ARE SMALL ISLAND DEVELOPING STATES MORE ECONOMICALLY VULNERABLE THAN OTHERS?

An empirical approach using composite indicator and data envelopment analysis

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ABSTRACT:

This paper proposes to determine a robust measure of economic vulnerability for developing economies. We focus particularly on small island developing states which are known to be highly vulnerable compared to other developing groups. We exploit the Economic Vulnerable Index [EVI] developed by the United Nations Committee for Development Policy [UNCDP], but we adopt an endogenous weighting system rather than the more common *ad hoc* weights system traditionally retained. So, following the methodological framework of "Data Envelopment Analysis", we apply the recent additive linear programming approach of Hatefi and Torabi (2011) to UNCDP's EVI for the year 2009. Then implementing this later to the set of developing countries including 34 small island states gives a mixed support to the conventional finding: Small island developing economies are obviously prone to high economic vulnerability, but the magnitude of this vulnerability seems to reduce significantly with our simulations.

Keywords: Economic vulnerability, Data Envelopment Analysis, Developing countries, Insularity.

JEL classification: O11, O13, O57

1. INTRODUCTION

"Although they are afflicted by economic difficulties and confronted by development imperatives similar to those of developing countries generally, small island developing States [SIDS] also have their peculiar vulnerabilities and characteristics, so that the difficulties they face in the pursuit of sustainable development are particularly severe and complex." This declaration of the United Nations Global Conference on the Sustainable Development of SIDS, adopting the 1994 Barbados' SIDS Programme of Action, is an historical event for the insular world[1]. A consensual view was adopted by the international community about the specific development problems the SIDS must face and so the need for a special treatment for these economies[2].

Following these Barbados Conference conclusions, the United Nations General Assembly recommended to "continue work on the development of vulnerability indices and other indicators that reflect the status of SIDS and integrate ecological fragility and economic vulnerability". Then, since thirteen years, many works have tried to build economic vulnerability indicators which directly focus on integrating the features of SIDS (Briguglio, 1995, 2004; Atkins *et al.*, 2001; Crowards, 1999; Encontre, 1999; UN, 2000, 2005; Briguglio and Galea, 2004; Guillaumont, 2004a, 2009a, 2010). While these later retained different variables and are based on different methodological frameworks, a common finding was put forward: as a group SIDS are more economically vulnerable than other groups of developing countries.

Among all the existing formulations of the vulnerability index, that of the United Nations Committee for Development Policy [UNCDP] appears to be the most suitable to analyze the special case of SIDS, and particularly the least developed of them (UN, 1999; Guillaumont, 2004b, 2009a). Indeed, this approach shows that, in considering economic vulnerability that is the risk for a country to experience a marked reduction in long-term average growth rates due to exogenous and generally unforeseen events[3], an important distinction should be made between structural vulnerability and the vulnerability resulting from bad economic policy choices[4]. Contrary to policy induced vulnerability, the structural one arises from environmental and economic factors that are independent of a country's current political will. So structural vulnerability can be seen as the result of two elements: (i) the size and frequency of the exogenous shocks (observed or anticipated) and (ii) exposure to shocks. The first block, which gives growth volatility due to exogenous shocks, has three sub-indices: (i) a "homeless" index proxied by the percentage of population displaced due to natural disasters, (ii) an index of agricultural production instability measured as the gap relative to its trend, and (iii) an indicator for instability of exports of goods and services as a gap relative to their trends. The second block, which measures the importance of structural exposure to external shocks, consists of four elements: (i) the population size, (ii) an export concentration coefficient, (iii) remoteness from major world markets, and (iv) the share of agriculture, including fisheries and forestry in GDP.

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[1] More precisely, numerous international conferences have highlighted the importance of developing strategies and actions to promote sustainable development for SIDS (the 1992 Rio Earth Summit, the 1994 conference in Barbados, the 2002 Johannesburg World Summit of Sustainable Development, the 2005 Mauritius conference).

[2] Therein, several barriers to development, particularly pronounced for those entities, have been identified: (i) geographical features (small size, remoteness, isolation, exposure to major hazards, fragile ecosystems, etc..), (ii) history (external dependence, close political links to former colonial powers, etc.), (iii) social situation (low intensity and volatility of human capital, labor market instability, insecurity, etc.), and (iv) economic structure (diseconomies of scale, limited local markets, lack of diversification activities, cost of access to external resources, prevalence of natural monopolies and oligopolistic structures, etc.).

