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Improving the measurement of export instability in the Economic Vulnerability Index: A simple proposal

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Abstract

The Economic Vulnerability Index (EVI) is a well-recognized measure of the structural vulnerability of developing countries and is one of the three criteria used for the identification of Least Developed Countries (LDCs). Both for effectiveness and equity reasons, the EVI is also retained as a relevant criterion for aid allocation between developing countries. Such an index, in its construction as in its measure, must be beyond reproach. Here, we propose an improvement in the measurement of one of the most important component of the EVI, namely the instability of exports of goods and services. The implications of the proposal in terms of scores and ranks are then discussed.

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1. Introduction

Alongside GNI per capita and the Human Assets Index (HAI), the Economic Vulnerability Index (EVI) is one of the three criteria used for the identification of the Least Developed Countries (LDCs), as used by the UN-CDP (Committee for Development Policy) at each triennial review of the list of LDCs (see LDC *Handbook*, United Nations, 2015). EVI has also been proposed as a relevant criterion for the allocation of development assistance (see UN General Assembly resolution on the smooth transition of graduating LDCs – A/C.2/67/L.5 – and a survey in Guillaumont 2009b, 2013). For the EVI to be still considered as a useful tool for the identification of LDCs, and also as an aid allocation criterion, some components (or at least their calculation) may need to be refined[1].

Since 1999, the instability of exports of goods and services has been included as a component in the EVI. The purpose was to reflect the fact that highly variable export earnings cause fluctuations in production, employment, and the availability of foreign exchange, with negative consequences for economic growth and sustainable development. Because of the large share of raw materials in production and exports (and often a geographical concentration of export markets), LDCs are characterized by high export instability. This instability constrains their capacity to implement investment programs through its impact on domestic saving, tax revenue, and import capacity. Moreover, instability in export earnings increases uncertainty with a negative impact on private investment. It also has detrimental social consequences, lowering the impact of the average rate of growth on poverty reduction (Guillaumont, 2009b).

The UN-CDP considers the instability of exports of goods and services to be one of the most important components of the EVI[2]. Thus, the way in which this component is calculated deserves particular attention. Since the EVI is a criterion for aid allocation, any improvement in the calculation of its components (especially, as here, export instability) would be commendable and could have direct repercussions on people through LDC identification and aid allocation.

In this note, we are interested in the method of measuring the instability of export of goods and services in the EVI. After assessing the current method using relevant statistical criteria, we propose an improvement of the method of calculation and evaluate its impact on the countries' instability scores and ranking, in particular those of LDCs. This study may be used in discussions on the merits of the EVI, especially in the context of future reforms of the index.

2. Measurement of Instability

In the literature, a variety of measures of instability have been proposed, each one with its particular strengths and weaknesses (see a recent review in Cariolle and Goujon, 2015). The coefficient of variation is the "natural" and the simplest measure of export instability. But in

[1] For example, the share of population in Low Elevation Coastal Zones (LECZ) introduced in 2012 to provide information on countries' vulnerability to coastal impacts associated with climate change should be revised, with the aim of making it more balanced and equitable (Guillaumont, 2014). The various modifications that can contribute to improving the EVI are also presented and discussed in the document "How to revise EVI?" (forthcoming).

[2] Instability of export of goods and services has a high weight in the EVI (1/4 of the EVI and 1/2 of the shock sub-index).

most cases, instability is calculated as the mean squared deviation from an estimated long-term trend, either linear or exponential (e.g. Massel, 1970). This approach of measuring instability around a trend may depend on the choice of the form of the trend. The choice of an appropriate form of the trend is thus a crucial element of the construction of a suitable index of export earnings instability.

Modelling trends in time series has long been of interest in the literature[3]. The exercise of identifying the appropriate trend remains a theoretical challenge, as noted by Phillips (2005) "no one understands trends, but everyone sees them in the data". Trends fall into two categories depending on whether the trends are stochastic or deterministic. A deterministic trend, which is generally modelled by a straight line over time, may produce fluctuations at each point generated by a purely stochastic mechanism[4]. In that respect, deterministic and stochastic trends are often indistinguishable, in particular when only a relatively short portion of the series is available. This is why, since the introduction of the instability of goods and services in the EVI, the trend is assumed to have both a deterministic and a stochastic component. This method used for a number of years is called a "mixed trend" regression, as shown in the following equation:

$$\log y_t = \alpha + \beta \log y_{t-1} + \gamma T + \varepsilon_t \qquad (1)$$

Where,
y_t is the value of exports of goods and services at constant US dollars in year t;
T is the time variable;
ε_t is the error term in year t;
α, β and γ are the regression coefficients.

