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A MACROECONOMIC VULNERABILITY INDEX FOR DEVELOPING COUNTRIES

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Introduction

Literature on economic development has advanced to the stage where it is clear that we cannot successfully deal with poverty unless we also deal with vulnerability. Moreover, the emerging consensus in international policy circles is that building resilience is a necessary and effective pathway for sustaining development progress. Recent evidence indicates that financial and economic shocks are not a rare occurrence but are increasingly becoming a systemic feature of the global economy. The increased frequency of such crises is now the 'new norm' that the international development agenda will need to adapt to.

Economists were not totally far from the concept of vulnerability, when they started to talk about vulnerability. The word 'vulnerability' was not widely used, but debates on price instability and risk, for instance, go back to 70s – and even more. In the last 10-15 year, a renewed, broad, concept of vulnerability has appeared high again on the international agenda. The 'new' concept of vulnerability comes from natural and engineering sciences. It refers to the vulnerability of eco-systems, buildings and infrastructures to natural shocks and hazards – earthquakes, floods, climate changes etc.

It is not just vulnerability to poverty that matters, but also vulnerability to various other hazards – such as climate, conflict, macroeconomic shocks and others. For this reason, the concept of vulnerability is increasingly recognized as being crucial at the level of individuals, socio-economic groups, countries and across time. The United Nations International Strategy for Disaster Reduction (UNISDR) gives the two main definitions of vulnerability and resilience. Vulnerability is "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard". Resilience is "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2009).

The present works aims at integrating the Macroeconomic Vulnerability Assessment Framework (MEVAF) developed by Anuradha Seth, Amr Ragab and Ambra Altimari within the MEVAF project at UNDP[1]. The MEVAF is a diagnostic tool that supports national policymakers and other development experts in conducting a rapid assessment to identify the critical determinants of macroeconomic vulnerability in a country. The tool also assesses a country's fiscal and institutional capacity to cope with a crisis in the short term and identifies the policy areas that will need to be strengthened to build resilience over the longer term.

Typically, macroeconomic vulnerability is manifest in a decline in the rate of economic growth subsequent to a shock, and by high growth volatility over the longer term. The MEVAF stresses the importance of many country's

[1] UNDP/Poverty Reduction Group Guidance Note: Macroeconomic Vulnerability Assessment Framework: A Practical Guide, Jan 2014, being printed

characteristics that act transmission channels in amplifying the negative impact of exogenous shocks, and factors that mitigate the negative impact.

The paper is organised as follow; chapter 1 analyses the current measures of economic vulnerability. Chapter 2 describes all the potential sources of vulnerability and resilience. Chapter 3 explains the methodology and the specification we adopt to compute the MEVI and report the main results, in comparison to the current UN measure (the economic vulnerability index proposed by Guillaumont). A final section summarizes the concepts and the results.

The large number of economic crises occurred during the last decades has brought economic literature to the stage where it is clear that we cannot successfully deal with poverty and underdevelopment unless we also deal with vulnerability.

The current synchronised crisis has opened the debate about the risk of globalization. Integration in the global financial and economic system increases the exposure to exogenous shocks. The largest part of developing countries have adopted development models based upon export-led growth paradigm and the importance of financial inflows. The identification of vulnerable developing countries has become fundamental for addressing international development assistance in the right way.

Ch1. Defining and assessing vulnerability. A literature review

Vulnerability is not a new concept; it goes back to the third United Nations Conference on Trade and Development (UNCTAD III) in 1972, where vulnerability to natural disasters was listed among the special disadvantages recognised to Small Island Developing States (SIDS). More recently, Millennium Development Goals (MDGs) and post-2015 Development Agenda highlight the importance of ensuring a sustainable development in terms of economic, social and environmental.

According to the United Nations International Strategy for Disaster Risk Reduction (UNIDSR) vulnerability is "[t]he characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard". The resilience, instead, is "[t]he ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions". (UNISDR, s.d.)

The definitions of vulnerability and resilience go together with their assessment, because they depend on the context. The *status* of the vulnerability manifests itself differently from country to country, because of the heterogeneity of economic, social and environmental conditions.
Contextualization is, then, the first challenge in defining vulnerability; vulnerability *of* what? Vulnerability *to* what? The debate is still ongoing.

Some measures of vulnerability focus on risk *ex-ante* assessment, other measures focus on *ex-post* evaluation of transmission channels. There are two main currents of thought on economic vulnerability; the first focuses on early warning indicators for assessing the risk of being affected by a negative exogenous shock. It refers to IMF studies on Early Warning Systems papers on vulnerability and resilience. The second current of thought focuses on the identification of

potential channels that may amplify or reduce country's vulnerability in case of adverse exogenous shock. It refers to UN, Commonwealth and World Bank indices for identifying countries that need international aid for development.

The second current does not consider the probability of being affected, but only the potential negative consequences in case of shock. While the EWS aim at forecasting risk of crisis.

1.1 Ex-ante measures: early warning system (EWS)

The main reference about EWS refer to International Monetary Fund works. EWS models focus on forecasts, because they aim at being a useful tool in monitoring vulnerabilities (Berg, Borensztein, & Pattillo, 2005). Reinhart *et Al.* (2000) tested several EW indicators of banking and currency crises in emerging markets in order to identify empirical regularities that allow recognizing crises at an earlier stage.

IMF-FSB EWS identified underlying vulnerabilities and risks that make a system prone to crisis, and transmission channels that are likely to affect the direction of the crisis. The purpose is to give policy advises for risk reduction. As for the second current of thought, vulnerability is necessary but not sufficient for a crisis to occur. Crises result from a combination of vulnerability and shock ("trigger event"). Vulnerabilities may be financial bubbles, balance sheet mismatches etc. Crisis triggers, instead, could be any event (IMF-FSB, 2010). Fragmented analyses are likely to underestimate risk, the combined risks across sectors and the macro-financial feedback loops (IMF-FSB, 2010) (Berg, Borensztein, Milesi-Ferretti, & Pattillo, 2000).

1.1.1 IMF Vulnerability Index (IMF-VI)

The IMF developed a vulnerability index that quantifies the risk to growth crises arising from exogenous shocks in low-income countries. The index highlights the key vulnerabilities that make countries prone to growth reductions after external shocks and gives advises about potential policy-actions to prevent risks (Dabla-Norris & Bal Gündüz, 2012).

They use multivariate regression to identify critical thresholds for each indicator, and averaging the indicators using their relative signaling power as a weight. The composite vulnerability index shows the number of indicators that exceed the thresholds.

Authors identify negative external shocks when the annual percentage variation of a variable goes below the 10th percentile in the left-tail of the country specific distribution.

The variables they use as shock variables are External demand; Terms of trade; FDI-to-GDP; Aid-to-GDP; Remittances-to-GDP; Climatic shocks.

Growth crises occur when two conditions hold: the post-shock two-year average real GDP falls below the pre-shock three-year trend, and the growth of real GDP per capita in the first post-shock year is negative.

They computed the index on a period from 1990 to 2009 for 71 LICs. Only the first year of the shock event is considered for shocks number computation.

Multivariate regression

The authors[2] specify the following probit model:

$y_{it} = 1$ in case of growth crisis;

$y_{it} = 0$ in case normal episodes;

$$P(y_{it} = 1|x_{it}, c_i) = \Phi(x_{it}^{'}\beta + c_i)$$

Where:
$i = 1, \dots, n$
$t = 1, \dots, T$
x_{it} is the vector of explanatory variables;
β is the vector of coefficients associated to explanatory variables;

The set of explanatory variables is explained in the table below:

AREA	VARIABLE
POLICY	Government balance-to-GDP
	Reserve as months of imports
	Dummy variable for flexible exchange rate regime
	Exchange market pressure index
STRUCTURAL AND INSTITUTIONAL	Country Policy and Institutional Assessment (CPIA)
	Real GDP growth in the previous period
	Average real GDP per capita growth over the sample period (proxy for cross-country differences in structural and institutional conditions)
SHOCK SIZE	Growth in trading partners weighted by the ratio of lagged exports to GDP.
	Export prices change weighted by the ratio of lagged exports to GDP

Table 1: Explanatory variables. Source: (Dabla-Norris & Bal Gündüz, 2012)

Signaling approach

Signaling approach is based on establishing cut-off values for each indicator that separates crisis from non-crisis events. The optimal cut-off threshold is the one that balances errors deriving from false signals in terms of missed crises and false alarms.

The overall IMF-VI is computed as follows:

[2] See (Dabla-Norris & Bal Gündüz, 2012).

$$IMF - VI = \sum_g w_g \sum_i w_{ig} d_i$$

Where:

w_{ig} is the weight of each indicator i in group g;

w_g is the weight of the group;

d_i a dummy if the indicator is above the threshold.

1.2.2 Critiques to the IMF-VI

The IMF-VI is an *ex-ante* measure for risk assessment. Nevertheless, because of the uncertainty about the future, we can only evaluate the vulnerability to a "known" event that is something observed in the past; although even similar hazards (shocks or stresses or whatever) might have different impacts over time. We can measure a risk, but not the uncertainty about the future. As pointed out also by Guillaumont (2009), negative impacts of natural hazards may be "forecasted", or at least imagined; but economic dynamics are different: they are social, political, institutional issues.

Things being so, we believe it would be better to focus on assessing countries' characteristics that might amplify or reduce negative effects of endogenous shocks, regardless of how probable negative shocks are.

1.2 Ex-post measures

1.2.1 Vulnerability and Resilience index (VRI)

The VRI is a combination of two indices, the Economic Vulnerability Index (VI) and the Resilience Index (RI). Briguglio attempted to create a first economic vulnerability index (VI) in the early 90s.

The vulnerability index of the VRI

The very first version of the VI does not consider resilience – although the author stresses the importance of countries coping capacities declaring that the aim is to investigate countries "vulnerability, fragility and lack of resilience in the face of outside forces" (Briguglio, 1995, p. 1618). The first VI is an un-weighted average of the following three variables:

- **Openness to trade**: sum of exports and imports over GDP. It is a proxy for country's exposure to foreign economic conditions
- **Transport and freight costs as a percentage of exports**. Transport costs are supposed to reflect country's insularity and remoteness.

- **Disaster damage as percentage of GDP**. The variable captures country's proneness to natural disasters.

Briguglio does not include a measure of the dependence on international sources of finance because he considers it as a proxy for country economic performances rather than country's economic fragility – due to its relation to GNP.

Results highlight that SIDS countries are more vulnerable than other developing countries.

After several improvement, Briguglio and Galea present the final version of their vulnerability index emphasizing the importance of countries' resilience: "Although economic vulnerability poses serious constraints, many SIDS have managed to attain relatively high GDP per capita, possibly because they have taken steps to build up resilience in order to cope with and withstand their inherent vulnerability" (Briguglio & Galea, 2003).

Variables used in the second version are four:

- **Trade openness**; computed as average imports and exports to GDP ratio – no more as a sum of exports and imports to GDP.
- **Export concentration** is computed by the UNCTAD Export Concentration Index for goods and services;
- Peripherality combines remoteness and insularity and is measured by the **transports and freight costs to imports** (no more as percentage of exports);
- **Dependence on strategic imports** is the average imports of commercial energy as percentage of domestic energy production.