[3] More obviously, economic vulnerability includes three determinants, namely the size and likelihood of shocks, exposure to the shocks and resilience to the shocks (the capacity for reacting to them) (Guillaumont, 2009a).

[4] The UNCDP indicator stands out from others in the extent that it focuses directly on structural vulnerability.

Then, when trying to identify the economies which need to retain the attention of the international community, this notion should be preferred. However despite of many advantages in terms of simplicity, transparency and adaptability, the UNCDP approach has been largely criticized. In particular, alongside the traditional problem of including other variables to better characterize the economic vulnerability phenomenon, two main methodological shortcomings are highlighted (Guillaumont, 2009a). First, the arithmetic average procedure retained to aggregate the different components into the overall index does not allow us to take into account the fact that structural vulnerability depends on the interaction of shocks and exposure. Indeed, its determinants must be considered as partly but not perfectly substitutable in their interactive impact on growth[5]. Second, the weighting scheme adopted is largely ad hoc and depends on the value judgments of the CDP experts. On the whole, equal weight is given to the sum of shock indices and the sum of exposures indices. In the shock indices, equal weight is given to natural and external shocks, while in the exposure indices equal weight is given to the population size and to the total of other indices. To avoid the possible arbitrariness of equal weighting, several authors (Atkins et al., 1998; Easter, 1998; Guillaumont and Chauvet, 2001) showed that the weighting system could be derived from their estimated impact on a relevant variable, such as the growth rate or volatility in growth rates. Nevertheless, as said by Guillaumont (2009a), the econometric measurement of structural vulnerability depends dramatically on the quality of the regressions and seems more appropriate for academic use than for international policy. Then our present work aims at giving a convenient answer to this second set of critics.

Therefore, the goal of this article is to propose a transparent and robust solution to the weighting system determination. Our main contribution is to give a least contestable approach to determine the weighting system from which the economic vulnerability index is calculated. More precisely, we simulate an EVI based on an endogenous weighting scheme obtained from the "Data Envelopment Analysis" [DEA] method (Charnes et al., 1978). Several empirical studies have applied this approach to determine composite indicators (see OECD, 2008 for a survey). Among the methods based on DEA, some authors have proposed an approach generating a common set of weights for all DMU (Despostis, 2005a, 2005b; Zhou et al., 2010; Hatefi and Torabi, 2010; among others). Their purpose was to face up to the criticism of the maximum flexibility in selecting the weights of the original DEA. Moreover, this is the first time at our knowledge that the DEA approach is used in the economic vulnerability framework. More precisely, we propose to implement the recent additive linear programming approach of Hatefi and Torabi (2010) to UNCDP's EVI in order to generate a set of common weights and thus derive a more robust measure of EVI. Thereafter, this one is performed on a large set of 130 developing countries including a panel of 34 Small Island Economies [SIE] for the year 2009. It will be especially interesting to see if the introduction of the endogenous weights system significantly changes the international rankings resulting from the standard equal weighting one.

The rest of the article is organized as follows. Section 2 describes the methodological design of the EVI built from the DEA procedure developed by Hatefi and Torabi (2010). Section 3 gives the simulated results for the whole sample of developing countries with a special focus on the group of insular economies. Finally, Section 4 reports the concluding remarks.

[5] Guillaumont (2009b) proposes two other methods of averaging to overcome this limit, namely (i) a geometric averaging of the two composite shock and exposure indices combined with an arithmetic averaging of the respective components of these shock and exposure indices, and (ii) an arithmetic average of the indices of the log values of both the shock and exposure indices.