Data on exports of goods and services come from the United Nations Statistics Division in its National Accounts Main Aggregates Database. Equation (1) is estimated separately for each country, using standard ordinary least squares (OLS) over a specific time period. Associated with the choice of the type of trend, choosing an appropriate time period is also of paramount importance. The length of the period retained by the UN-CDP has changed over time (15 years for the 2006 and 2009 reviews, 20 years for the 2012 review, and 21 years for the 2015 and 2018 reviews). A trend calculated over 15, 20 (or 21) years seems to be a reasonable basis (as discussed by Cariolle and Goujon, 2015).

In this note, we question the linearity of the deterministic part of the trend, which may be too restrictive to capture asymmetries and observed non-linear dynamics. When the time period is longer, there is a risk that the deterministic component of the trend is no longer linear. Thus, both for capturing a possible change in the deterministic trend and avoiding a high impact of the chosen time period, we propose to fit a quadratic trend to the model using the following equation:

$$\log y_t = \alpha + \beta \log y_{t-1} + \gamma T + \theta T^2 + \varepsilon_t \qquad (2)$$

[3] Phillips (2005) provides an overview covering the development, challenges, and some future directions of trend modelling in time series. White and Granger (2011) offer working definitions of various kinds of trends and invite more discussion on better methods of estimating trends.
[4] Shocks may permanently affect the series and lead to a purely stochastic series. The stochastic trend is one that can change in each run due to the random nature of the process.

3. Is the current fit of the trend valid for all countries?

Because developing countries are heterogeneous, applying a single predefined model to all countries could have its limits, since a model may be more relevant for some countries than others. On the other hand, making the instability indicator comparable across countries requires the use of an identical de-trending method, which amounts to applying the mixed trend to all countries. This is why we first test whether the mixed trend method is suitable for all the countries in our sample. The trend aspects of each country can be assessed by a measure called the Mean Absolute Scaled Error (MASE)[5], which is calculated by:

$$MASE = mean(|q_t|); \text{ where } q_t \text{ is defined as } q_t = \frac{Y_t - \hat{Y}_t}{\frac{1}{T-1}\sum_{t=2}^{T}|Y_t - Y_{t-1}|}$$

With Y_t the value of exports of goods and services at constant US dollars in year t, $\hat{Y}_t$ the predicted value of exports of goods and services in year t obtained using the models from Equation (1) and Equation (2), T the forecasting horizon.

The bigger the MASE, the worse the fit of the trend to the data. This measure is easily interpretable. Values of MASE greater than one indicate that the trend fitting method does not provide a good enough fit to the exports series for which it is estimated. Overall, if we take the sample of 145 developing countries (the same sample as the UN-CDP), the mixed trend method is a good estimate of the trend. But for 11 countries[6], a MASE greater than one reveals that the mixed trend is not a good enough form of the trend.

So, considering the MASE criterion after adding a quadratic trend, the MASE is greater than one only for 7 countries (Palau, Tuvalu, Papua New Guinea, Gambia, Central African Republic, Comoros and Timor-Leste), they have a poorly estimated trend. These countries, except the Central African Republic, are already in the list of the 11 countries mentioned in the case of the use of a simple mixed trend. For the vast majority of countries, adding a quadratic trend to the simple mixed trend lowers the MASE values.

