The Volatility Trap: Effects on Human Capital Accumulation

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Abstract

This paper presents results from instrumental variable estimates of the effect of per capita GDP volatility on secondary school enrollment. For a panel of 189 countries spanning from the years 1970 through 2000, we construct five-year historical measures of rainfall volatility, and show that these are a significant predictor of per capita GDP volatility. Rainfall volatility also has a significant reduced-form effect on secondary school enrollment. Our 2SLS results suggest that per capita GDP volatility has a significant, negative effect on secondary school enrollment.

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1 Introduction

The idea of a poverty trap has become ubiquitous in the field of development economics. If we are to understand exactly how underdevelopment may be self-reinforcing, the poverty trap writ large must be broken down into its component parts. The present paper seeks to explore the effects of macroeconomic volatility on human capital accumulation and in doing so, investigate the potentially vicious cyclical nature of volatility. Lucas (1988) notes that the growth of developed countries is much more stable than that of developing countries. Ramey and Ramey (1995) study the link between real GDP per capita growth rates and macroeconomic volatility, finding empirical support for the claim that macroeconomic volatility and growth are connected, with higher volatility associated with lower real growth rates. Ramey and Ramey posit that the costs of volatility come from "uncertainty-induced planning errors by firms" (1148). Barro (1991) demonstrates in a cross-sectional analysis that human capital levels are also an important determinant of economic growth. If volatility causes "planning errors" in firms, might it also cause errors in the decision of whether or not to invest in human capital accumulation? This paper seeks to answer that question and to enrich the understanding of the impact of volatility on economic development.

The sources of volatility, while still fairly opaque, have received attention in the development literature recently. Koren and Tenreyro (2007) show that as countries develop they alter their industrial composition, moving from high-volatility to low-volatility sectors. Krishna and Levchenko (2009) look at why certain sectors display higher volatility than others. Drawing on evidence from Costinot (2009) and Nunn (2007), the authors assert that developing countries are more volatile because they specialize in the production of low-complexity goods, or goods that do not require a high number of inputs. Such simple industries are more volatile due to the fact that a shock to any singular input has a larger proportional effect on the cost of producing the final good, in other words the industry is not well-diversified vis-à-vis inputs. Krishna and Levchenko model how this specialization in simple industries occurs, proposing low initial endowments of human capital as one theoretical explanation. They show that, in an environment of open trade, a country with a lower initial human capital endowment relative to a trading partner will also specialize in a less complex industry. Our paper seeks to build off this insight. If countries with low levels of human capital indeed specialize in more volatile industries, and if macroeconomic volatility impedes the accumulation of human capital, then volatility is self-reinforcing and displays elements of a trap.

The relationship between macroeconomic volatility and human capital accumulation is, however, theoretically ambiguous. As Flug et al. (1998) discuss, education may function as a type of insurance against economic volatility, as the more educated have a broader range of skills and thus more employment options in the event of a downturn. Furthermore, economic upturns increase the opportunity costs of education with the inverse being true for a downturn. However, in poor countries, children may need to drop out of school in downturns to support their families. It is also conceptually unclear how the anticipation of future macroeconomic volatility may affect the decision to enroll or drop out today. Given this lack of theoretical clarity about the role of volatility in determining whether to invest in human capital, the question is an empirical one. Flug et al. document a negative relationship between volatility and human capital accumulation (measured as the percent of children of the relevant age range enrolled in secondary school). However, there are concerns of omitted variable bias. As Krishna and Levchenko point out, another potential source of macroeconomic volatility is low state capacity, specifically a state's lack of ability to enforce contracts. Without a robust legal system, specialization in complex industries that rest on multiple contractual agreements will be much more costly relative to high-capacity states. Low state capacity may also negatively affect financial depth, as lenders will be more reluctant to extend their services in view of greater enforcement uncertainty.

Another issue to contend with is human capital accumulation across generations. There are a number of channels, both economic and cultural, through which children's school enrollment is influenced by their parents' level of educational attainment. Chiu (2001) outlines the unsurprising feedback effect of parents with higher levels of education receiving greater economic benefits that then reduce the opportunity cost of sending their children to school. On the other hand, in developing economies, the relatively low returns to education (due to the prevalence of simple industries) may act as an incentive to send children to the labor market rather than to the classroom, especially if the parents never went to school themselves.