2. THE DEA-LIKE APPROACH WITH COMMON WEIGHTS OF HATEFI AND TORABI (2010)

First of all, assume that we have information for *m* countries about *n* sub-indicators which allows the calculation of a CI. Let I_{ij} denote the value of country *i* with respect to sub-indicator j. Let also w_{ij} be the weight associated to sub-indicator *j* for the country *i*. We seek to aggregate $I_{ij}\left(j=1,2,\ldots,n\right)$ into a CI for country as follows:

$$\mathrm{CI}_i = \sum_{j=1}^{n} w_{ij} I_{ij}, \quad i=1,2,\ldots,m \tag{1}$$

At this level, the topic is on the determination of the weights (w_{ij}) required to construct the composite indicator. In the literature, several approaches exist to determine the weights (see OECD (2008) for a survey). Among these, we find the methodology derived to Data Envelopment Analysis (DEA) initially proposed by Charnes et al. (1978) and known as the "benefit of the doubt" in the field of composite indicators. DEA is a method of evaluation relative efficiency of units with multiple inputs and outputs using mathematical programming. It focuses on each unit to select the weights assigned to the inputs and outputs. These weights correspond to the most favorable and are specific for each unit.

In DEA literature, we find several adaptations of this methodology used to generate common set of weights (Roll et al., 1991; Li and Reeves, 1999; Kao and Hung, 2005; Karsak and Ahiska 2005, 2007; Hatefi and Torabi, 2010, among others). Beyond the advantage of DEA which is to avoid the arbitrary attribution of weight, the common weight method allows a fair assessment since all entities share the same set of weights. In nutshell, all entities are compared on one only scale. In this paper, we propose to exploit the recent approach of Hatefi and Torabi (2010) that is herself derived from Karsak and Ahiska (2005, 2007).

To understand the Hatefi and Torabi (2010) model, we start from the following DEA formulation which computed the efficiency (or value of CI) for the decision making unit (DMU) *o*:

$$\begin{aligned}
&\max_{w}\ E_o = \sum_{j=1}^{n} w_{oj} I_{oj} \\
&\text{subject to:} \\
&\sum_{j=1}^{n} w_{oj} I_{ij} \le 1 \qquad i=1,2,\ldots,m \\
&w_{oj} \ge \varepsilon, \qquad i=1,2,\ldots,m,\ j=1,2,\ldots,n
\end{aligned} \tag{2}$$

where E_o is the efficiency of the evaluated DMU *o*, w_{oj} is the weight assigned to sub-indicator *j* for evaluated DMU *o*. I_{ij} is the value of sub-indicator *j* of DMU *i*. In order to assure that none of the weights will take a zero value, we introduce the constraint $w_j \ge \varepsilon$ with ε a non-Archimedian small number (here, 0.00001). $E_o \in [0,1]$. If $E_o = 1$, then the entity is deemed efficient.

For each entity *o*, this model (2) seeks the best set of weights which are used to aggregate the sub-indicators into a performance score. In essence, model (2) is an output maximizing multiplier DEA model with multiple outputs and constant inputs (Charnes et al. 1978) in which the sub-indicators represent the different outputs and a single dummy input with value unity is assigned to each country.

Next, consider d_o as the deviation of the entity *o* (E_o) from the ideal efficiency equal to unity (i.e. $d_o = 1 - E_o$). Maximize E_o is equivalent to minimize d_o. Consequently, from the model (2), we can deduce the maximization model (3) which can also be solved *m* times in order to provide a set of best weights for each entity.

$$\begin{aligned}
&\min_{d,w} \; d_o \\
&\text{subject to:} \\
&\sum_{j=1}^{n} w_{oj} I_{ij} + d_i = 1 \qquad i = 1,2,\ldots,m \\
&w_{oj} \geq 0, d_i \geq 0, \qquad i = 1,2,\ldots,m, \; j = 1,2,\ldots,n
\end{aligned} \tag{3}$$

The model (3) is solved for each unit, so different weights are obtained. Thus, this program does not permit to deal with the problem of different systems of weights and the weak discrimination power of DEA in which each entity is evaluated by using different weight systems. Thus, Hatefi and Torabi (2010) proposed to reformulate this program as a new multi-criteria decision making (MCDM) model using a set of common weights which maximize the efficiency scores of all entities. They used *minimax* approach consisting on minimizing the maximum deviation among all entities (M). The program is written as follows:

$$\begin{aligned}
&\min_{M,d,w} \; M \\
&\text{subject to:} \\
&M - d_i \geq 0, \; \forall i \\
&\sum_{j=1}^{n} w_j I'_{ij} + d_i \leq 1 \qquad i = 1,2,\ldots,m \\
&w_j \geq \varepsilon, d_i \geq 0, \qquad i = 1,2,\ldots,m, \; j = 1,2,\ldots,n
\end{aligned} \tag{4}$$