To confirm this outcome, and to supplement the MASE criterion, another criterion called the Mean Absolute Percentage Error (MAPE) is used to select a better fitted model for trends. The MAPE is one of the most popular measures in the forecasting literature (Ahlburg, 1995; Hyndman and Koehler, 2006; Wilson, 2007); it is simple to calculate and easy to understand. But MAPE has a significant drawback: it is not a robust measure in the presence of outliers, and it produces infinite or undefined values when the observed values are zero or close to zero. It can be defined as:

$$MAPE = \frac{1}{n}\sum_{1}^{n}|PE_t|; \text{ where } PE_t = 100*(Y_t - \hat{Y}_t)/Y_t$$

[5] When series include outliers or extreme values, it is advisable to apply scaled measures such as MASE. However, to use the MASE, the time period should be large enough (21 years in our case).

[6] These countries are: Tuvalu, Palau, Timor-Leste, Papua New-Guinea, Libya, Comoros, Bhutan, Nepal, Democratic People's Republic of Korea, South Sudan, and Gambia.

With Y_t the value of exports of goods and services at constant US dollars in year t, $\hat{Y}_t$ the predicted value of exports of goods and services in year t obtained using the models from Equation (1) and Equation (2), T the forecasting horizon.

The Spearman rank's correlation between MASE and MAPE is moderate (0.53 for the model from equation 1 and 0.58 for the model from equation 2) and statistically significant at 1 percent level. Nonetheless, what would be more interesting to examine is the difference in MASE and MAPE when we move from the mixed trend to the augmented mixed trend. The higher this difference, the less the augmented mixed trend seems appropriate for estimating the trend. This value allows us to identify the countries for which the mixed trend (or the augmented mixed trend) is more suited to estimating the trend. To do this, whether we use MASE or MAPE, the results are very close. This is evidenced by a very strong and significant Spearman rank's correlation (0.94).

The countries for which a mixed trend leads to a better fit of the trend are presented in Table 1. The countries are arranged in order of importance of the difference between the MASE (or MAPE) of the mixed trend and that of the augmented mixed trend. According to both criteria, the list of countries is the same, except for Somalia for which the MAPE is the same for the two estimated trends. The mixed trend is better suited to estimating the trend of countries such as Palau, Marshall Islands, Central African Republic, and Gambia. That is because the difference between the MASE (or MAPE) of the mixed trend and that of the augmented mixed trend is much larger for these countries. With the exception of the countries listed in Table 1, it is clear that for the bulk of developing countries, the addition of the quadratic term contributes to a better estimate of the trend and consequently to a better calculation of instabilities.

In addition to the MASE and MAPE criteria, the selection of the appropriate model for each country can be done in several ways, the best known of which is R^2. The greater the R^2, the better the fit of the trend to the data. Since the models from equations (1) and (2) are nested, R^2 cannot decrease when we add a quadratic trend; the fit will be equal or better. This is why we do not use the R^2 criterion, although the use of adjusted R-squared can help to partially overcome this difficulty. The choice of R^2 criterion would have made sense, if for example the question was whether the deterministic or stochastic trend is the most appropriate for a given country.

Table 1: Countries which best fit mixed trend

MASE criterion				MAPE criterion			
Country	ISO	MT	MT+QT	Country	ISO	MT	MT+QT
Palau	PLW	1.092	1.282	Palau	PLW	1.098	1.270
Marshall Islands	MHL	0.714	0.816	Gambia	GMB	2.242	2.318
Central African Republic	CAF	0.970	1.017	Marshall Islands	MHL	0.257	0.293
Gambia	GMB	1.001	1.048	Central African Republic	CAF	0.484	0.507
Algeria	DZA	0.774	0.792	Chad	TCD	0.852	0.867
Ghana	GHA	0.704	0.720	Ghana	GHA	0.544	0.555
Iran	IRN	0.898	0.912	Iran	IRN	0.260	0.264
Barbados	BRB	0.986	0.998	Turkey	TUR	0.157	0.161
Turkey	TUR	0.544	0.556	Barbados	BRB	0.256	0.259
Chad	TCD	0.887	0.897	Nigeria	NGA	0.625	0.628
Philippines	PHL	0.637	0.644	Mauritania	MRT	0.336	0.339
Mauritania	MRT	0.765	0.772	Philippines	PHL	0.228	0.231
Papua New Guinea	PNG	1.072	1.078	Algeria	DZA	0.123	0.126
Mexico	MEX	0.502	0.507	Lao PDR	LAO	0.470	0.472
Solomon Islands	SLB	0.751	0.756	Solomon Islands	SLB	0.591	0.593
Lao PDR	LAO	0.847	0.852	Lesotho	LSO	0.420	0.422
Lesotho	LSO	0.707	0.711	Mexico	MEX	0.117	0.119
Nigeria	NGA	0.804	0.808	Papua New Guinea	PNG	0.328	0.329
Morocco	MAR	0.379	0.381	Oman	OMN	0.277	0.277
Somalia	SOM	0.419	0.422	Morocco	MAR	0.104	0.105
Oman	OMN	0.855	0.858				