Again, the index is an un-weighted average of the four component, after normalization[3].

Authors' concept of vulnerability refers to country's features that make it exposed to economic forces outside its control. Vulnerability is now combined with resilience, defined as country's ability to cope with its inherent vulnerability. Nevertheless, authors do not compute a resilience index. They use per capita GDP as a proxy for country resilience, and combine per capita GDP with vulnerability index in order to construct what they call the Economic Vulnerability Index Augmented by Resilience (EVIAR).

[3] They normalize values using the min-max procedure.

In 2006 Briguglio *et al.* propose a VRI incorporating a first version of RI (Briguglio, Cordina, Buheja, & Farrugia, 2006).

According to Briguglio *et al.*, two types of resilience exist: shock-absorbing and shock-counteracting resilience. Resilience arises from four areas:

1. **Macroeconomic stability:** The idea is that in equilibrium the economy would be characterized by internal balance (sustainable fiscal position), low price inflation and an unemployment rate close to the NAIRU, external balance (low level of external debt). Variables used for this component are:
    - Fiscal deficit-to-GDP ratio;
    - The sum of unemployment and inflation rates[4];
    - The external debt-to-GDP ratio.

    A healthy fiscal position would allow adjustments to taxation and expenditure policies in the face of adverse shocks – shock-counteracting resilience.
    Unemployment and inflation are associated with resilience because if an economy already has high levels of unemployment and inflation, it is likely that adverse shocks would impose significant costs on it – shock-absorbing resilience.
    Countries with a high level of external debt to GDP may find it more difficult to mobilize resources in order to offset the effects of external shocks – shock-counteracting resilience.

2. **Microeconomic market efficiency.** If markets adjust rapidly to achieve equilibrium, then the effects of shocks can be easily absorbed in the economy.
    Authors use data from Economic Freedom of the World Index to measure microeconomic market efficiency. The component is aggregates two indicators:
    - The size of government:
        - General government consumption as percentage of total consumption;
        - Transfers and subsidies as a percentage of GDP;
        - Government enterprises and investment as a percentage of total investment;

[4] The sum of unemployment and inflation rate is also known as Economic Discomfort Rate (or Economic Misery Index).

    - Top marginal income tax rate (considering the income threshold at which it applies).
- Freedom to trade internationally:
    - Revenues from taxes on international trade as a percentage of exports plus imports;
    - Regulatory trade barriers – Hidden imports barriers and cost of importing;
    - Size of trade sector;
    - Exchange rates;
    - International capital market controls – access of citizens to foreign capital markets and foreign access to domestic capital markets and restriction on the freedom of citizens to engage in capital market exchange with foreigners.

The size of government is supposed to have a crowding-out effect on private sector involvement, reducing the "autonomous resilience which freely-operating markets can produce".

Freedom to trade internationally refers to the "interference by government" in international trade, which can reduce economy's ability to react flexibly to shocks. It combines the revenues from trade taxes; tariffs on trade; trade barriers; the size of trade sector, exchange rates and controls of the movement of capital and people.

3. **Good governance**. Authors measure good governance through the following variables from the EFW (Gwartney & Lawson, 2005):
    - Judicial independence—the judiciary is independent and not subject to interference by the government or parties in disputes;
    - Impartial courts;
    - Protection of intellectual property;
    - Military interference in the rule of law;
    - Integrity of the legal system.
4. **Social development**. It refers to social relations and social cohesion that affect the effective functioning of the economic apparatus, without civil unrest. Variables used come from UNDP Human Development Index:
    - Adult literacy rate;
    - School enrollment ratios;
    - Life expectancy at birth as a proxy for health.

The Resilience Index is an average of the previous four components normalized with the min-max procedure.

In 2009, Briguglio *et al.* present the updated version of the RI. The main change refers to microeconomic market efficiency component, which now refers to the Area5 of the EFW 2005 (Gwartney & Lawson, 2005): Regulation of credit, Labor and Business. The measure is composed by the following indicators:

- Credit market regulations:
    - Ownership of banks – percentage deposits held in privately owned banks;
    - Competition from foreign banks – denial rate of foreign bank license applications and on foreign bank assets;
    - Extension of credit – percentage of credit extended to private sector;
    - Avoidance of interest rate controls and regulations that lead to negative real interest rates - credit-market controls and regulations;
    - Interest rate controls.
- Labor market regulations:
    - Impact of minimum wage;
    - Hiring and firing practices;
    - Share of labor force whose wages are set by centralized collective bargaining;
    - Unemployment benefits;
    - Use of conscripts to obtain military personnel.
- Business regulations:
    - Price controls – extent to which businesses are free to set their own prices;
    - Administrative conditions and new businesses;
    - Time with government bureaucracy – average time senior management spends dealing with government bureaucracy;
    - Starting a new business;
    - Irregular payments – irregular, additional payments connected with import and export permits, business licenses, exchange controls, tax assessments, police protection, or loan application.

All of these measures are proxies for the degree of "government interference in the financial markets, which could prevent the economy from reacting flexibly to shocks", "the extent to which bureaucratic procedures limit competition and the operation of markets", preclusion of

"work effort, thereby limiting the ability of a country to recover from adverse shocks.". (Briguglio, Cordina, Farrugia, & Vella, 2009)

Authors find small vulnerable countries spread over the entire range of this component, showing that such countries adopted different policies in terms of microeconomic market efficiency.

The VRI in summary

In summary, the VRI is the overall risk of being negatively affected by exogenous shock:

$$Risk = Vulnerability - Resilience$$

- **Vulnerability**. Un-weighted average of four variables:
  - Trade openness – average of exports and imports as percentage of GDP;
  - Export concentration – Herfindahl concentration index from UCTAD;
  - Peripherality – transport and freight costs to imports;
  - Dependence on strategic imports – average imports of commercial energy as a percentage of domestic energy production.
- **Resilience**. Un-weighted average of four components:
  - Macroeconomic stability:
    - Fiscal deficit-to-GDP;
    - Sum of unemployment and inflation rates;
    - External debt-to-GDP.
  - Microeconomic market efficiency:
    - Credit market regulation;
    - Labor market regulations;
    - Business regulations.
  - Good governance:
    - Judicial independence—the judiciary is independent and not subject to interference by the government or parties in disputes;
    - Impartial courts;
    - Protection of intellectual property;
    - Military interference in the rule of law;
    - Integrity of the legal system.
  - Social development:
    - Adult literacy rate;
    - School enrolment ratios;
    - Life expectancy at birth.

They find a positive relation between GDP and RI and a negative relation between VI and GDP. Moreover, they find GDP to be more sensitive to resilience variables than to vulnerability variables.

The authors define four possible scenarios describing the overall risk of being harmed by external shocks, as in the following figure:

1. The "self-made" scenario refers to countries with high inherent vulnerability that adopt good policies to build up resilience and mitigate their vulnerability.

2. Countries in the "prodigal son" scenario are those with a low inherent vulnerability, but which adopt policies that exacerbate their exposure to negative exogenous economic shocks.
3. The "best-case" scenario refers to low inherent vulnerability countries that adopt good policies to improve their resilience.
4. The "worst-case" scenario, instead, applies to countries that adopt bad policies that increase their exposure to negative exogenous shocks even if they already have a high inherent vulnerability.

	Countries that adopt policies to withstand vulnerability	**Countries that adopt polices that exacerbate vulnerability**
Inherently vulnerable countries	The "self-made" scenario	Worst case scenario
Inherently resilient countries	Best case scenario	The "prodigal son" scenario

Figure 1: Scenarios. Source: Briguglio & Galea, 2003

Thresholds for the quadrants of the four scenarios are computed as the vulnerability and resilience average scores for all countries. A grey area (called borderline) is computed as +/-15% the RI.

Separating exogenous factors from endogenous factors is useful in order to understand how and where international donors can help developing countries to build up resilience. Actually, economic vulnerability concerns inherent conditions affecting a country's exposure to exogenous shocks, while economic resilience refers to policies adopted by policy-makers and private agents that make country able to withstand or recover from the negative effects of exogenous shocks.

1.2.2 Critiques to the VRI

Main critiques to the VRI are linked to aspects that are not considered in the index. In particular:

1. Instability of trade is not considered;
2. The role of foreign capitals not considered;
3. Natural disasters are not considered;
4. Poverty is not considered.

Instability of trade is important. Countries that adopt export-led growth model are highly exposed to export revenues fluctuations.

Countries dependent on some strategic imports expose themselves to price fluctuation that may make the cost of imports excessively unstable.

Developing countries often refer to foreign capitals for financing development (FDI and ODA). Several empirical studies show the correlation between aid effectiveness and policies and some exogenous factors, such as exports instability, environmental shocks etc. (Guillaumont & Chauvet, 2001) (Hailu & Shiferaw, 2012).
Moreover, the economic vulnerability and resilience index was proposed as a criterion for identifying countries that need international aid in order to build-up their ability to withstand and recover from negative shocks.
Consequently, we believe that taking into account the effects of foreign capitals would be desirable.

Natural disasters are listed among SIDS disadvantages. The ERI does not take natural disasters' effects into account.

The VRI was not intended to reflect poverty and the level of GDP, thus these variables were not considered (Briguglio & Galea, 2003).

Another critical aspect concerns the role of market efficiency in resilience. Many scholars criticized the neo-classical approach behind the microeconomic market efficiency component presented in 2006 in the light of market failures that have occurred during the current economic crisis.
In the 2009 version authors respond to such critiques by modifying the microeconomic market efficiency component of the RI as described above. The argument is that variables used in the 2009 version of market efficiency component of RI are balanced by the governance index.
Thus, the ability of an economy to reallocate resources quickly and effectively following shocks, and an appropriate government intervention to foster economic resilience are two necessary conditions to reach a high level of economic resilience (Briguglio, Cordina, Farrugia, & Vella, 2009).

1.2.3 Commonwealth's composite vulnerability index (CVI)

The Commonwealth Secretariat started to focus on vulnerability issues in 1997, when a report titled *A future for small states: overcoming vulnerability* was presented during the Edinburg meeting of Commonwealth Heads of Government.

The CVI focuses on vulnerability and resilience of SIDS because 29 of the 54 member countries have a population of 1.5 million or less (*i.e.* they are considered as small)[5]. In 2008 a Commonwealth Secretariat and World Bank Joint Task Force on Small Countries (hereafter "the task force") was created in order to study the situation of small states and World Bank's policies towards them. The aim was to create a criterion for eligibility to concessional lending access and to LDC status better than the per capita GDP[6].

The CVI is an operational tool for determining whether small states need different treatment by international development policies.

Vulnerability impact index (VII)

The CVI associates economic vulnerability with "the exposure of a country to external economic and environmental shocks and events over which it has little, if any, control" (Easter, 1999).

The task force regress almost 30 determinants to output volatility *(OV)* in order to identify a limited number of indicators that are significantly related to the response variable:

- Economic exposure:
  - Trade openness;
  - Export concentration;
  - Capital openness;
  - Degree of access to or reliance on external financial resources flows;
  - Dependence on the non-manufacturing sectors;
  - Dependence on imports of key commodities.
- Remoteness and insularity:
  - International transport costs.
- Susceptibility to natural events and hazards:
  - Proportion of population affected by natural disasters.