where w_j is the weights of each sub-indicator *j* shared by all countries. ε is a small positive scalar considered as a lower bound of the weights.. The constraint $M - d_i \geq 0, \forall i$ assures that $M = \max\{d_i = 1,2,\ldots,m\}$. By using the model (4), we can compute the composite indicator of country i i.e. $\text{CI} = 1 - d_i$. In this model, all entities are evaluated with the same set of weights. As noted by Karsak and Ahiska (2005), minimax efficiency measure has a higher discriminating power than the classical efficiency measure, since it considers the favour of all DMUs simultaneously. Thus, this method restricts the freedom of a particular DMU to choose the factor weights in its own favour.

When model (4) results in more than one efficient DMU, and thus, does not enable the determination of the best DMU, the use of the following common weight multi-criteria decision making (MCDM) model is proposed by Karsack and Ahiska (2005, 2007) :

$$
\begin{aligned}
&\min_{M,d,w} M - K\sum_{e\in EF} d_e \\
&\text{subject to:} \\
&M - d_i \geq 0,\ \forall i \\
&M - \sum_{i\in EF} d_i \geq 0, \\
&\sum_{j=1}^{n} w_j I'_{ij} + d_i \leq 1 \qquad i = 1,2,\ldots,m \\
&w_j \geq \varepsilon, d_i \geq 0, \qquad i = 1,2,\ldots,m,\ j = 1,2,\ldots,n
\end{aligned}
\tag{5}
$$

where *EF* is the minimax efficient DMUs that are determined using model (4) and $K \in [0,1]$ is a discriminating parameter. The solutions obtained in the formulation (5) minimize the maximum deviation from efficiency while simultaneously maximizing the sum of the deviations from the efficiency of minimax efficient DMUs. It allows us to obtain the best entity with CI value of 1 by augmenting the value of *K*. In the next section, models (4) and (5) are applied to construct EVI.

3. RESULTS AND COMMENTS

Our study focuses on the EVI dataset built by the UNCDP for the year 2009 including 130 developing countries[6]. Note that we have normalized the standard EVI (m-score) to ensure the comparability with our EVI resulting from the DEA-like models. So a value of 0 is assigned to the less vulnerable country and a value between 0 and 100 to all relatively more vulnerable countries. Then in order to cope with the arbitrary determination of the weighting scheme we compare this latter with our own EVI calculated from a DEA-like model in the spirit of Hatefi and Torabi (2010). More precisely, two DEA-like models are simulated, one with a *K*=0 (model 1) and one other with *K*=0.19 (model 2). Furthermore, several groups of countries were identified to isolate possible characteristics of insular countries in the field of economic vulnerability[7] (see details in appendix A.1.).

The required data and the calculated EVI values for all developing countries are showed in Table 1. On the whole, several interesting findings must be exposed.

Firstly, we observe that the new method presents a good discrimination performance. The step by step determination of the parameter *K* enables to reduce the number of efficient countries to one. Thus, the model 2 put forward only one best performer, namely Israel.

[6] Data are available at the following address: http://webapps01.un.org/cdp/dataquery/selectCountries.action.

[7] This study considers only the countries whose dataset was available.

Table 1. The EVI and the simulated results for the 130 developing economies, year 2009