A final important consideration is the existence of credit market inadequacies, which are well documented in developing economies (Flug et al. 1998). The issue at hand is that the lack of a well-developed credit market has effects on both macroeconomic volatility and school enrollment. Developing economies tend to have low levels of financial access, depth and stability, all of which contribute to the persistence of the simple industries that are associated with macroeconomic volatility. These relatively poor credit market outcomes also inhibit a family's ability to borrow the money needed to send their children to school or to offset the income lost by not having their child participate in the labor market. Given these concerns, and the fact that Krishna and Levchenko's model suggests a high degree of endogeneity with respect to the impact of volatility on human capital accumulation, we will seek to isolate a plausibly exogenous portion of macroeconomic volatility to examine its influence on enrollment.

The World Bank's Development Indicators Catalog serves as our primary source of data. The bank provides data on secondary school enrollment, which we use as our measure of human capital accumulation. As discussed above, the direct estimation of the relationship between per capita GDP volatility and secondary school enrollment may be biased by endogeneity and omitted variables. Thus we seek a variable that is strongly correlated with per capita GDP volatility but does not affect secondary school enrollment except through its impact on macroeconomic volatility.

Recent literature suggests that rainfall volatility can serve as an efficacious instrument for per capita GDP volatility. Miguel et al. (2004) use rainfall variation as an instrument for GDP growth in assessing the impacts of growth on the probability of civil conflict in Africa. Our approach is also motivated by Brückner and Gradstein (2013) who use rainfall volatility as an instrument for GDP volatility in their examination of the effects of volatility on government size. While historical per capita GDP volatility may seem at first glance to be orthogonal to current human capital accumulation, there are several reasons to believe the two may be related, as detailed above. GDP volatility in developing economies can be seen as a function of existing human capital levels, particularly because such economies tend to specialize in simple industries with relatively unskilled labor forces (Krishna and Levchenko 2009). If human capital levels themselves contribute to macroeconomic volatility, it becomes imperative to separate out this effect by focusing on exogenous factors, such as rainfall volatility.

The paper proceeds as follows. Section 2 describes the data in more detail. Section 3 presents the argument for our instrument and specifies our regression strategy. Section 4 reports and analyzes the results. Section 5 concludes.

2 Data

The first stage of our two-stage least squares approach uses rainfall volatility to predict GDP volatility. The underlying data on rainfall come from Mitchell et al. (2003). Rainfall was observed at gauge stations, and recorded on a 0.5°x0.5° (latitude-longitude) grid over global land mass. These high-density data were aggregated at the country level by Jefferson and O'Connell (2004). Our measure of rainfall volatility, following Brückner and Gradstein, is the rolling standard deviation of the annual percentage change in rainfall over a five-year period. $Rainvol_{it}$ thus equals the standard deviation of the annual rainfall growth rate in country i over the years t-5 to t. The rainfall data cover the period 1901 to 2000.

GDP per capita data come from the World Bank. We construct a volatility measure $GDPvol_{it}$ in a manner identical to our rain volatility measure: the standard deviation of the annual growth rate of real GDP per capita in country i over time period t-5 to t. The World Bank also provides data on school enrollment, our ultimate dependent variable of interest. Following Flug et al. (1998), we focus on secondary school enrollment rather than primary, as the opportunity costs of secondary school are higher than for primary school, and it is more of a choice variable due to the prevalence of mandatory primary schooling laws. Enrollment is measured as the number of students enrolled in secondary school as a percentage of the population of age-appropriate children. In the present paper we rely on gross measures, meaning that the figures exceed 100 in some cases, due to the fact that the numerator is not age-restricted (e.g. a 30-year-old enrolled in secondary school gets counted in the numerator but not the denominator). The data on net enrollment (age-restricted numerator) are not nearly as complete as the gross data. This will not affect detection of an overall effect of GDP volatility on enrollment, but it will remain unclear whether the effect is distributed uniformly among age cohorts. This may pose a question for further research.

The data on school enrollment extend from 2012 back to 1970. Thus, our period of analysis is from 1970 to 2000, given that 2000 is the last year for which rain data exist. There are 189 countries in our sample, a complete list of which is availabe in the Appendix. Table 1 presents descriptive statistics for some of our main variables.