They end up with three variables:

- Lack of diversification – UNCTAD Diversification Index *(Div)*;
- Dependence on exports – proportion of exports in GDP *(ExpDep)*;
- Impact of natural disasters – proportion of population affected *(NatDis)*.

Using a sample of 111 developing countries (37 small and 74 large), the task force estimates the following regression model:

$$OV_i = \beta_0 + \beta_1 NatDis_i * D_i + \beta_2 ExpDep_i + \beta_3 Div_i + \varepsilon_i$$

[5] 70% of the 42 small countries around the world belong to the Commonwealth.

[6] See also Advisory Board of the Joint Commonwealth Secretariat/World Bank Task Force on Small states, 2000

Where $i = 1, \dots, N$ is the number of countries that enter the sample. Errors are assumed to be uncorrelated with $E(\varepsilon_i) = 0$ and $Var(\varepsilon_i) = \omega_S^2 \sigma^2$ if $D_i = 1$ $Var(\varepsilon_i) = \omega_L^2 \sigma^2$ otherwhise

They use a weighted least square procedure in order to consider the different distributional properties for small and large countries. 11 countries have been deleted because of their outlier behaviors.

In order to estimate ω_S^2 and ω_L^2 it was necessary to estimate two separate regressions for small and large countries within the sample:

$$\omega_S = 2.5459 \qquad \omega_L = 1.6246$$

Regression results are the following:

	SMALL STATES	LARGE STATES	ALL
INTERCEPITON	-9.7624	2.3170	104142
VULNERABILITY	.0074**		0.0096***
EXPORT DEPENDENCE	0.0615**	0.0201	0.0322***
DIVERSIFICATION	15.2609*	2.5456	3.3442**
N	32	68	100
$\hat{\omega}$ ($\hat{\sigma}$ IN THE WEIGHTED REGRESSION)	2.5459	1.6246	1.0007
R^2	0.3506	0.0588	0.3286
F-STATISTIC	5.0389***	2.0299	15.6647***

Table 2: Regression results. Source: (Easter, 1999)

Predicted values from weighted regression represent the VII. Equations to compute VII for small and large countries respectively are:

$$OV_s = 1.4142 + 0.0096 * NatDis_s * D_s + 0.0322 * ExpDep_s + 3.3442 * Div_s$$

$$OV_L = 1.4142 + 0.0322 * ExpDep_L + 3.3442 * Div_L$$

The task force uses the average GDP as a proxy for resilience. The logic is that external shocks must be borne immediately, in terms of recovering from damages to physical infrastructure or supporting population affected through income transfers.

Combining VII and GDP

Task force uses the principal component analysis (PCA) to estimate weights for combining VII and GDP.

PCA gives uncorrelated linear combinations of the variables. They raise VII to the power of 5, then they apply a log transformation to VII and GDP.[7]

The PC1 explains the 85.4% of the total variability. The PC2 explains the 14.6% of the total variability:

$$PC1 = 0.42\log(VII^5) - 0.91\log(GDP)$$

$$PC2 = -0.91\log(VII^5) - 0.42\log(GDP)$$

They discard the $PC2$ and keep the $PC1$, that explains 85.4% of total variability. Thus, the CVI can be written by multiplying the $PC1$ by 100:

$$CVI = \frac{VII^{2.1}}{GDP^{0.91}} * 100$$

1.2.4 Critiques to the CVI

The methodology that the task force uses is interesting. The strength of PCA is that it allows measuring different dimensions of the data.

Nevertheless, the use of GDP as the only measure for country's resilience seems to be a limit. Task force's argument for such a choice refers to the necessity of facing high costs for emergency after a shock occurs.

We believe that resilience should reflect absorption capacity too. GDP may be a good proxy, but in order to face after-shock emergency government resources and system's capacity to react are fundamental.

Thus, a first distinction should be between public and private resources that are available in case of crisis.

A second argument links resilience to long-run policies. Resilience is not only about the ability to quickly recover from crisis, but also the capacity to prevent future crises, even in case of exogenous shocks.

Back to first stage of CVI estimation, the task force selects variables starting from a general model in which output volatility is the response variable. In other words, they measure shock impact only on GDP volatility, without considering other social variables such as poverty.

[7] By raising to the power of 5 the VII they ensure that the scales of VII and GDP are comparable.

1.2.5 The economic vulnerability index (EVI)

Vulnerability is not only a matter of SIDS. Vulnerability is relevant for low-income countries (LICs) in general. In 1999, indeed, the CDP recognized the importance of inserting a vulnerability in the criteria to identify LDCs (CDP, 2008) (Guillaumont, 1999).

"Vulnerability is the risk that economic growth is reduced markedly and extensively by shocks. According to another somewhat broader dynamic definition, risk is the likelihood of negative and lasting effects on poverty reduction from shocks" (Guillaumont, 2009, p. 197).

United Nations distinguishes between economic vulnerability and ecological fragility, highlighting that in part economic vulnerability derives from ecological aspects[8]. Nevertheless, the two concepts should be measured as separate – although their consequences might be correlated.

A further distinction has to be made between structural vulnerability and state fragility. "[S]tructural vulnerability should be clearly distinguished from *state fragility*. […] Fragile states are developing, but low income only occasionally) countries having with a (very) low policy score." (Guillaumont, 2008, p. 3) Fragile states are defined according to institutional indicators like the World Banks' CPIA. Since it is likely that some countries may meet both criteria of economic vulnerability and state fragility, we consider state fragility as feature affecting countries' resilience.

The EVI is the composite index set up by the United Nations Committee for Development Policy (CDP) and applied the first time in 2000 as a criterion for identifying the least developed countries (LDCs).

The EVI identifies three factors: shocks, exposure and resilience. Nevertheless, the EVI captures only the first two. In general Guillaumont talks about "unforeseen events, in general and in economics as well" (1999). Being vulnerability related to *unforeseen* shocks, Guillaumont underlines that handicaps usually recognized to many developing countries (*i.e.* remoteness, insularity or landlockedness etc.) should not be considered as factors of vulnerability, because they are not unforeseen.
A second important distinction refers to structural and policy induced (lack of resilience) vulnerability.

[8] See Advisory Board of the Joint Commonwealth Secretariat/World Bank Task Force on Small states, 2000 for details about UN *Development of a vulnerability index for small states: Report to the Secretary General,* Draft document, 1998; and *How to include an index of vulnerability in the criteria for identifying the LDCs?,* Draft document CDP12.98/WG3/3, 8 September 1998.

If the vulnerability index has to identify LDCs, or in general to draw attention to some communities, then the *structural* vulnerability must be considered (Guillaumont, 1999).

Several factors affect vulnerability negatively. *Primary instabilities* (climatic instability, political instability and instability in the terms of trade) have a negative impact on growth; but such an impact is often an indirect impact. *Primary instabilities* have a strong impact on the rate of change of factor productivity than on the level of investment. Primary instabilities affect growth through *intermediate instabilities* (rate of investment and real exchange rate) and, in economies based on agriculture, through microeconomic impacts (at farmer level) (Guillaumont, 2001) (Guillaumont, 2009).

The effect of primary instabilities (such as the instability in the terms of trade, or of the real value of exports, or of the agriculture value added) on the rate of growth is significantly higher in Sub-Saharan Africa than in other developing countries. In general, primary instabilities affect the rate of change in the factor productivity more than the level of investment. Intermediate instabilities (instability of the rate of investment and instability of relative prices) negatively affect growth and are directly related to policies. The instability of the rate of investment reflects low average capital productivity. When investment face a declining marginal productivity, the gain in total output is smaller than the loss due to a low investment level. Instability of the relative prices is measured by the instability of the real effective exchange rate. It reduces growth because it induces a misallocation of investment (Guillaumont, 2008).

Guillaumont disaggregates vulnerability into three aspects: shock, exposure and resilience. The first two belonging to the structural concept of vulnerability, the third reflecting policies adopted by the country. Gluillaumont focuses on structural vulnerability and in particular on shock indices. He identifies two kind of shocks:

1. **Natural shocks** – measured by the instability of agricultural production. Guillaumont does not use the frequency of natural disasters nor the number of people affected by, or the economic damages of, because he does not believe on the reliability of such indicators. Aggregate indicators give average values about events that are likely to be very different from one another, thus data do not give a good image of actual situation.
2. **Trade shock**s - measured by exports instability. Exports instability is assumed to be structural in small "price-taker" countries. Usually developing countries are commodity exporters. Commodity prices are highly volatile and small price-taker commodity exporters depend on world prices and demand that are out of their control. Guillaumont

does not considers foreign capital inflows because his focus is on commodity exporters that usually do not experience high capital inflows.

EVI over time

The following table shows the evolution of the EVI as a criterion for identifying LDCs over time. It relates the different definitions of LDCs to the different editions of the EVI (news highlighted in bold)[9]:

1999: LDCs are low-income countries suffering from low level of human resources and high degree of economic vulnerability	EXPOSURE INDEX Population size; Export concentration*; Share of manufacturing and modern services in GDP. *UNCTAD export diversification index SHOCK INDEX Instability of agricultural production; Instability of exports of goods and services.
2005: LDCs are low-income countries suffering from low level of human resources and high degree of economic vulnerability	EXPOSURE INDEX Population size; **Remoteness*;** Export concentration; Share of agriculture, forestry and fisheries in GDP. *Adjusted for landlockedness SHOCK INDEX **Homelessness due to natural disasters**; Instability of agricultural production*; Instability of exports of goods and services. *fluctuations around trend are likely to be due to natural shocks
2011: LDCs are low-income countries suffering from **the most severe structural impediments to sustainable development**	EXPOSURE INDEX Population size; Remoteness; Export concentration; Share of agriculture, forestry and fisheries in GDP; **Share of population in low elevated costal zones**. SHOCK INDEX **Victims of natural disasters;** Instability of agriculture production; Instability of exports of goods and services.

Table 3: EVI over time

In order to compare our index, we use the version of the EVI as presented in 2005 and updated by Guillaumont and Cairolle (Guillaumont & Cairolle, 2011; Cairolle, 2011)[10]:

[9] The CDP publishes the EVI every three years. We did not report 2002 and 2009 versions because they did not introduce new elements.