Countries	Standard EVI		Model 1			Model 2			Countries	Standard EVI		Model 1			Model 2		
	m-score	Rank	Score	Rank	Var.	Score	Rank	Var.		m-score	Rank	Score	Rank	Var.	Score	Rank	Var.
Afghanistan	28.580	53	28.628	69	-16	31.602	72	-19	**Liberia**	59.211	127	53.184	125	2	53.937	124	3
Algeria	21.174	36	28.093	67	-31	28.635	66	-30	**Libyan Arab Jam.**	20.540	35	23.227	46	-11	20.266	36	-1
Angola	40.686	89	43.974	115	-26	41.642	106	-17	**Madagascar**	25.803	44	17.508	33	11	21.541	40	4
A&B	42.162	94	33.091	85	9	35.355	89	5	**Malawi**	47.898	109	53.184	125	-16	53.937	124	-15
Argentina	17.513	26	8.301	!20	6	10.883	21	5	**Malaysia**	12.055	18	6.490	15	3	9.142	17	1
Bahamas	43.841	98	34.682	88	10	35.628	90	8	**Maldives**	50.620	118	53.184	125	-7	53.937	124	-6
Bahrain	26.801	49	29.050	72	-23	26.350	56	-7	**Mali**	31.886	59	42.860	110	-51	44.086	112	-53
Bangladesh	9.321	15	17.347	31	-16	20.291	37	-22	**Mauritania**	37.566	79	37.968	97	-18	39.305	98	-19
Barbados	35.785	75	23.656	47	28	26.131	54	21	**Mauritius**	36.183	77	25.853	56	21	27.228	60	17
Belize	34.897	72	20.123	40	32	19.543	32	40	**Mexico**	4.305	5	0.822	3	2	3.811	2	3
Benin	32.103	61	34.813	89	-28	36.857	94	-33	**Mongolia**	44.188	99	33.820	86	13	32.867	83	16
Bhutan	44.420	103	30.570	78	25	32.077	79	24	**Morocco**	8.028	11	13.145	26	-15	14.992	24	-13
Bolivia	32.570	65	26.391	59	6	27.897	64	1	**Mozambique**	39.403	84	42.541	108	-24	43.870	110	-26
Botswana	49.602	116	46.600	118	-2	46.043	116	0	**Myanmar**	26.066	45	25.712	54	-9	28.429	65	-20
Brazil	6.666	8	1.791	5	3	4.633	6	2	**Namibia**	28.923	55	25.801	55	0	24.969	51	4
Brunei Darussalam	39.648	85	39.970	103	-18	36.800	93	-8	**Nepal**	21.648	37	12.653	24	13	16.815	26	11
Burkina Faso	33.646	67	37.432	95	-28	38.764	95	-28	**Nicaragua**	32.980	66	19.257	39	27	21.385	39	27
Burundi	48.998	114	42.870	111	3	44.044	111	3	**Niger**	36.038	76	42.210	107	-31	44.825	113	-37
Cambodia	47.609	108	32.198	82	26	34.293	87	21	**Nigeria**	32.005	60	36.331	91	-31	36.272	91	-31
Cameroon	18.861	28	18.852	38	-10	19.944	34	-6	**Oman**	27.232	50	27.708	63	-13	24.815	50	0
Cape Verde	38.662	81	37.739	96	-15	39.161	97	-16	**Pakistan**	8.190	12	10.543	23	-11	14.851	23	-11
Cent. African Rep.	35.125	74	37.383	94	-20	41.418	104	-30	**Panama**	23.449	39	15.486	28	11	17.563	29	10
Chad	45.127	104	51.672	123	-19	50.809	122	-18	**Papua New Guinea**	34.547	71	28.817	70	1	32.432	81	-10
Chile	20.327	34	18.337	36	-2	19.900	33	1	**Paraguay**	40.483	88	25.223	51	37	26.864	59	29
China	8.964	13	3.956	8	5	8.176	14	-1	**Peru**	20.032	31	17.495	32	-1	20.189	35	-4
Colombia	6.553	7	5.022	11	-4	8.690	16	-9	**Philippines**	13.057	21	16.440	29	-8	19.395	31	-10
Comoros	49.148	115	31.935	81	34	33.927	86	29	**Qatar**	32.168	62	27.156	61	1	24.815	49	13
Congo	38.931	82	39.683	102	-20	39.323	99	-17	**Rep. of Korea**	7.669	10	4.963	10	0	7.603	11	-1
Costa Rica	24.523	41	14.221	27	14	17.220	27	14	**Rwanda**	46.918	106	50.293	122	-16	50.654	121	-15
Côte d'Ivoire	19.092	29	17.786	35	-6	33.250	84	-55	**SK&N**	48.613	112	47.433	120	-8	47.164	119	-7
Cuba	31.471	57	32.205	83	-26	20.589	38	19	**Saint Lucia**	41.889	93	29.475	75	18	30.638	71	22