Table 1: Summary Statistics

Variable	Mean	Std. Dev.
Gross Secondary School Enrollment (percent)	61.122	34.19
Annual Rainfall (mm)	1310.759	975.566
Rainfall Volatility	0.217	0.173
GDP Per Capita (current dollars)	7256.708	14061.25
GDP Per Capita Volatility	3.818	3.739

3 Empirical Strategy

We employ a two-stage least squares estimation approach to examine the impact of per capita GDP volatility on secondary school enrollment. As noted in the Introduction, there are significant concerns of endogeneity and omitted variable bias when trying to identify a causal effect of income volatility on school enrollment. Using an instrumental variable identification strategy allows us to isolate the portion of per capita GDP volatility that is exogenous to school enrollment, which in turn allows us to interpret any effects we find as causal. A two-stage least squares methodology first involves predicting the independent variable of interest, in this case per capita GDP volatility, using another variable, the instrument, which is unrelated to our ultimate dependent variable of interest, school enrollment, except through its effect on GDP volatility. Given that rainfall is unrelated to government policy, economic history, and other human choice variables (at least in the short-to-medium run), it provides an excellent source of exogenous variation in per capita GDP. Using only the variation in GDP per capita volatility predicted by rainfall in our investigation of its effects on school enrollment allows us to interpret any relationship we find as causal. We construct our model in the following way. The second-stage equation using our panel data is given by:

$$E_{it} = \alpha + \beta_1 GDPvol_{it} + \beta_2 X_{it} + \beta_3 \lambda_t + \varepsilon_{it} \tag{1}$$

where E is gross secondary school enrollment for country i in year t; *GDPvol* is the five-year rolling standard deviation of per capita GDP growth; X is a vector of control variables that includes the natural log of per capita GDP, the growth rate of per capita GDP in year t for country i, the natural log of average rainfall in year t for country i, and continent dummies; λ represents year fixed effects. The corresponding first-stage equation is given by:

$$GDPvol_{it} = \theta + \pi_1 Rainvol_{it} + \pi_2 X_{it} + \pi_3 \tau_t + \mu_{it} \tag{2}$$

where *Rainvol* is the rolling five-year standard deviation of rainfall growth for country i in year t. Our choice of controls is motivated in part by Brückner and Gradstein (2013). Our use of the natural log of GDP per capita controls for variation related to country i's level of development, as countries in tropical climates with heavy rainfall are also less developed on average. We include the growth rate of per capita GDP in year t to control for business cycle effects. Since we are only interested in how historical rainfall volatility affects per capita GDP volatility, we control for the rainfall level in year t. We include continent dummies to control for regional characteristics, for example the Africa-specific effects Barro (1991) finds. As Brückner and Gradstein argue, time-invariant country-level fixed effects are unnecessary when using rainfall as an instrument, as the unobserved country characteristics usually captured by the use of fixed effects (such as colonial history) do not affect rainfall.

There are two conditions an instrument must meet to be valid: it must be relevant (strongly correlated to the independent variable it seeks to predict), and it must not violate the exclusion restriction. The relevance of our instrument will be proven in the next section. With respect to the latter, we see no plausible explanation of how historical rainfall volatility affects the decision to enroll in school in a given year, other than through its potential impact on GDP volatility. Our use of the rainfall level control ensures that we are not merely capturing effects that come from rainfall in the year in question. As a hypothetical illustration, reduced enrollment due to road deterioration caused by high precipitation in year t will be entirely captured by the coefficient on the natural log of rainfall variable; it will not bias our estimates of β_1 in Equation (1).

4 Results

As an illustrative first step, before approaching our research question with more sophisticated identification strategies, we demonstrate that macroeconomic volatility and school enrollment are in fact related. Figure 1 shows the simple bivariate relationship between per capita GDP volatility and secondary school enrollment. The t-statistic on the coefficient for GDP volatility is -12.9 and is significant at the 1% level. GDP volatility and secondary school enrollment are thus significantly correlated. The effect remains significant when level of GDP per capita, continent dummies, and year and country fixed effects are included. The results of the OLS regressions are presented in Table 2. While the correlation is significant throughout, these results cannot be interpreted as causal for the reasons laid out above. We thus must turn to estimating the effect of GDP volatility using our instrumental variable approach.