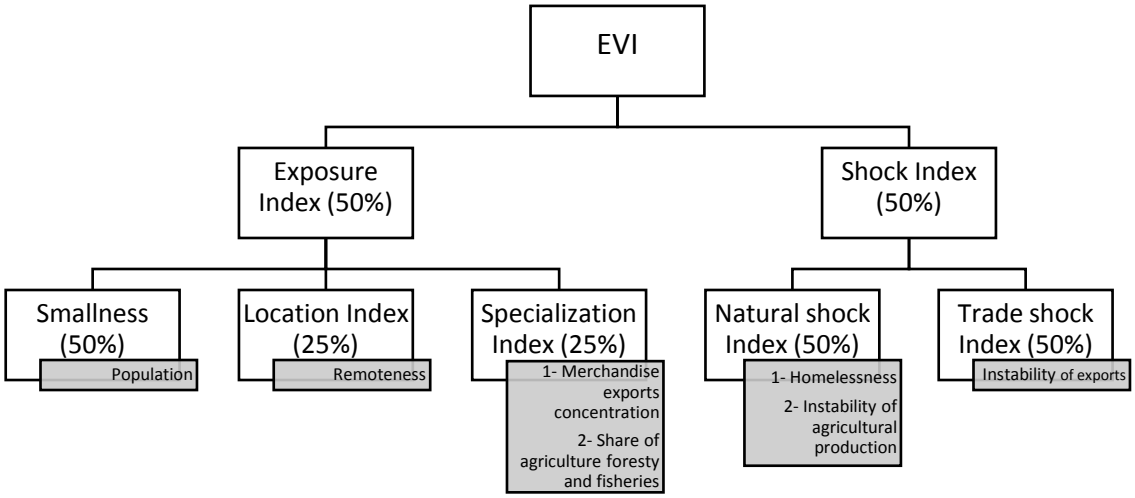


Figure 2: The EVI. Sources: (Guillaumont & Cairolle, 2011; Cairolle, 2011)

The EVI combines two indices:

1. Exposure index is a weighted average of *population size* (50%), *remoteness from world markets* (25%), *exports concentration* (UNCTAD Herfindahl exports diversification index, 12.5%) and the *share of agriculture, forestry and fishery in GDP*.
2. Shock index is a weighted average of *annual mean share of homeless due to natural disasters in the population* (25%), the *instability in the agricultural production* (25%) and the *instability in exports of goods and services* (50%).

The *Inclusion threshold* corresponds to the first quartile in the distribution of the EVI. It is not fixed, but it requires at least 25% of countries to lie under the threshold. *Graduation threshold* is established at 10% below the inclusion threshold.

Population (in log) is a proxy for country size. Countries with a small size are more likely to be open to international trade and thus to be exposed to trade shocks.

Share of agriculture, forestry and fisheries in GDP and Export concentration compose the specialization index (proxy for country's economic structure). Countries dependent on agriculture are more vulnerable to climatic shocks. Export concentration increases the impact and the likelihood of shocks (Cairolle, 2011).

Remoteness from main world markets, adjusted for landlockedness is a proxy for location.

[10] See also: (Guillaumont, 2007) (Guillaumont, 2007b) (Guillaumont, 2007c) (Guillaumont, 2008) (Guillaumont, 2009)

Instability of agricultural production and homelessness due to natural disasters compose the natural shock index.
Instability of exports receipts is a proxy for trade shocks.

Instability of agricultural production and of exports are measured as average deviation from trend (deterministic and stochastic), estimated as follow:

$$\log X_t = \alpha + \beta \log X_{t-1} + \gamma t + \varepsilon_t$$

Where:
X_t is the agricultural production or the value of exports of goods and services deflated by import unit values;
t is a deterministic trend;

Variables are normalized by the min-max procedure in order to be measured on the same 0-100 scale. The EVI is on a 0-100 scale too; with high scores corresponding to high level of vulnerability and vice versa.

Boundaries used for normalization:

Variable	Lower boundary	Upper boundary
Population	150,000	100,000,000
Remoteness	0.100	0.900
Export concentration	0.100	0.950
Share of agriculture, forestry and fisheries in GDP	0	60
Homeless due to natural disasters (average annual % of population)	1.3	0.0001
Instability of the agricultural production	1.50	20
Exports instability	3	35

Table 4: Boundaries for normalization of the EVI. Source: (Cairolle, 2011)

We have three components of vulnerability: shock (size and frequency of exogenous shocks), exposure and resilience (capacity to react).
Shocks are two: natural (earthquakes, volcanic eruptions etc.), and exogenous (because of international trade or exchange rates).

Focus is still only on exogenous aspects. The main difference between natural and exogenous shocks (beyond the natural or economic nature) is that natural shocks are *one-sided* shocks, while external shocks are *two-sided* shocks. Instability results from a succession of booms and slumps. The impact of such instability is asymmetrical because of different ex-post reaction to positive and negative shocks. This is why Guillaumont underlined the importance of assessing the impact of instability rather than the impact of separate shocks.

1.2.6 Critiques to the EVI

The EVI aims at providing a criterion for identifying LDCs, but also for aid allocation. We believe that including the role of foreign capitals and external debt would improve the vulnerability assessment.

Guillaumont highlights the importance of separating structural vulnerability from *policy induced* vulnerability: "[V]ulnerability of the Asian countries in the mid nineties, after the 1997 crisis, is very different from the vulnerability of small economies which export raw materials or of small islands. It is less structural, more the result of policy, more transient. […] If a vulnerability index is to be used for selecting certain countries and providing them with a durable support by the international community, the vulnerability to be measured is the structural one, which essentially results from the size of the shocks that can arise and the exposure to such shocks" (Guillaumont, 2007, p. 7).

We believe that such a way of looking at resilience might be misleading because policies may also have a positive impact on overall vulnerability. We agree with Briguglio *et al.* (2009) about the possibility of offsetting structural (inherent) vulnerability through appropriate policies.

We believe that the final effect, as a combination of both structural vulnerability and country's capacities to reduce negative impacts of shocks, is the principal aspect to consider in making decision about aid allocation.

Ch2. What does affect economic vulnerability?

We now live in a world where global development is continuously evolving. Growth poles and traditional donor-recipient relations are changing. Shocks seems to be the norm, rather than the exception, and uncertainty governs the world. Economic crises have become more and more frequent and they seem to have become a systemic feature of the globalised economy. Systemic crises are likely to jeopardize the progresses made towards Millennium Development Goals (MDGs), raising the problem of protecting and sustaining development (UNDP, 2011).

Economic vulnerability is due to countries' inability to mitigate or delete characteristics and factors that make them vulnerable to negative economic consequences from exogenous shocks. Such concept of vulnerability can be also thought as countries' inability to build their coping capacities. It is not possible to separate the concept of vulnerability from the concept of resilience.

Crises are triggered by different events that span both natural and socio-economic aspects. Economic vulnerability results from a complex interaction of factors and the impact of crisis depend on the origin and nature of the crisis, but also on the detail of economic structure in the country. "Developing economies are vulnerable to financial and economic shocks on account of a specific, structural conditions, which act as drivers of macroeconomic vulnerability" (UNDP, 2011).

2.1 Natural and geographic aspects

During the third conference on trade and development (UNCTAD III) in 1972, remoteness and insularity were identified as special disadvantages faced by countries. After that, several studies on developing countries produced a document presented during a UN meeting held in Malta in 1988 that led to a resolution recognizing the general problems faced by developing countries (small island developing countries in particular): smallness, remoteness, geographical dispersion, vulnerability to natural disasters and highly limited internal markets. In particular, the main disadvantages recognized to SIDS were:

1. **Smallness**. It is unusually measured by population, land area, GNP or a combination of these three measures. Smallness is supposed to affect country's vulnerability through a series of channels:
    a. Limited natural resource endowment and high import content. Small size implies few natural resources, thus small countries are likely to have ha high import content to GDP ratio.

b. Limitations on import-substitution possibilities.
c. Small domestic market and dependence on export markets.
d. Dependence on a narrow range of products. Small size tends to restrict country's ability to diversify exports. Exports concentration affects vulnerability because it makes the country dependent on few industries' performances.
e. Limited ability to influence domestic prices.
f. Limited ability to exploit economies of scale.
g. Limitations on domestic competition.
h. Problems of public administration. Often specialists can be trained overseas without guarantee that their services will be needed on their return. For this reason, many specialists decide to emigrate. Moreover, public administration services tend to be more expensive per capita when population is small. A third problem derives from the inefficiency and impartiality that are likely to arise in small countries where people know each other.

2. **Insularity and remoteness**. Remoteness give rise to high transport and communication costs, especially when combined to insularity.
    a. High per-unit transport. Small economies are used to require small and fragmented cargoes, thus they are likely to face relatively high per-unit costs.
    b. Uncertainties of supply. Linked to unreliability and delays in transport services.
    c. Large stocks. When transport services are not regular, firms find it difficult to meet sudden changes in demand, unless they store a large amount of goods.
3. **Proneness to natural disasters**. Cyclones, earthquakes, floods, landslides and volcanic eruptions are likely to threaten the survival of small islands.
4. **Environmental factors**. Processes' sustainability is important. Often economic indicators do not reflect environmental degradation.
    a. Pressure arising from economic development. Small countries tend to suffer pressures of economic development more than other countries do. Increasing demand for residential housing and industrialization, for instance reduces agricultural land. Tourism is likely to produce more and more waste in the coastal areas etc. economic development increases also the demand for resources, lot of which are not renewable. This is the case of Fiji for gold, Vanuatu for manganese, Trinidad and Tobago for oil, Haiti for bauxite and Nauru for phosphate (Briguglio, 1995).

b. Environmental characteristics of SIDS. SIDS are fragile eco-systems, very susceptible to environmental changes. Moreover, the increasing level of the sea, due to global warming, is a threat for low-lying coral atolls.
c. Demographic factors. Small countries face a big migration, especially of high skilled individuals. People often study abroad and decide to remain there, because they do not find good opportunities in their countries.

The first composite index of overall vulnerability was proposed in 1990[11]. UNCAD engaged Lino Briguglio to prepare a paper on the construction of a vulnerability index; the paper was presented in Geneva in 1992 (Briguglio, 1995). Briguglio's index is then the first vulnerability index constructed.

2.1.1 Country size

Economic literature identifies country size as a potential source of vulnerability because of the growth challenges small countries face. Vulnerability of small states is the results of two factors: incidence and risk of adverse events; and country's ability to cope with them. Then, the additional ability to bounce back from negative consequences of events, make a country *resilient* (Atkins, Mazzi, & Easter, 2001) (Briguglio, 1995).

Lot of small states are very far from a continent. Moreover, they often have poor public institutions and lack of adequate social and education services. These problems are compounded because a small population implies a high cost of provisioning for public goods. Small domestic markets face high per capita cost of social services provisioning, when taxation finances public expenditure. Large countries, on the contrary, benefit from economies of scale, power and influence in the international framework (Alesina & Spolaore, 1997). Limited natural resource endowment due to small land area, and limited labour supply due to small population suggest that the comparative advantage of small states should be based on high-skilled labour in high value-added sectors. On the contrary, many small states follow labour-intensive export-led models (Armstrong & Read, 2002).

Because of few internal resources and small domestic markets, small countries are more dependent on international trade. Moreover, since they are not able to diversify their economies, they are more vulnerable to the terms of trade shocks than larger countries (Briguglio, 1995).