DPRK	41.178	91	26.257	58	33	29.485	68	23	**SV&G**	37.193	78	27.233	62	16	26.399	57	21
DRC	40.091	86	28.346	68	18	30.462	70	16	**Samoa**	57.828	125	52.672	124	1	53.937	124	1
Djibouti	42.369	95	21.671	43	52	24.241	46	49	**ST&P**	46.825	105	42.970	112	-7	41.448	105	0
Dominica	48.272	110	36.259	90	20	39.344	100	10	**Saudi Arabia**	17.431	25	26.048	57	-32	23.033	43	-18
Dominican Rep.	30.414	56	13.120	25	31	15.658	25	31	**Senegal**	26.288	48	30.504	77	-29	32.408	80	-32
Ecuador	26.160	47	27.811	65	-18	28.729	67	-20	**Seychelles**	44.385	102	40.526	105	-3	40.283	102	0
Egypt	6.694	9	6.817	16	-7	8.617	15	-6	**Sierra Leone**	41.742	92	39.430	100	-8	41.666	107	-15
El Salvador	20.252	33	6.320	14	19	8.147	13	20	**Singapore**	25.070	43	28.058	66	-23	26.470	58	-15
Equatorial Guinea	53.401	122	38.067	98	24	34.926	88	34	**Solomon Islands**	50.385	117	50.028	121	-4	51.152	123	-6
Eritrea	47.400	107	32.573	84	23	33.831	85	22	**Somalia**	55.875	124	43.313	113	11	46.844	118	6
Ethiopia	19.747	30	24.678	50	-20	27.470	63	-33	**South Africa**	9.934	16	7.411	18	-2	9.210	18	-2
Fiji	38.656	80	28.951	71	9	31.653	75	5	**Sri Lanka**	20.209	32	17.508	34	-2	21.557	41	-9
Gabon	27.499	51	26.578	60	-9	23.938	45	6	**Sudan**	44.336	101	46.273	117	-16	45.990	115	-14
Gambia	48.357	111	53.184	125	-14	53.937	124	-13	**Suriname**	52.648	120	30.130	76	44	27.359	62	58
Ghana	34.407	70	29.104	73	-3	31.861	77	-7	**Swaziland**	39.151	83	25.554	53	30	25.588	53	30
Grenada	32.535	64	9.246	22	42	9.431	19	45	**Syrian Arab Rep.**	12.335	20	7.307	17	3	7.455	10	10
Guatemala	16.399	24	4.122	9	15	6.048	7	17	**Thailand**	6.197	6	1.185	4	2	4.579	5	1
Guinea	14.859	23	18.447	37	-14	18.162	30	-7	**Timor-Leste**	48.870	113	25.427	52	61	27.237	61	52
Guinea-Bissau	53.392	121	44.110	116	5	45.131	114	7	**Togo**	32.447	63	27.738	64	-1	31.649	74	-11
Guyana	40.234	87	29.370	74	13	32.811	82	5	**Tonga**	63.450	128	47.303	119	9	49.388	120	8
Haiti	43.537	97	39.102	99	-2	40.002	101	-4	**T&T**	28.863	54	22.884	45	9	22.477	42	12
Honduras	26.068	46	20.583	41	5	23.100	44	2	**Tunisia**	11.345	17	17.316	30	-13	17.274	28	-11
India	2.632	3	3.236	7	-4	7.269	9	-6	**Turkey**	0.000	1	0.000	1	0	4.096	4	-3
Indonesia	9.072	14	6.118	13	1	9.457	20	-6	**Tuvalu**	76.021	130	53.184	125	5	53.937	124	6
Iran	33.737	69	31.498	80	-11	30.444	69	0	**Uganda**	43.209	96	23.741	48	48	26.203	55	41
Iraq	33.724	68	36.549	92	-24	32.041	78	-10	**Unit. Arab Emir.**	28.095	52	34.169	87	-35	31.767	76	-24
Israel	1.975	2	0.000	1	1	0.000	1	1	**Tanzania**	18.547	27	21.227	42	-15	24.498	47	-20
Jamaica	22.772	38	24.481	49	-11	24.984	52	-14	**Uruguay**	31.808	58	22.762	44	14	24.781	48	10
Jordan	12.280	19	7.681	19	0	7.775	12	7	**Vanuatu**	55.481	123	53.184	125	-2	53.937	124	-1
Kenya	3.630	4	2.036	6	-2	3.954	3	1	**Venezuela**	24.762	42	37.290	93	-51	36.327	92	-50
Kiribati	70.779	129	41.481	106	23	42.110	108	21	**Viet Nam**	13.214	22	8.413	21	1	12.148	22	0
LPDR	52.634	119	42.678	109	10	46.790	117	2	**Yemen**	34.936	73	39.572	101	-28	38.866	96	-23
Lebanon	24.119	40	5.164	12	28	7.138	8	32	**Zambia**	44.250	100	43.901	114	-14	42.831	109	-9
Lesotho	40.881	90	31.226	79	11	31.638	73	17	**Zimbabwe**	57.865	126	40.501	104	22	40.753	103	23