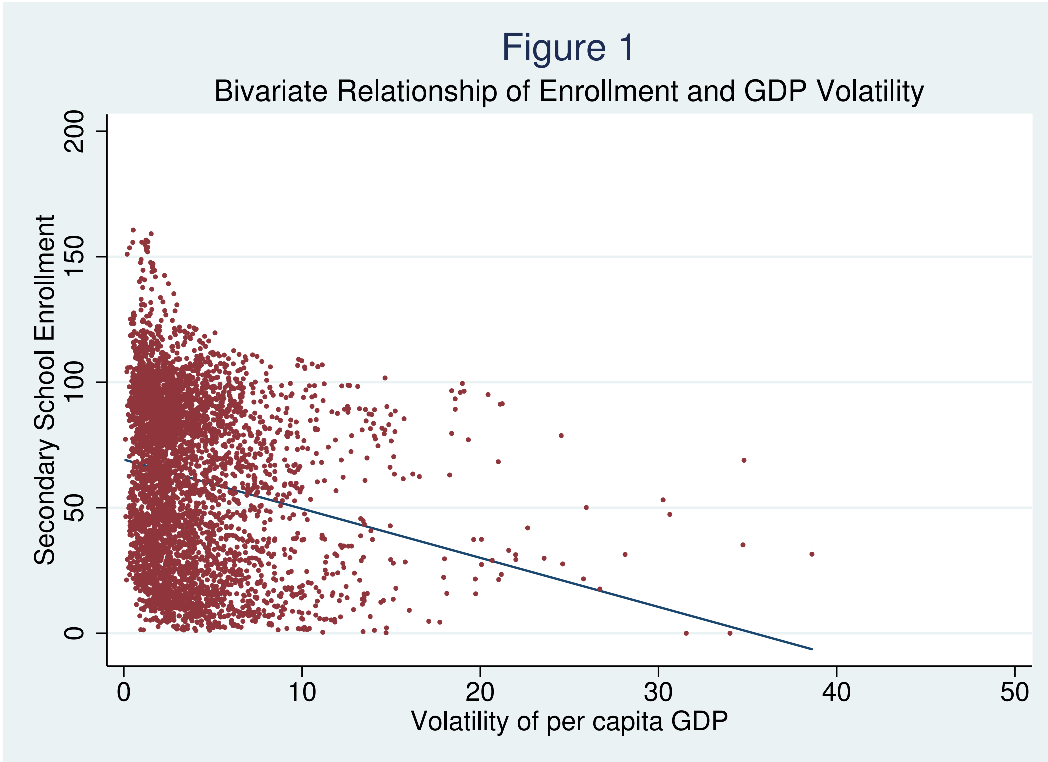

Table 2: Basic OLS Estimates

	(1) Enrollment	(2) Enrollment	(3) Enrollment	(4) Enrollment	(5) Enrollment	(6) Enrollment
GDPvol	-1.956***	-0.317**	-0.317**	-0.370***	-0.475***	-0.161**
	(0.152)	(0.123)	(0.122)	(0.104)	(0.0792)	(0.0550)
lnGDP		16.97***	16.96***	12.78***	15.39***	6.103***
		(0.172)	(0.172)	(0.235)	(0.260)	(0.429)
GDP per capita growth			-0.0320	-0.104	-0.157***	-0.158***
			(0.0735)	(0.0590)	(0.0332)	(0.0276)
Constant	69.16***	-66.54***	-66.46***	-49.97***	-23.64***	62.78***
	(0.738)	(1.517)	(1.531)	(1.575)	(5.916)	(5.745)
Continent FE	No	No	No	Yes	Yes	Yes
Country FE	No	No	No	No	Yes	Yes
Year FE	No	No	No	No	No	Yes
N	4629	4568	4555	4524	4524	4524

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 presents the results of the first stage of our two-stage least squares estimation strategy, with year and continent fixed effects. The t-statistic of the rain volatility coefficient is 6.64 and the standard error is about .42. Our first-stage results show that volatility of rainfall is significantly correlated with volatility of per capita GDP, at the 0.1% level. We may confidently say that our instrument is relevant, given this t-statistic and level of significance. Before turning to our second-stage estimates, we briefly comment on the reduced form estimates, presented in Table 4. The reduced form estimates shows that rain volatility has a significant, negative effect on secondary school enrollment.