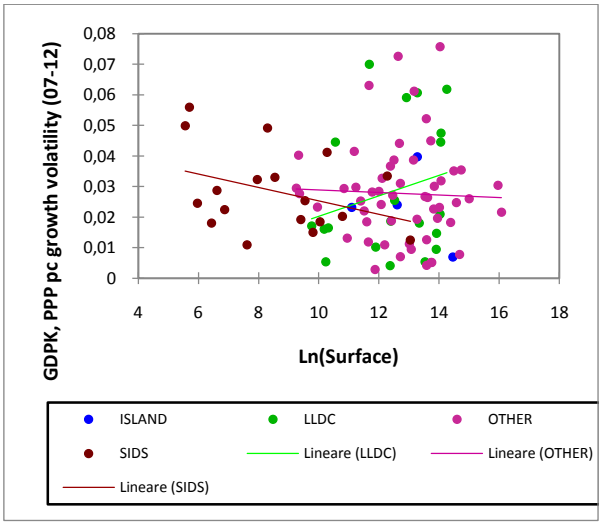
[11] During the UN meeting of Government Experts of Island Developing Countries and Donor Countries and Organizations, in 1990, the Maltese Ambassador to the UN stressed the importance of a quantitative index of vulnerability because the GDP was not a good measure of development, as it did not consider structural and institutional weaknesses.

Empirical evidence on small states is controversial; the academic debate is open. Easterly and Kraay find that economic performances of small states (in terms of growth rates, productivity and income levels) are higher than economic performances of larger countries. Offsetting factors play crucial roles, such as higher secondary school enrolment rates (Easterly & Kraay, 2000).

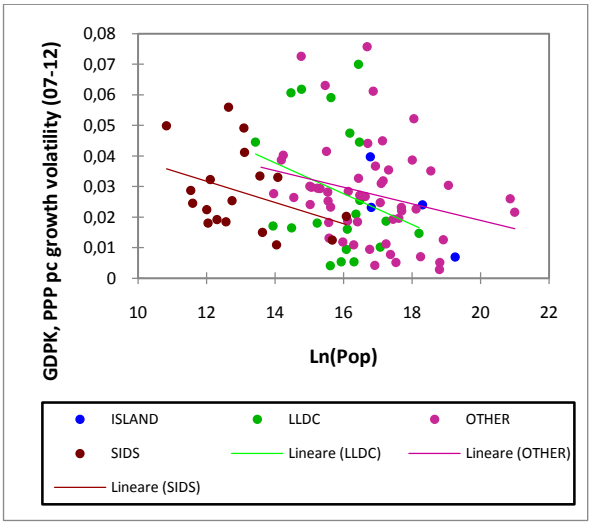
Country size may be measured by land area, population, GDP, GNP or Gross Domestic Expenditure; there is not general agreement, and all of these factors may have a role in explaining vulnerability. However, international trade theory is mainly interested in countries' market power, because it is correlated with natural resources endowment and because of it affects country's importance in international markets. "Of course, a poor country with low per capita income could still have a large GNP (because of its large population). But it would still be only a small potential market, because the bulk of its population is too poor to be potential demanders of anything but basic commodities." (Srinivasan, 1986)

Usually population is used as an indicator of country size, because of its high correlation with income and territory size. Furthermore, there is not a consensus about the threshold that should be used. Usually the Commonwealth Secretariat and World Bank use 1.5 million people as the threshold. However, they conclude that each of these three measures is not likely to be fully satisfactory, and results may be applied to all countries. That is, size does not matter. (Advisory Board to the Joint Commonwealth Secretariat/World Bank Task Force on Small States, 2000)

We measure country smallness using the **population** and the **country surface**. The following plots show the volatility of per capita GDP PPP growth between 2007 and 2012 versus the log-transformation of surface and population.



GDP GROWTH VOLATILITY VS SURFACE



GDP GROWTH VOLATILITY VS POPULATION

Figure 3: GDP growth volatility

It seems there is a negative relation between population and GDP volatility in all sub-samples. The relation between surface and output volatility seems to be negative for SIDSs and positive for LLDCs. Nevertheless, the relations are not significant – as shown in the following table. The correlation between population and the output volatility is significant for the group of "Other" only – equal to -0.351. The correlations between population and GDP volatility in the groups of SIDS and LLDCs are non-significant at 5%. The overall correlation between variables show a significant negative relation between population and output volatility. No significant relation between surface and output volatility. The following table shows the overall correlation matrix. Values in bold are different from 0 with a significance level alpha=0.05.

	Ln(Surface)	*Ln(Pop)*	*GDP volatility*
Ln(Surface)	**1**	**0.805**	-0.041
Ln(Pop)	**0.805**	**1**	**-0.212**
GDP volatility	-0.041	**-0.212**	**1**

Table 5: Correlation matrix between country size and GDP volatility

2.1.2 Remoteness

Remote countries face difficulties in importing production inputs and transporting outputs either to the capital city or abroad. High international transport costs and uncertainties of industrial supplies due to insularity and remoteness hamper both production and competitiveness.

Remoteness may discourage agricultural diversification, especially the development of non-traditional crops, such as spices and vanilla. Exports volumes of non-traditional crops with high added value are usually limited; this increases unit transport costs. On the contrary, industries oriented toward the domestic market (such as handicraft for tourists) may be competitive (Encontre, 1999).

We use three variables to measure remoteness:

- **Geographical distance** refers to the index used by Guillaumont in the retrospective EVI as a proxy for remoteness. Remoteness is measured as a weighted average of the distance to the main world markets. Weights are given by the minimum average distance to a significant fraction of the world market and choose the threshold of one third. The *minimum distance* is the minimum average distance to reach a given size of the world markets. It fits requirements, because it is an exogenous measure and weights differ for each country (Guillaumont, 2007b).

  Landlockedness is another great obstacle, because landlocked countries face higher transport costs for a given distance. Remoteness index used in the EVI make an upward adjustment to remoteness measure.

The adjustment coefficient derives from estimation of the impact on trade-to-GDP ratio of the log of the remoteness index (unadjusted), and a dummy variable for landlockedness condition.

In summary, remoteness in formula is:

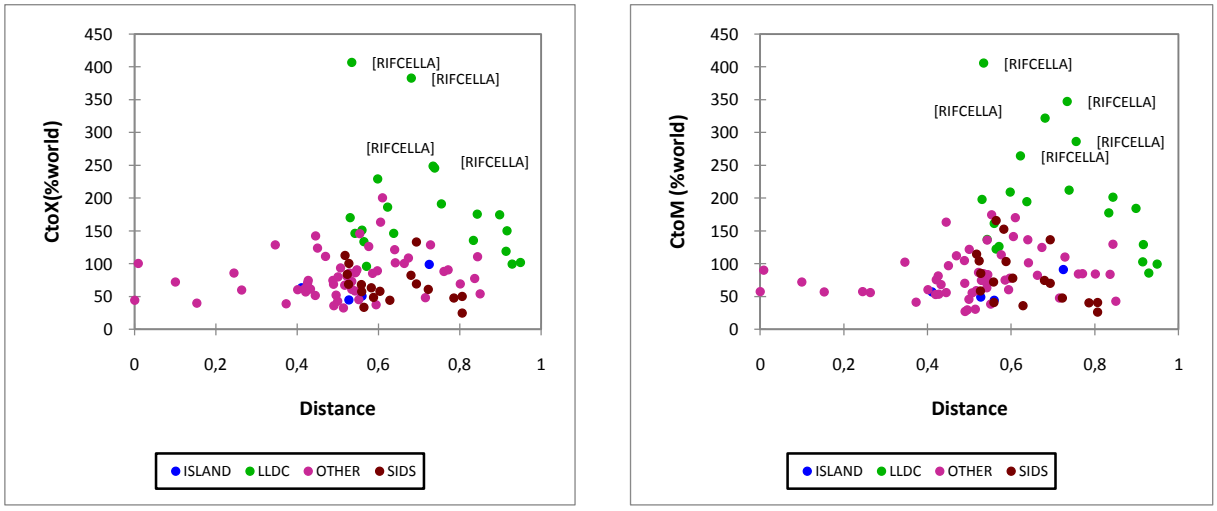
$$AD = 0.85 * \ln D + 0.15 * L$$

Where:
L is a dummy variable for landlockedness condition;
D is the normalized distance from world markets: $D = Min \sum_{j=1}^{k} D_{ij} * \frac{X_j}{X_w}$
i is the country; j is the trade partner; k the whole set of trade partners allowing to reach 33% of the world market with a minimal distance; D_{ij} is the bilateral distance between country i and j; X_j are the total exports of trade partner j; and X_w are the world exports.

- **Cost to trade.** Some indices like Briguglio's and Commonwealth vulnerability indices, measure remoteness (sometimes referred to also as "peripherality") as the ratio of the cost of insurance and freight to the import value. We constructed an indicator as proxy for costs to trade compared to the average cost to trade in the world. In formula:

$$Cost\ to\ X\ (\%\ world) = \frac{Cost\ to\ X}{Average\ world\ cost\ to\ X}$$

The following two graphs show the relation between geographical distance and costs to trade. Landlocked countries face higher costs compared to other groups.



Cost to export

Cost to import

Figure 4: Cost to international trade

When small countries are very close to other developed nations "neighbouring countries can share certain infrastructural activities, such as electric power generation, education, communications, and health facilities" (Srinivasan, 1986). This would mean that small landlocked countries should have better performances than small island countries. Empirical evidence does

not confirm this hypothesis. LLDCs seem to face the highest cost to trade, confirming that landlockedness implies higher costs than insularity. Correlation test shows that there is not a significant relation between distance and cost to trade within groups. There is, instead, a significant positive correlation between the distance and the cost to trade in the whole sample. No significant correlation with GDP volatility. The following table shows the overall correlation. Values in bold are different from 0 with a significance level alpha=0.05.

	Distance	*CtoX(%world)*	*CtoM (%world)*	*GDP volatility*
Distance	**1**	**0.228**	**0.230**	0.030
CtoX(%world)	**0.228**	**1**	**0.905**	0.063
CtoM (%world)	**0.230**	**0.905**	**1**	0.059
GDP volatility	0.030	0.063	0.059	**1**

Table 6: Correlation matrix between Remoteness and GDP volatility

2.1.3 Proneness to natural disasters

Vulnerability to environmental hazards has economic implications in terms of productive capacity, and population affected. United Nations distinguish between economic vulnerability and ecological fragility and recognise that vulnerability derives in part from natural disasters too.

Vulnerability to natural hazards combines exposure and social response. Vulnerability is seen as a biophysical risk as well as a social response, within a specific geographic domain. Variables related to the exposure to natural disasters usually include proximity to the source of threat, frequency and magnitude of events. Social impacts are measured by damages to infrastructures, poverty or wealth indicators, damages to population etc. (Cutter, 1996).

There is general consensus in the literature that the social and economic costs of natural disasters are borne by poor people in developing countries, and that there is a decreasing linear relation between the level of income and the damages from natural disasters. Nevertheless, results are controversial.

Some surveys, such as Albala-Bertrand (1993) find a positive relation with GDP, investments and agricultural and construction outputs. Tol and Leek (1999) argue that disaster destroy the stock of capital in the country, increasing the flows of new production. GDP captures these flows; this is why disaster have a positive relation with GDP[12].