Note: (*) Var. gives the rank gap between the standard EVI and the simulated EVI resulting from Model 1 and 2. **Source:** Authors' calculations.

Secondly, in accordance to Table 2, the Spearman's rank correlation coefficient relative to the standard EVI resulting from the two models are 0.8552 and 0.8534, so giving some robustness to our analysis. Moreover, the P-value of this test is zero, then the null hypothesis is rejected at $\alpha = 0.001$. However this strong correlation should not obscure the presence of large rank variations (see Table 1). Indeed many countries are associated with very important gains or losses (≥±30): Algeria (-30), Belize (+40), Benin (-33), Cent. African Rep. (-30), Côte d'Ivoire (-55), Mali (-53), Niger (-37), Nigeria (-31), Djibouti (+49), Dominican Rep. (+31), Equatorial Guinea (+34), Ethiopia (-33), Grenada (+45), Lebanon (+32), Senegal (-32), Suriname (+58), Swaziland (+30), Timor-Leste (+52), Uganda (+41) and Venezuela (-50). Table 2 also states the correlation between each EVI and the seven sub-indicators. One major difference appears. The standard EVI is more correlated with population and export instability although our new composite indicator (both models 1 and 2) is more correlated with the export concentration coefficient and export instability. Note that this structural effect should benefit to small entities.

Table 2. The spearman's rank correlation test

	Dimensions	EVI Model 1	EVI Model 2	EVI Standard
Dimensions	Population	0.4697	0.4372	0.6506
	Remoteness	0.2603	0.3040	0.3802
	Export concentration coefficient	0.7453	0.6777	0.4881
	Shares of agriculture, forestry and fisheries	0.2539	0.3534	0.2404
	Percentage of homeless	0.2080	0.2971	0.2073
	Agricultural instability	0.4704	0.4206	0.3854
	Export instability	0.5522	0.5234	0.6571
EVI	Model 1	1.0000		
	Model 2	0.9757	1.0000	
	Standard	0.8552	0.8534	1.0000

Source: Authors' calculations.

Table 3. The simulated and traditional weighting schemes for EVI

Dimensions	EVI Model 1	EVI Model 2	EVI Standard
Population	0.0968	0.1000	0.2500
Remoteness	0.0907	0.0853	0.1250
Export concentration	0.2691	0.2394	0.0625
Shares of agriculture, forestry and fisheries	0.1003	0.1256	0.0625
Percentage of homeless	0.1459	0.1776	0.1250
Agricultural instability	0.2402	0.2289	0.1250
Export instability	0.0569	0.0432	0.2500

Source: Authors' calculations.

Thirdly, according to Table 3, the DEA simulations lead to two endogenous weighting schemes highly different from that given by the standard EVI. Especially, the population and

export instability components have relatively low weights although the export concentration coefficient and the share of agriculture in GDP have relatively high weights. This is not the case with the UNCDP approach which adopts a more homogenous weighting structure.
Lastly, the analysis by developing groupings partially supports the traditional wisdom given by the standard EVI. Indeed, Table 4 indicates that the insular economies (SIE and SIDS) and LDC groups are much more vulnerable than the other groups (ALL, NIE and LIC). However, contrary to the standard EVI, the simulated ones state that insular economies are slightly less vulnerable that the LDC group. This surprising result comes from the modification of the weight structure presented above which attributes a lower importance to the population and remoteness dimensions in the determination of the overall index. Table 3 clearly puts forward that the population and the remoteness dimensions, which are well established strong handicaps for small islands, together represent 18.75% of the global index with our methodology against 37.5% with the UNCDP approach. So, the new weighting structure is obviously more advantageous for small island countries. Nevertheless these latter still remain significantly economically fragile. Note especially the fact that insular economies groups have EVI scores higher than the LIC group whatever the methodology adopted. Otherwise, the simulated EVI scores of the SIDS group are very close to those of the LDC group, approving the fact that insularity is a factor increasing economic vulnerability.