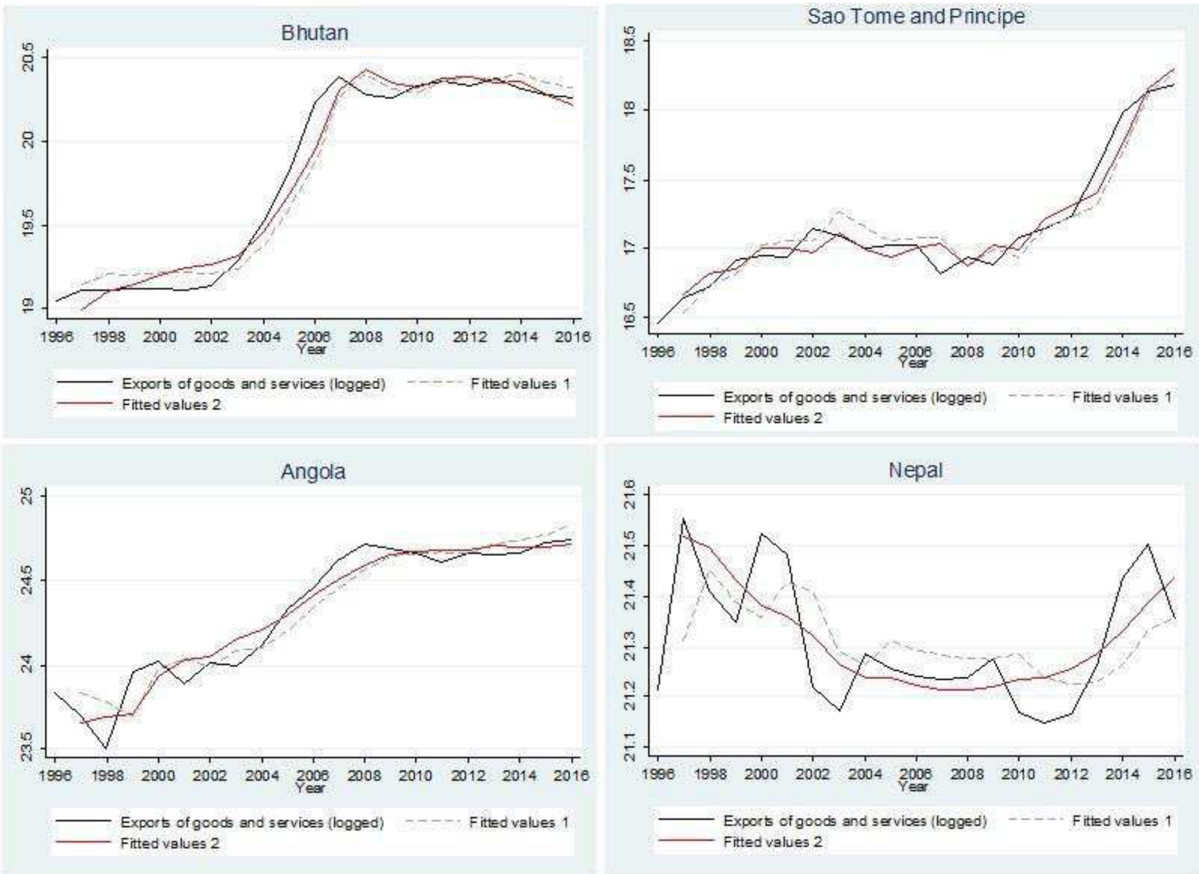
Note: MT=Mixed Trend; QT=Quadratic Trend; the lower the MASE or MAPE score, the better is the fit.