Noy (2009) finds a negative relation between damages to infrastructures, housing, crops etc. and GDP growth. No significant relations between population affected and GDP growth. He finds that developing countries face deeper macroeconomic impacts of natural shocks than developed

[12] Some countries, notably the USA, are adopting a modified measure of GDP, which will fall with the consequences of a natural disaster. Hence, this problem may be less severe in the future.

countries. Moreover, small economies seem to be more vulnerable than larger countries to negative consequences. Countries with high literacy rates, better institutions, higher openness to international trade and high per-capita income are more able to cope with natural disasters.
Toya and Skidmore underline negative relation with GDP and a crucial role of international trade, governance and education too (Toya & Skidmore, 2007)
Kellenberg and Mobarak (2008) find a non-linear relation between a special type of disasters (floods, landslides, windstorms and extreme temperatures) and income. They argue that such type of disasters relate to behavioural choices; risk averse people are likely to make different risk-return trade-off choices at different income levels.

In summary, there is not a linear negative relation between income and resilience to natural hazards. "[E]xtreme care must be taken when modelling and analysing the relationship between wealth and economic development. […] [T]he exposure to natural hazards is an important driving force behind any relationship between economic losses and wealth" (Schumacher & Strobl, 2011).
Income is not the only relevant measure in evaluating damages from natural disasters. Resilience variables, such as human capital, trade openness, and good governance are also important.

The larger part of surveys use data from EM-DAT database published by the Centre for Research on the Epidemiology of Disasters (CRED)[13]. The database contains data on the occurrence and impacts of natural disasters from 1900 to the present. Natural disaster is "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering" (Guha-Sapir, Hoyois, & Below, 2013).
Among the top 10 countries in terms of mortality in 2012, six countries were low or lower-middle income countries, and four were high or upper-middle income countries. They accounted for 68.2% of global mortality due to natural disasters in 2012 (Guha-Sapir, Hoyois, & Below, 2013).
We use three variables from EM-DAT database for capturing the impacts of natural disasters:

- **Population affected by natural disasters (% of total population)**

$$Population\ affected\ by\ natural\ disasters(\%) = \frac{Total\ affected_{1995-2007}}{Average\ population_{1995-2007} * 13}$$

- **Average economic damage from natural disasters (%GDP)**

[13] http://www.emdat.be/

$$Economic\ damages\ from\ natural\ disasters = \frac{Total\ damage_{1995-2007}}{Average\ GDP_{1995-2007} * 13}$$

- **Natural disasters per year (average number of natural disasters occurred between 1995 and 2007).**

The following graphs show the impacts of natural disasters by country group.

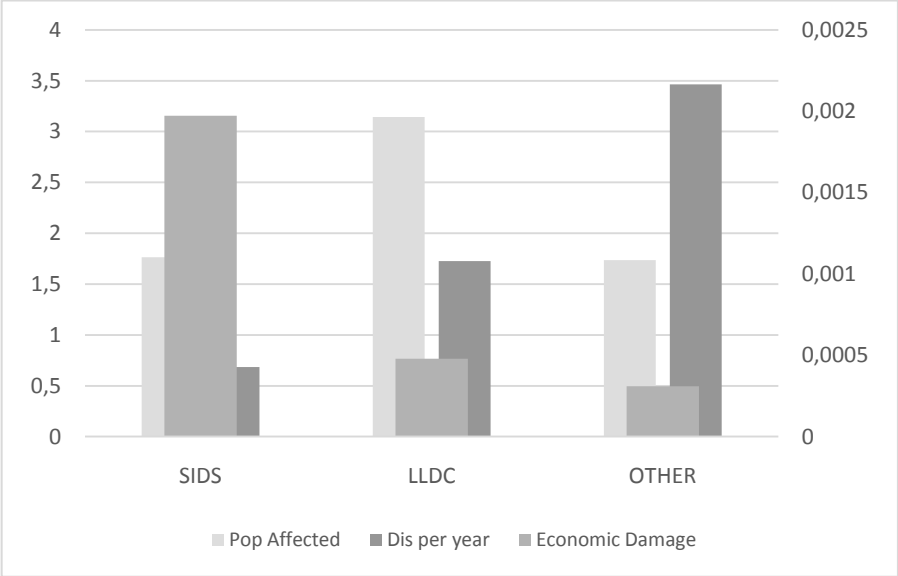


Figure 5: Impact of natural disasters by group. Data from EM-DAT

Economic damages (on the right axis) represent a very low percentage of GDP. The number of disasters in SIDS is lower than the number of disasters in LLDCs and all the other developing countries. Population affected by natural disaster is higher in LLDCs. No difference in the average percentage of population affected in SIDS and the other developing countries. In general, empirical evidence does not sustain the idea that small states are located in regions where there is high incidence of natural disasters like cyclones, volcanic eruptions etc. The following scatter plot shows the relation between the average number of natural disaster and the output volatility[14].

[14] China, India, Philippines and Indonesia are not in the plot because their average number of natural disasters per year is higher than 10.

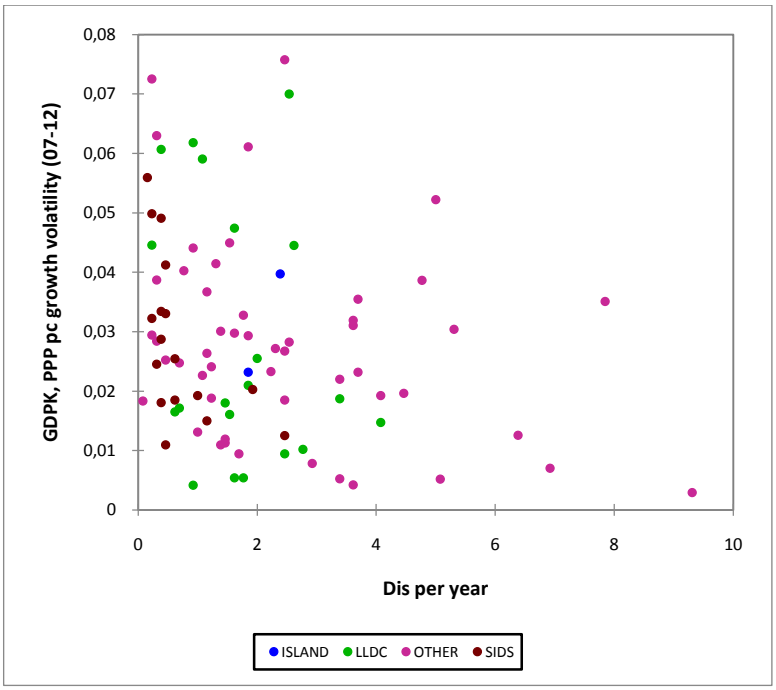


Figure 6: GDP volatility and average number of natural disasters per year.

There is not a significant relation between output volatility and the average number of disasters per year in the group of SIDS. This result confirms what Encontre (1999) underlines, that empirical evidence does not show a direct relation between the economic performance and the average number of natural disasters faced by island states.

Population affected and economic damages show a positive and significant correlation with GDP volatility in the group "Other". The overall correlation between economic damages and output volatility is significant and equal to 0.211[15].

2.2 Socio-economic aspects

2.2.1 Governance

Governance consists of "the traditions and institutions by which authority in a country is exercised. This includes (a) the process by which governments are selected, monitored and replaced; (b) the capacity of the government to effectively formulate and implement sound policies; and (c) the respect of citizens and the state for the institutions that govern economic and social interactions among them" (Kaufmann, Kraay, & Mastruzzi, 2010).

The impact of economic crises varies between countries because of differences in the economic structures, history, policies and the levels of structural vulnerability too. There is a growing recognition of the importance of the role of institutions and governance in responding to economic shocks. During economic crises, the ability of governments to design and implement

[15] Pearson correlation. Alpha=0.05

the right policy measures is crucial for achieving MDGs and building countries' resilience. The quality of institutions and the overall functioning of country make the difference, especially if states want to take countercyclical measures and to protect welfare and livelihoods of their citizens (UNDP/BDP, 2011).

Improvements in the governance have a positive relation with countries' development. Social infrastructure is the key determinant of cross-country differences in output per worker, and it can be interpreted as a combination of the aspects of governance (Kaufman, Kraay, & Zoido-Lobaton, 1999).

Discussions about state capacity to respond to external shocks have several interpretations. Performing institutions that are able to deliver basic public services and to implement policies are fundamental. Impact of economic shocks at the household level affects the national responses. The UN CDP highlights some examples of interventions that target poverty reduction, such as the cash transfers in Mexico encouraging poor families to maintain their children's school enrolment (Johnson, 2006).

Institutions play a crucial role in improving the social impact of instability and mediating conflicts. Good institutions are those that protect human rights, care about the rule of law and sustain equality and social insurance. Developing countries are integrating themselves in the global economy, increasing their exposure to shocks. It is, then, important to develop institutions that mediate social conflicts. Democratic institutions, rule of law and social insurance are necessary for building resilience to external instability (Brautigam & Woolcock, 2001).

In countries significantly affected by external shocks, the government can mitigate risk by controlling a larger share of the resources. The larger the share of government consumption in the economy, the larger the share of households' income deriving from the public sector. Assuming that the government sector is "safe" (in the sense that an expansion in it would reduce aggregate income risk) and uncorrelated with economic shocks, incomes from public sector will be more stable than incomes from other sectors. "And if the government acts as the agent of households that dislike risk, it will choose to consume a greater share of the society's resources in economies that are subject to greater amounts of external risk" (Rodrik, 1998).

There have been several efforts to develop indicators of governance. The most important indicators are the World Bank's Worldwide Governance Indicators (WB WGI). WB WGI are composite measures of governance generated by a methodology called *Unobserved Components Model (UCM).* UCM are in units of a standard normal distribution, with mean zero, standard deviation of one, and running from approximately -2.5 to 2.5, with higher values corresponding to better governance (Kaufmann, Kraay, & Mastruzzi, 2010).

We measure governance using the percentile rank[16] of the six aggregate WB WGI:

- **Voice and accountability (VA);**
- **Political stability and absence of violence (PS/AV);**
- **Government effectiveness (GE);**
- **Regulatory quality (RQ);**
- **Rule of law (RL);**
- **Control of corruption (CC).**

The following graph shows the average values of WB WGI in developing countries and LDCs in 2007.

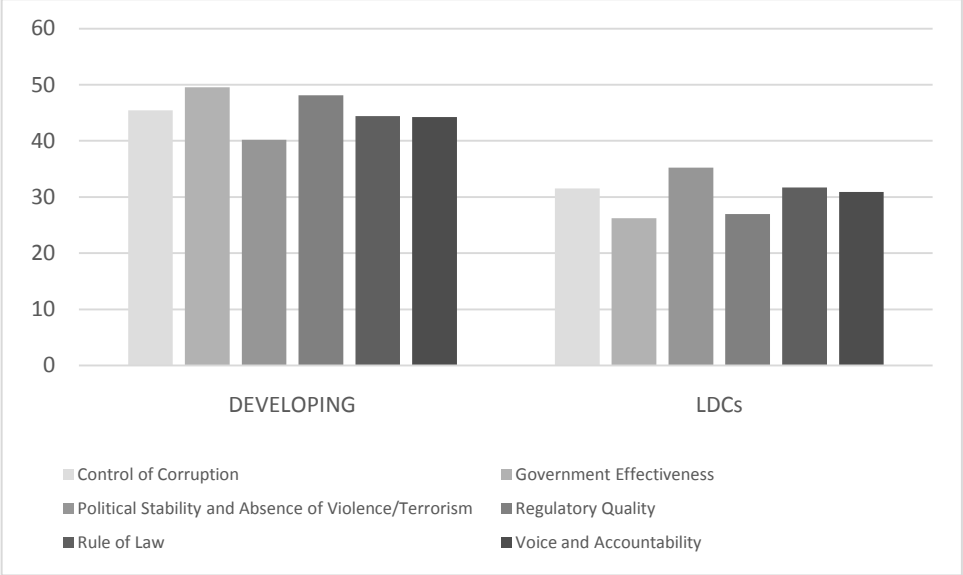


Figure 7: Average values of WGI

LDCs have on average lower scores of governance. Nevertheless the linear correlation between governance scores and the volatility of GDP does not seem to be significant, as shown in the following table.