Table 3: First Stage

	(1) GDP Volatility
Rainvol	2.773***
	(0.418)
lnRain	-0.632***
	(0.0857)
lnGDP	-0.728***
	(0.0519)
GDP Per Capita Growth	0.0659***
	(0.00869)
Constant	12.87***
	(0.744)
Continent FE	Yes
Year FE	Yes
N	4944
adj. R^2	0.088

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Reduced Form

	(1) Enrollment
Rainvol	-13.02***
	(2.581)
lnRain	-4.062***
	(0.590)
lnGDP	10.81***
	(0.290)
GDP Per Capita Growth	-0.201***
	(0.0594)
Constant	-6.627
	(4.984)
Continent FE	Yes
Year FE	Yes
N	3091
adj. R^2	0.758

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Examining the reduced form results when utilizing an instrumental variable can provide a useful check on our research hypothesis that GDP volatility affects school enrollment. The results of our panel regression suggest that this is the case. Table 5 presents the results of the second stage IV estimates, using different sets of fixed effects following Brückner and Gradstein. The coefficients on the controls are significant, as expected. The sign on the natural log of GDP and the natural log of rain are in the expected directions, but the fact that per capita GDP growth has a negative coefficient is interesting and may be due to the fact that growth raises the opportunity costs of attending school.We hesitate to make any strong comments on this observation, given that it is simply used here as a control and thus we have not attempted to correct for endogeneity, omitted variable bias, etc. This could be an avenue for further research. Based on our 2SLS results, GDP volatility has a negative and causal effect on secondary school enrollment, significant at the 0.1% level. Evaluated at the sample means, our baseline results suggest that a 10% increase in GDP volatility causes a reduction in secondary school enrollment of roughly 2.5%.

Table 5: 2SLS Results

	(1) Enrollment	(2) Enrollment	(3) Enrollment	(4) Enrollment
GDPvol	-4.160***	-3.659***	-3.888***	-3.705***
	(0.897)	(0.819)	(0.790)	(0.793)
lnGDP	15.39***	15.06***	8.651***	8.827***
	(0.546)	(0.526)	(0.601)	(0.573)
lnRain	-2.557***	-1.813*	-5.438***	-5.516***
	(0.751)	(0.703)	(0.825)	(0.854)
GDP Per Capita Growth	-0.469***	-0.401**	-0.413***	-0.397***
	(0.136)	(0.122)	(0.114)	(0.112)
Constant	-22.81	-30.48**	15.52	28.86
	(11.66)	(11.10)	(11.74)	(15.08)
Continent FE	No	No	Yes	Yes
Year FE	No	Yes	Yes	Yes
Continent-Year FE	No	No	No	Yes
N	3069	3069	3050	3050
adj. R^2	0.480	0.535	0.613	0.635

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As a further robustness check, we clustered standard errors at the country level, to account for potential serial correlation of the error terms. The p-value for the coefficient on *GDPvol* increased slightly but remained quite significant. The results of that regression are not reported simply because they are otherwise almost identical to our baseline results. By comparing the results from the basic OLS regression (Table 2) and the 2SLS specification (Table 5), we see the importance of instrumenting for endogenous sources of GDP volatility. Using rainfall volatility as an instrumental variable captures the true effect of macroeconomic volatility on secondary school enrolment, which is nearly twice that of the OLS regression without controls. 2SLS shows that a one standard deviation increase in per capita GDP volatility produces a reduction in secondary school enrollment of 3.71%, whereas OLS suggests the magnitude is closer to 1.96%. This divergence becomes even more pronounced when we add controls and fixed-effects in the OLS model. Robustness checks in the OLS model greatly reduce the economic significance of GDP volatility's effect on school enrollment, whereas the results from the 2SLS approach remain relatively consistent to the robustness checks. Failing to account for issues of endogeneity thus understates the true effect of GDP volatility on human capital accumulation.

5 Concluding Remarks

Our results provide strong evidence for the existence of a volatility trap that inhibits human capital accumulation in developing countries. Following a recent trend in the development literature, we employ an instrumental variable approach that uses rainfall volatility to isolate an exogenous portion of macroeconomic volatility. This allows for a clearer identification of the causal effect of GDP volatility on secondary school enrollment rates in the 189 countries in our sample.