4. What happens when we add a quadratic trend?

The trend of export earnings is clearly non-linear, and an infinite number of functions enables dealing with this non-linearity. It requires significant effort to determine the function that provides the optimal fit for the value of exports of goods and services. In our case, we show how a simple addition of a quadratic trend contributes to a better calculation of export instabilities in the EVI. It makes it possible to highlight and better capture possible changes in trend compared to a mixed trend where the deterministic component is linear. It is an augmented mixed trend.

Time series plots of export earnings are given for 4 LDCs: Bhutan, Sao Tome and Principe, Angola, and Nepal. These are among the countries for which the addition of a quadratic trend has the largest influence on the country's instability calculation by the MASE criterion, since for the 4 countries the trend in the series of exports is far from linear. For each of these countries, fitted values of exports are generated from the mixed trend (Fitted values 1, following equation 1) and the addition of quadratic trend to mixed trend (Fitted values 2, following equation 2).

Figure 1: Exports of goods and services, fitted values for Bhutan, Sao Tome and Principe, Angola, and Nepal



A quadratic trend is likely to capture the nonlinearity of a deterministic trend. The model might not be the best for all countries, but it is clearly better than the current model used for the EVI calculation by the UN-CDP. So, applying the new model to the computation of the instability of export of goods and services would lead to an improvement in the results of the EVI. For LDCs, we have tentatively calculated the export instability with this new formula for the trend. Table 2 contains several analyses from which important lessons can be drawn.

First, we compare the country ranks with those obtained by using the mixed trend method (for two different time periods). Let us consider "instability 1" the instability obtained from the UN-CDP and "instability 2" the instability obtained from the new formula based on a trend form that includes a quadratic trend. The rank difference is computed as a positive difference between countries that rank relatively better because of a lower score in instability 2 than in instability 1. If we use a 21-year period to calculate the trend and instability (as used in the 2018's CDP review), the countries which have the biggest positive rank changes are Bhutan (+9), Sao Tome and Principe (+6), and Malawi (+5); the biggest negative rank changes are for Lao PDR and Mauritania (-6). The results are more sensitive when the calculation period is 15 years: Sao Tome and Principe, Ethiopia and Guinea-Bissau rise 10, 8 and 7 ranks respectively, while Zambia and Solomon Islands fall 5 ranks, and Rwanda and Guinea 4 ranks. At the bottom of the ranks column, we give the average of the absolute differences of rank between the two measures of instability. This average is lower for the 21 year period than for the 15 year period.

Second, what also matters is the impact of the new formula on countries' instability indices and consequently on their levels of EVI. The results by country and the average value of absolute differences between various measures of instability are thus presented. When we use a 15 year time period, the instability indices (or scores) of all countries fall, except Zambia and Liberia. Timor-Leste is by far the country with the largest decline (-22.7 points), followed by Guinea-Bissau (-4.9points) and Sao Tome and Principe (-4.8 points). Also, when a 21 year time period is used, only the instability scores of Madagascar, Guinea, Myanmar and Togo do not fall. The largest decreases are observed in Sudan (-14.7 points), Timor-Leste (-14.1 points) and Eritrea (-9.5 points).

Third, we highlight the sensitivity of instability to the length of the calculation period. The result shows that the longer the period, the higher the average absolute value of differences between instability 2 and instability 1. As well, for both types of instability, we look closely the impact of the length of the calculation period (15 years versus 21 years) by calculating the average absolute value of differences. It appears that the impact of the period increases when the instability is calculated with the addition of a quadratic trend.

5. Conclusion

Given the importance of the instability of export of goods and services in the EVI, any significant error in scores and ranks may have an impact on the EVI, and in turn on people through resource allocation. That is why special attention should be devoted to measuring the instability of exports of goods and services in the EVI.

The UN-CDP calculates the instability of export of goods and services by estimating the trend of export earnings using a mixed trend linear regression. The standard deviation of the differences between trend and observed values is then taken as a measure of instability. The determination of the appropriate form of trend to calculate instability remains a big challenge. In this note, we show that the calculation of the index of export earnings instability could be improved by estimating an augmented mixed trend. This consists of adding a quadratic trend, which would help to capture nonlinearity in the deterministic trend. As the UN-CDP calculates instability over a long period of time, this method would better capture possible changes in the deterministic trend which are more likely to occur when the time period is longer. This proposal results in significant ranking changes of the index for some countries, as shown in Table 2.