LDCs	*GDP volatility*	*CC*	*GE*	*PS/AV*	*RQ*	*RL*	*VA*
GDP volatility	**1**	0.059	0.055	-0.057	0.062	0.115	0.004
CC	0.059	**1**	**0.786**	**0.632**	**0.753**	**0.795**	**0.503**
GE	0.055	**0.786**	**1**	**0.376**	**0.900**	**0.840**	**0.476**
PS/VA	-0.057	**0.632**	**0.376**	**1**	0.315	**0.664**	**0.537**
RQ	0.062	**0.753**	**0.900**	0.315	**1**	**0.755**	**0.554**
RL	0.115	**0.795**	**0.840**	**0.664**	**0.755**	**1**	**0.524**
VA	0.004	**0.503**	**0.476**	**0.537**	**0.554**	**0.524**	**1**
DEVELOPING	GDP volatility	CC	GE	PS/AV	RQ	RL	VA

[16] Rank terms from 0 to 100

GDP volatility	**1**	**-0.305**	**-0.317**	-0.222	-0.232	**-0.295**	-0.138
CC	**-0.305**	**1**	**0.854**	**0.632**	**0.758**	**0.872**	**0.693**
GE	**-0.317**	**0.854**	**1**	**0.521**	**0.860**	**0.887**	**0.631**
PS/VA	-0.222	**0.632**	**0.521**	**1**	**0.528**	**0.703**	**0.483**
RQ	-0.232	**0.758**	**0.860**	**0.528**	**1**	**0.805**	**0.658**
RL	**-0.295**	**0.872**	**0.887**	**0.703**	**0.805**	**1**	**0.655**
VA	-0.138	**0.693**	**0.631**	**0.483**	**0.658**	**0.655**	**1**
ALL	GDP volatility	CC	GE	PS/AV	RQ	RL	VA
GDP volatility	**1**	0.049	0.020	0.145	0.089	0.058	-0.012
CC	0.049	**1**	**0.831**	**0.635**	**0.757**	**0.845**	**0.619**
GE	0.020	**0.831**	**1**	**0.470**	**0.874**	**0.872**	**0.572**
PS/VA	0.145	**0.635**	**0.470**	**1**	**0.448**	**0.690**	**0.508**
RQ	0.089	**0.757**	**0.874**	**0.448**	**1**	**0.787**	**0.618**
RL	0.058	**0.845**	**0.872**	**0.690**	**0.787**	**1**	**0.606**
VA	-0.012	**0.619**	**0.572**	**0.508**	**0.618**	**0.606**	**1**

Values in bold are different from 0 with a significance level alpha=0.05

Table 7: Correlation matrix between governance indicators and GDP volatility

GDP volatility is significantly correlated with governance only in the case of developing countries. Correlations between Control of corruption, Government Effectiveness and Rule of law and GDP volatility are significant and negative. Correlations with GDP growth rate in 2008 are not significant too.

2.2.2 Human capital

Human capital is a proxy for development. Reduced mortality and increased investment in education are two of the most significant aspects of economic growth. Economies evolve from high mortality, high fertility, slow human capital accumulation and slow growth to low mortality, due to human capital accumulation. Low mortality reduces fertility. Higher life expectancy increases the incentive to invest in education, increasing the level of human capital and the growth rate (Tamura, 2006) (Kalemli-Ozcan, Ryder, & Weil, 2000).

Human capital increases the productive capacity and the ability to acquire and develop new technologies. Global competition requires high rates of human capital to sustain technological development. The average growth rate after trade liberalization policies in South Korea and Brazil, in the late 60s, was equal to 22.3% in South Korea, and to 10.3% in Brazil. Such a difference was due to a different level in the initial stock of human capital – South Korea had a higher stock of human capital and invested more in education than Brazil (Keller, 1996). Human capital helps also the switching from agricultural to industrial economy, making the country able to differentiate (Tamura, 2002).

We use five indicators of education as proxies for human capital in 2007:

- **School enrolment rates for primary, secondary and tertiary;**
- **Primary completion rate;**
- **Progression to secondary school.**

Primary completion rate shows whether a country is on track to achieve the MDG of universal primary education by 2015, and whether an education system has the capacity to meet the needs of universal primary education. It is an important measure because official enrolments sometimes differ significantly from attendance and even school systems with high average enrolment ratios may have poor completion rates.

The transition rate from primary to secondary education conveys the degree of access or transition between the two levels. A low transition rate can be a signal of inadequate examination and promotion system or insufficient secondary education capacity.

The following graph shows the average values of the five indices in developing countries and in LDCs.

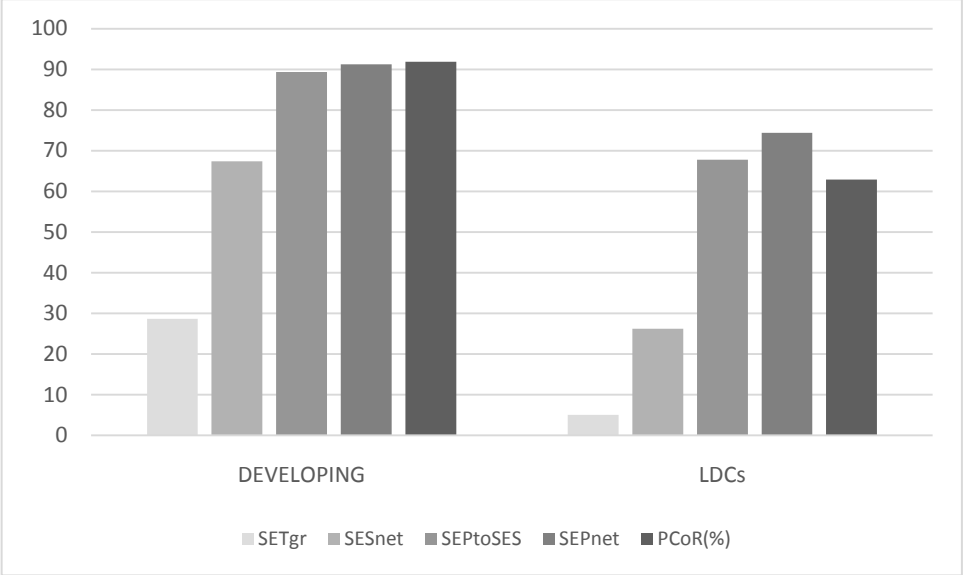


Figure 8: Average values of school enrolment by group

LDCs have on average lower values of tertiary and secondary school enrolment, as expected.

2.2.3 Productive structure

Domestic socio economic conditions play a crucial role in offsetting negative effects of external shocks. Domestic conditions are not intended to capture the risk that a negative shock occurs; they rather measure the capability of country to cope with negative shocks.

The production structure of a country is a useful measure for identifying the type of risk the country is exposed to. We use value added by economic activity as a proxy for productive structure.

In the model, we use Industry value added and Services value added only in order to avoid redundancy. The following graph shows the combination of three sectors by geographic group.

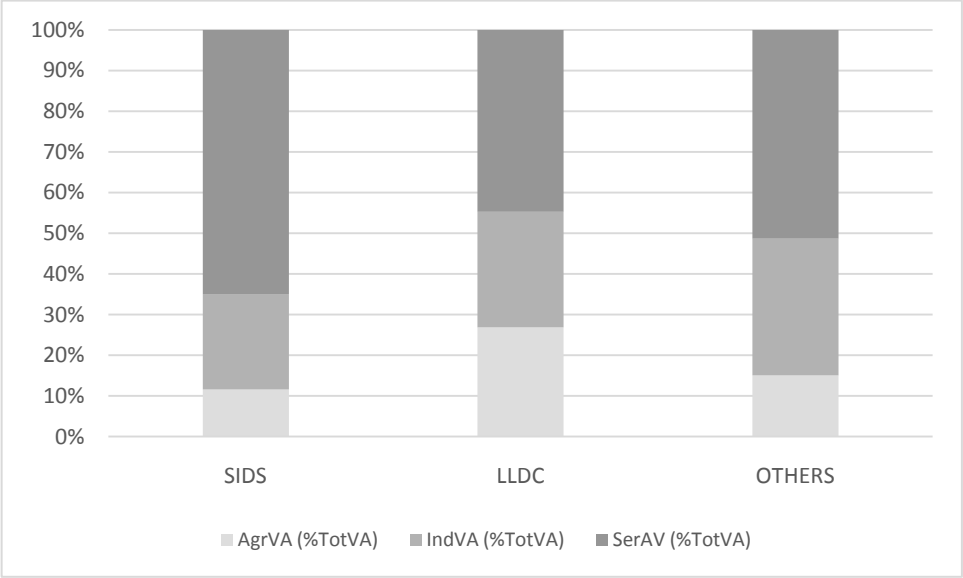
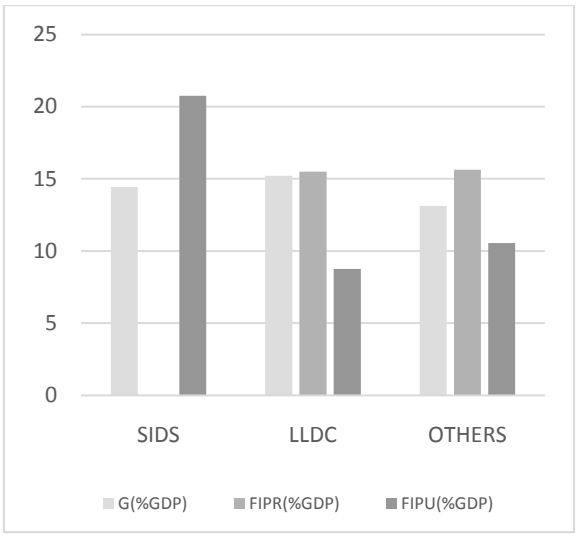


Figure 9: Productive structure by geographic group

On average, 65% of total value added in SIDS comes from the services. LLDCs appear to be more balanced, even if services account for the 45% of total value added. The other developing countries have, on average, a higher share of industrial sector than SIDSs and LLDCs.

2.2.4 Domestic investment and public expenditure

As we already said, the role of public sector in the economy might be crucial in offsetting vulnerability to exogenous shocks, because the public sector would be more protect against exogenous economic shocks than the private sector. Thus, an expansion in the public sector would reduce aggregate income risk, because incomes from public sector will be more stable than incomes from other sectors (Rodrik, 1998). The following graphs show the value of total public expenditure as percentage of GDP in 2007 and the domestic private and public fixed investment, as share of GDP.