Table 4. The EVI score for different groups of developing countries

	EVI		
Groups (average)	**Model 1**	**Model 2**	**Standard**
Developing countries	27.4368	28.6354	32.1042
Small Island Economies	34.3225	34.8009	43.5949
Small Island Developing States	36.0678	37.1727	45.7505
Least Developed Countries	37.2190	38.6579	41.8572
Non Insular Economies	24.9982	26.4518	28.0346
Low Income Countries	31.4320	33.3726	34.6654

Source: Authors' calculations.

4. CONCLUSION

In this paper, we propose to exploit the last development proposed in the DEA literature in order to construct a robust composite indicator of economic vulnerability for developing countries. The main concern was on the determination of weights used to aggregate the seven sub-indicators compounding the economic vulnerability. More precisely, our contribution was to substitute the *ad hoc* weighting system adopted by the UNCDP by a less arbitrary endogenous one. To this regard, we follow the recent model of Hatefi and Torabi (2010) generating a set of common weights shared by all countries. Then, the revised indicator results in significant changes concerning the group of small island countries even if the whole sample ranking is highly correlated to the ranking based on the standard EVI. These economies still remains fragile compared to the other developing countries groupings but the magnitude of the economic vulnerability has decreased. Our simulation stated especially that insular economies are now more vulnerable than LDCs. This finding can be explained by a structural effect concerning the design of the common weights system. In contrast with the standard EVI, our robust indicator attaches less importance to the more handicapping factors the insular economies must face that is population and remoteness.

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APPENDIX

A.1. Description of the various groups of developing countries

The different groupings have been built to show if small island countries reveal strong handicaps in terms of economic vulnerability compared to others developing economies :

- Group 1: all developing countries.

- Group 2: the SIDS according to the United Nations Conference on Trade and Development [UNCTAD] classification, namely Antigua and Barbuda [A&B], Bahamas, Barbados, Cape Verde, Comoros, Dominica, Fiji, Grenada, Kiribati, Mauritius, Maldives, Solomon Islands, Jamaica, Papua New Guinea, Saint Kitts & Nevis [SK&N], Saint Vincent & the Grenadines [SV&G], Saint Lucia, Sao Tome & Principe [ST&P], Samoa, Seychelles, Timor-Leste, Trinidad & Tobago [T&T], Tonga, Tuvalu and Vanuatu.

- Group 3: the SIE according to the classification of United Nations[8], namely the countries of Group 2 plus Belize, Bahrain, Cuba, Guinea-Bissau, Guyana, Haiti, Dominican Republic, Singapore and Suriname.

- Group 4: the non insular developing countries [NIE]: the group of all developing countries except from the members of the SIE group.

- Group 5: the LDC according to the UNCTAD classification, namely Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Congo, Democratic Republic of the Congo [DRC], Djibouti, Equatorial Guinea, Eritrea,

[8] Note that Micronesia, Marshall Islands and Palau also belong to the list of SIE established by the United Nations. However, we did not include them due to the lack of data.

Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Lao People's Democratic Republic [LPDR], Lesotho, Madagascar, Malawi, Maldives, Mali, Mauritania, Mozambique, Myanmar, Niger, Papua New Guinea (eligible), Rwanda, Samoa, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Sudan, Timor-Leste, Togo, Tuvalu, Uganda, Vanuatu, Yemen, Zambia and Zimbabwe (eligible).

- Group 6: the Low Income Countries [LIC] according to the World Bank classification, namely the Group 5 except from Samoa, Timor-Leste, Tuvalu and Vanuatu and plus Afghanistan, Cameroon, China, Côte d'Ivoire, Democratic People's Republic of Korea [DPRK], Egypt, Ghana, Honduras, India, Indonesia, Kenya, Liberia, Mongolia, Nepal, Nicaragua, Nigeria, Pakistan, Somalia, Sri Lanka, United Republic of Tanzania, Vietnam.