Table 2: Instability of exports of goods and services of LDCs: Current CDP version and revised version for different time periods: 15 and 21 year periods

Country	ISO	15 years [A]				Rank. diff.	Value[A2] - Value[A1]	21 years [B]				Rank. diff.	Value[B2] - Value[B1]	Value[B1] - Value[A1]	Value[B2] - Value[A2]
		Instability1		Instability2				Instability1		Instability2					
		Value [A1]	Rank	Value [A2]	Rank			Value [B1]	Rank	Value [B2]	Rank				
Afghanistan	AFG	19.57	9	17.34	9	0	-2.22	20.86	10	17.10	10	0	-3.76	1.29	-0.24
Angola	AGO	6.29	37	6.00	36	-1	-0.29	12.63	27	12.00	24	-3	-0.63	6.35	6.00
Burundi	BDI	16.51	13	12.23	14	1	-4.29	17.19	11	16.87	11	0	-0.31	0.68	4.65
Benin	BEN	10.40	26	9.57	26	0	-0.83	10.37	35	9.18	35	0	-1.19	-0.03	-0.39
Burkina Faso	BFA	10.00	28	9.27	28	0	-0.73	13.02	23	12.77	21	-2	-0.25	3.02	3.50
Bangladesh	BGD	8.03	33	5.47	39	6	-2.56	7.02	42	6.44	42	0	-0.58	-1.01	0.97
Bhutan	BTN	11.88	22	10.22	21	-1	-1.66	13.53	22	10.66	31	9	-2.88	1.65	0.43
Central African Republic	CAF	10.40	25	9.76	25	0	-0.63	11.41	32	11.21	28	-4	-0.20	1.01	1.44
DR Congo	COD	11.27	24	10.09	22	-2	-1.18	15.44	16	14.96	15	-1	-0.48	4.17	4.87
Comoros	COM	16.86	11	16.84	10	-1	-0.02	15.89	15	15.57	14	-1	-0.32	-0.97	-1.27
Djibouti	DJI	4.57	43	4.57	42	-1	-0.01	5.67	44	5.58	44	0	-0.09	1.10	1.01
Eritrea	ERI	41.13	3	40.73	2	-1	-0.40	46.09	3	36.56	3	0	-9.53	4.96	-4.17
Ethiopia	ETH	11.52	23	8.62	31	8	-2.89	12.69	26	10.70	30	4	-1.99	1.17	2.08
Guinea	GIN	15.51	15	14.90	11	-4	-0.62	14.24	19	14.35	18	-1	+0.10	-1.27	-0.55
Gambia	GMB	57.41	2	56.08	1	-1	-1.33	51.22	2	47.65	2	0	-3.57	-6.19	-8.44
Guinea-Bissau	GNB	16.72	12	11.79	19	7	-4.93	22.61	9	20.03	9	0	-2.58	5.89	8.24
Equatorial Guinea	GNQ	8.84	31	7.19	33	2	-1.65	13.01	24	11.34	26	2	-1.67	4.17	4.15
Haiti	HTI	5.58	41	5.02	41	0	-0.56	6.12	43	5.97	43	0	-0.15	0.54	0.95
Cambodia	KHM	6.03	39	5.62	37	-2	-0.41	10.37	36	7.24	40	4	-3.13	4.34	1.62
Kiribati	KIR	11.98	20	11.84	18	-2	-0.14	16.76	13	16.67	12	-1	-0.09	4.78	4.83
Lao PDR	LAO	9.75	30	9.10	29	-1	-0.65	12.53	28	12.47	22	-6	-0.07	2.78	3.36
Liberia	LBR	34.27	5	35.04	5	0	+0.76	32.11	6	31.54	4	-2	-0.57	-2.17	-3.49
Lesotho	LSO	6.14	38	6.13	35	-3	-0.01	10.84	33	10.12	33	0	-0.71	4.70	3.99
Madagascar	MDG	15.52	14	14.43	13	-1	-1.10	14.61	17	14.80	16	-1	+0.19	-0.92	0.37
Mali	MLI	8.69	32	8.69	30	-2	-0.00	10.79	34	10.62	32	-2	-0.17	2.10	1.92