The first-stage and reduced-form analysis suggest that greater volatility in rainfall causes an increase in GDP volatility and a decrease in secondary school enrollment rates. Our second-stage estimates provide greater clarity on the causal relationship between GDP volatility and school enrollment, indicating that the former has a highly significant negative effect on the latter. These results are robust even when accounting for continent, time and continent-time fixed effects. Given that the primary motive of our research was to elucidate a theoretically ambiguous relationship, these results provide strong empirical evidence for the deleterious effects of macroeconomic volatility on human capital accumulation. In light of the importance of education in the overall picture of development, our findings suggest that the stability of economic growth, while valuable in and of itself, also has an important secondary effect on human capital accumulation that must be taken into consideration. This is where the elements of a cyclical trap arise: the slower the accumulation of human capital, the longer it takes for countries to develop their economies away from agriculture and "simple" industries, which in turn leads to greater exposure to volatility shocks.

An avenue for potential further research could be to examine the underlying mechanism that causes an individual to opt out of schooling during periods of greater macroeconomic volatility. There are a number of possible explanations that could be explored. For one, the relatively high costs compared to the benefits of accumulating human capital in developing countries may disqualify education from being an adequate form of insurance during periods of volatility. Furthermore, high volatility may increase the interest rates demanded by lenders, thus creating a credit constraint inhibiting a family's ability to send their children to school rather than into the workforce. Our research shows that a causal channel from income volatility to lower school enrollment does exist and adds an important new insight to the development economics literature.

Country Appendix

Africa	Americas	Asia	Europe	Pacific
Algeria	Antigua & Barbuda	Azerbaijan	Iceland	Australia
Angola	Argentina	Bahrain	Ukraine	Fiji
Benin	Bahamas	Bangladesh	Albania	Kiribati
Botswana	Barbados	Bhutan	Andorra	Micronesia
Burkina Faso	Belize	Brunei Darussalam	Armenia	New Caledonia
Burundi	Bermuda	Cambodia	Austria	New Zealand
Cameroon	Bolivia	China	Belarus	Palau
Cape Verde	Brazil	India	Belgium	Solomon Islands
Central African Republic	Canada	Indonesia	Bosnia and Herzegovina	Tuvalu
Chad	Chile	Iran	Bulgaria	Vanuatu
Comoros	Colombia	Iraq	Croatia	
Congo	Costa Rica	Israel	Cyprus	
Republic of the Congo	Cuba	Japan	Czech Republic	
Djibouti	Dominica	Jordan	Denmark	
Egypt	Dominican Republic	Kazakhstan	Estonia	
Equatorial Guinea	Ecuador	Korea, North	Finland	
Eritrea	El Salvador	Korea, South	France	
Ethiopia	Grenada	Kuwait	Georgia	
Gabon	Guam	Kyrgyzstan	Germany	
Gambia	Guatemala	Laos	Greece	
Ghana	Guyana	Lebanon	Greenland	
Guinea	Haiti	Malaysia	Hungary	
Guinea-Bissau	Honduras	Mongolia	Ireland	
Ivory Coast	Jamaica	Myanmar	Italy	
Kenya	Mexico	Nepal	Latvia	
Lesotho	Nicaragua	Oman	Liechtenstein	
Liberia	Panama	Pakistan	Lithuania	
Libya	Paraguay	Papua New Guinea	Luxembourg	
Madagascar	Peru	Philippines	Macedonia	
Malawi	Puerto Rico	Qatar	Malta	
Mali	St Kitts & Nevis	Saudi Arabia	Moldova	
Mauritania	St Vincent & Grenadine	Singapore	Monaco	
Mauritius	Suriname	Sri Lanka	Netherlands	
Morocco	Trinidad & Tobago	Syria	Norway	
Mozambique	Turks And Caicos Islands	Tajikistan	Poland	
Namibia	United States	Thailand	Portugal	
Niger	Uruguay	Turkey	Romania	
Nigeria	Venezuela	Turkmenistan	San Marino	
Rwanda	Virgin Islands	United Arab Emirates	Slovakia	
Sao Tome & Principe		Uzbekistan	Slovenia	
Senegal		Vietnam	Spain	
Seychelles		Yemen	Sweden	
Sierra Leone			Switzerland	
Somalia			United Kingdom	
South Africa				
Sudan				
Swaziland				
Tanzania				
Togo				
Tunisia				
Uganda				
Zaire				
Zambia				
Zimbabwe				

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