text{highest corruption rank}}$

N(Natural resources) $= \frac{\text{per capita total natural resource rents} - \text{lowest per capita total natural resource rents}}{\text{highest per capita total natural resource rents} - \text{lowest per capita total natural resource rents}}$

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

Democracy and corruption are rank ordered, where the highest=1 and the lowest = the number of countries. *G* is measured in $/capita/year.

$\hat{g} = 1.53C + 0.14D + 0.23R - 1.21C{\cdot}D{\cdot}R + 0.38N$

t= (6.60) (1.69) (2.60) (4.40) (5.59) F ratio = 81.

Partial correlations (contributions to R^2_{adj}):

59% 5% 10% 3% 6% R^2_{adj} *= 83%.*

where ^ denotes estimated or fitted value and *G* can be estimated from

$\hat{G} = \hat{g}$ (highest *G*-lowest *G*) + lowest *G*.

Highest *G*=83,066. Lowest *G*=1,112.

The CDR index = $1.53C + 0.14D + 0.23R - 1.21C{\cdot}D{\cdot}R$comprises positive *C, D* and *R* effects and a negative component due to friction from democracy that reduces *G* from what it might otherwise be if there were perfect agreement amongst decision contributors. The contribution from *N* is negligible and can be dropped from the model since it is not a decision variable that is under the control of government.

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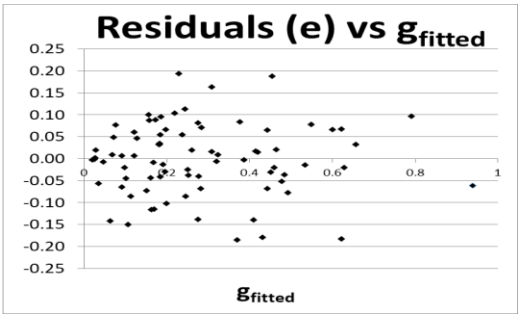

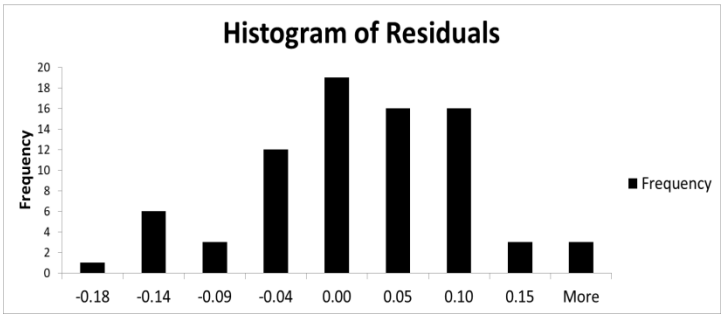

Figure 2a. Plot of residual vs. fitted values of *g*. Figure 2b. Histogram of residuals

Appendix B: Entrepreneurship: information theory of economics

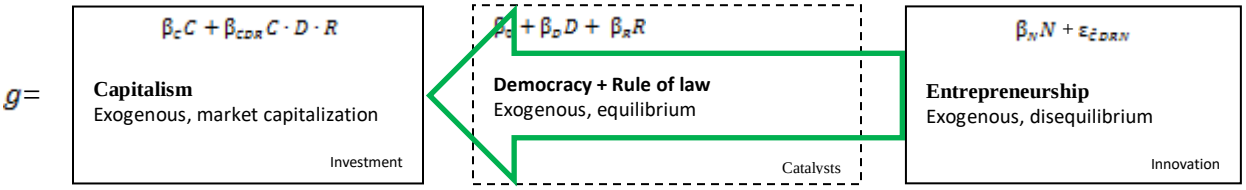

Figure 3. Conversion of exogenous innovation *C* to g through a DR channel.

Capital is typically converted via a production process into products and services. R is necessary to attract *C*and *D* is necessary to create additional pathways that deploy *C* effectively. New ideas appear to us as quanta of information that must be detected and acted on (Gilder, 2013, Romer, 1986, 1990, Lucas, 1988). But, a low *D*, low *R* high noise environment blocks exogenous innovative *C*. A high *D*, high *R* low noise environment is required for the detection of human entrepreneurial ideas. Sometimes it is the people who no one imagines anything of, that do the things that no one can imagine (Moore, 2014). Heterogeneous exogenous catalysts *D* and *R* are government variables that provide positive social equilibrium effects. Heterogeneous variables do not change their form. Exogenous variables are external to the process, do not get used up, and at the end of process are ready for reuse as before. Catalysts do not take part in the process (Berzelius, 1835).The process by which exogenous innovative *C* is converted to products is depicted in Figure 4. The variable g is the standardized version of *G* used to estimate the CDR model.

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