Country	ISO	15 years [A]				Rank. diff.	Value[A2] - Value[A1]	21 years [B]				Rank. diff.	Value[B2] - Value[B1]	Value[B1] - Value[A1]	Value[B2] - Value[A2]
		Instability1		Instability2				Instability1		Instability2					
		Value [A1]	Rank	Value [A2]	Rank			Value [B1]	Rank	Value [B2]	Rank				
Myanmar	MMR	13.03	19	11.97	17	-2	-1.07	13.81	20	13.81	20	0	+0.01	0.77	1.85
Mozambique	MOZ	4.82	42	3.61	43	1	-1.21	9.91	37	8.63	37	0	-1.28	5.09	5.02
Mauritania	MRT	13.37	18	12.10	15	-3	-1.27	12.34	29	12.25	23	-6	-0.09	-1.03	0.15
Malawi	MWI	18.25	10	14.73	12	2	-3.52	17.06	12	14.38	17	5	-2.68	-1.19	-0.35
Niger	NER	7.91	34	5.31	40	6	-2.60	8.81	38	8.75	36	-2	-0.05	0.90	3.44
Nepal	NPL	7.32	36	7.05	34	-2	-0.27	11.44	31	10.07	34	3	-1.37	4.12	3.02
Rwanda	RWA	10.20	27	9.90	23	-4	-0.31	11.50	30	11.00	29	-1	-0.49	1.29	1.10
Sudan	SDN	24.08	8	23.92	8	0	-0.16	40.73	4	25.98	7	3	-14.75	16.65	2.06
Senegal	SEN	3.04	45	2.33	45	0	-0.71	4.04	45	3.71	45	0	-0.33	1.00	1.38
Solomon Islands	SLB	9.90	29	9.79	24	-5	-0.10	14.52	18	13.94	19	1	-0.58	4.62	4.14
Sierra Leone	SLE	35.24	4	35.08	4	0	-0.16	30.28	8	30.14	5	-3	-0.14	-4.96	-4.94
Somalia	SOM	1.31	46	1.12	46	0	-0.19	2.04	46	1.88	46	0	-0.16	0.73	0.75
Sao Tome and Principe	STP	14.26	17	9.45	27	10	-4.80	13.78	21	11.28	27	6	-2.51	-0.47	1.82
Chad	TCD	27.02	7	25.84	7	0	-1.18	30.35	7	25.83	8	1	-4.53	3.33	-0.02
Togo	TGO	7.49	35	7.47	32	-3	-0.02	7.93	39	7.93	38	-1	0.00	0.44	0.46
Timor-Leste	TLS	61.04	1	38.36	3	2	-22.68	74.33	1	60.26	1	0	-14.07	13.29	21.90
Tanzania	TZA	5.70	40	5.51	38	-2	-0.19	7.46	40	6.68	41	1	-0.78	1.76	1.17
Uganda	UGA	15.47	16	10.94	20	4	-4.53	16.54	14	16.32	13	-1	-0.22	1.07	5.38
Vanuatu	VUT	4.55	44	3.41	44	0	-1.13	7.42	41	7.41	39	-2	-0.01	2.87	4.00
Yemen	YEM	31.00	6	29.11	6	0	-1.89	32.14	5	29.43	6	1	-2.71	1.15	0.33
Zambia	ZMB	11.96	21	11.98	16	-5	+0.02	12.81	25	11.71	25	0	-1.10	0.84	-0.28
Average absolute value of the instability measures and their differences		15.26		13.60		2.13	1.69	17.31		15.52		1.73	1.81	2.93	2.97

Note: Instability 1 is the instability calculated by the UN-CDP method (deterministic trend and a stochastic modelled with a one year lag variable as defined from Equation 1). Instability 2 is the instability calculated by the augmented mixed trend (a regression on the trend, quadratic trend and one year lag variable as defined from Equation 2).

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