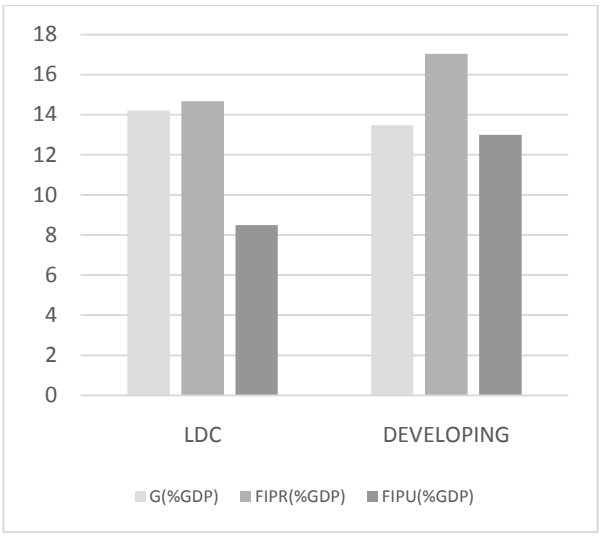


Figure 10: Public expenditure (% GDP) and domestic investment (% GDP)

On average, the share of private investment is higher than the share of public investment. In LDCs the share of public expenditure equates the share of private investment. The average share of public investment in SIDSs is above the average of all the other countries in the sample.

2.2.5 Poverty

Poverty is a condition in which households or individuals do not have enough resources to meet their needs. Measuring poverty is not easy. Several sources of data that are useful for poverty analysis exist at country level only (Haughton & Khandker, 2009).

Often poverty in developing countries is associated with chronic poverty, a condition in which individuals are poor in every period. Nevertheless, transitory poverty is also important. Transitory poverty relates to events that reduce households' income. Poverty for people that suffer transitory poverty is like chronic poverty. The drop in income is likely to hamper the capacity to borrow in order to remain above the poverty line; this is likely to reduce the permanent income (Morduch, 1994).

Vulnerability on different levels of group, places and countries is important in order to improve ability of households, regions and countries to cope with risk of exogenous negative shocks (Naudé, Santos-Paulino, & McGillivray, 2009).

Poverty makes a country vulnerable because it represent a condition of unease. It amplifies the already negative effects of crises, especially when combined with income inequality. There seem to be a correlation between income inequality and the frequency of domestic financial crises, in developing countries as in advanced economies. Greater inequality reduces the positive effect of economic growth (UNDP, 2011).

Measuring poverty is not easy. There is growing consensus about the limits of current indicators of poverty, starting with the critiques of Amartya Sen on income-based analysis of poverty.

Monetary dimension of poverty raises the need for choosing between income and consumption as measures of well-being. Consumption is strictly correlated to resource endowment and availability. Income is one of the key elements that allow consumption – together with access, availability etc.

Moreover, income assessment does not reflect the informal sectors and the households' production that can be consumed – typical in poor agrarian economies. It is difficult to assess the net income for farmer, excluding inputs for agricultural production. In general, consumption provides a better picture of actual standards of living than income. We use both variables, income and consumption to construct two indices of poverty, Lack of income and Lack of consumption.

Choosing and estimating poverty lines is one of the main issues, because often there is not a clear cut borderline between poor and non-poor individuals (Qizilbash, 2002). A good analysis of poverty should be at country level, using the national poverty line (NPL). An even better disaggregation would separate between rural and urban national poverty lines. Nevertheless, in a cross-country macro analysis such level of detail is difficult to manage. We use one of the absolute poverty lines (APL), equal to 2$ PPP. Absolute poverty lines derive from the assessment of resources needed to meet some basic needs.

The main reason for using APL is data availability; poverty rates and poverty gap at NPL are available for fewer countries than data with APL. A second reason derives from considering that in developing countries the largest share of population survives with the bare minimum or less. In such cases, it is better to rely on an ABL rather than NPL. We use the poverty gap and the poverty rate from WB WDI. Data refer to the most recent value between 2003 and 2007.

The following graphs show the average values of per capita real consumption of households' and the average real GNI per capita in 2007. Average GNIpc is the average GNI per capita, PPP (constant 2005 international $); Average CKpc is the average per capita household final consumption expenditure, PPP (constant 2005 international $).

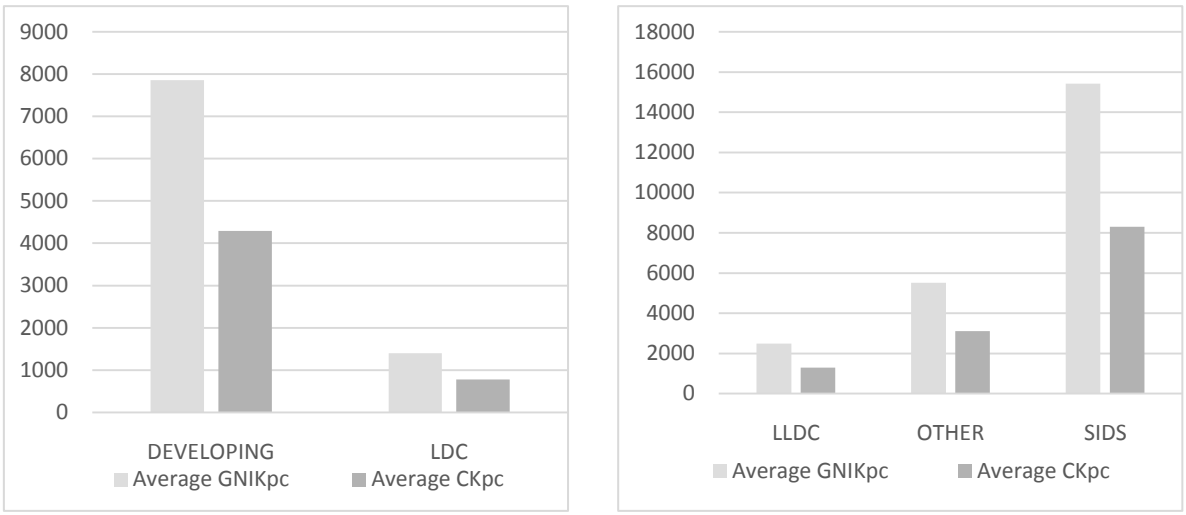


Figure 11: Average GNI and average real consumption per capita

As expected the average income and average consumption are higher in developing countries than in LDCs; this might be due to SIDSs. Looking at the average values by geographic group, on the right graph, we can see that SIDSs have the highest average real income among all the countries in the sample. The following graph shows the average values of poverty rate (Ph2$) and poverty gap (Pg2$) at the absolute poverty threshold of 2$, PPP in 2007, by geographic group.

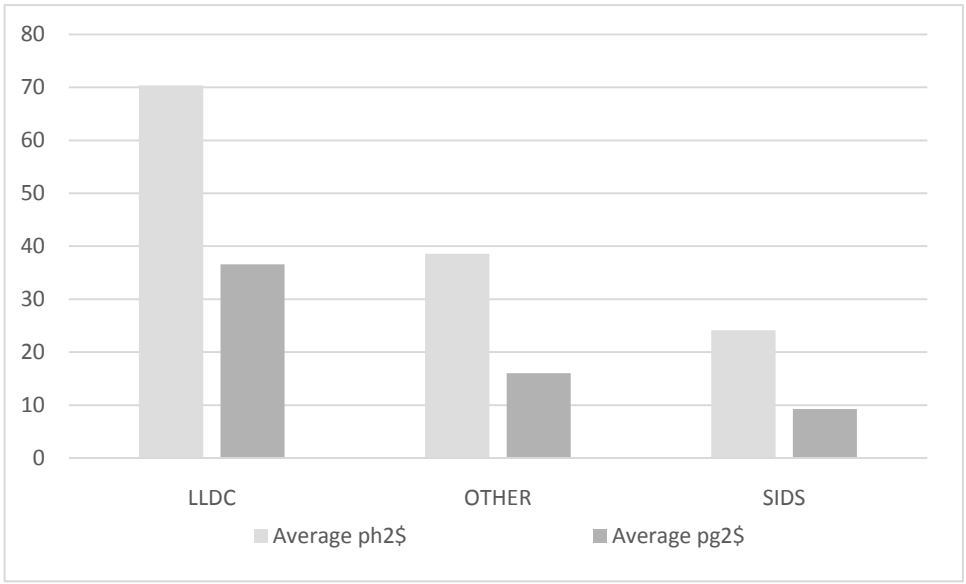


Figure 12: Poverty rate and poverty gap

LLDCs have the highest average value of poverty rate, almost 70% of the population lie below the 2$PPP poverty line. SIDSs appear to be the group with lower incidence of poverty.

2.3 Trade and financial aspects

International trade and financial markets have an equally important role to play in vulnerability. During economic and financial crises, international trade markets are heavily impacted: demand

for exports falls, commodity prices become highly volatile (either rising or falling sharply), and some strategic import commodities become prohibitively expensive for low-income populations in developing countries.

From the early 90s many countries have started to adopt an export-led growth model, in particular because of changes in US policy.

Despite the different schools of thought, there is agreement about the natural tendency of countries to expand beyond their national boundaries. Global economic integration leads to an interconnection of countries' production and financial structures, making them dependent on each other. Sometimes globalization becomes synonym for greater openness, linked to liberalization of domestic and foreign transactions. Trade liberalization, in turn, has been widely interpreted and associated to a reduced role for the State. Instead, disagreements arise over whether globalization brings destabilization and economic crises or not (Bairoch & Kozul-Wright, 1996).

2.3.1 International trade

It is widely acknowledged that the exposure to exogenous shocks depends on the degree of openness to the external environment.

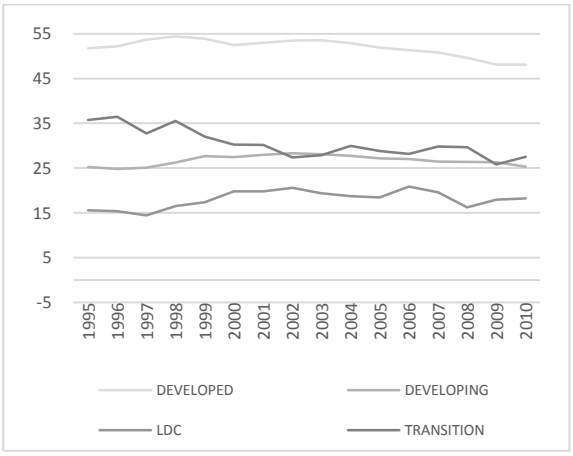
The majority of developing countries have joined the World Trade Organization (WTO) and have taken initiatives aimed at opening their economies. Nevertheless, the outcome has not been systematically positive since export performance sometimes remains inadequate. Integration into the world economy hardly substitutes for a development strategy. Openness has institutional prerequisites (a social safety net, WTO prerequisites, enforcement of property rights, etc.) that divert resources from alternative purposes, whereas the payoffs of this integration are limited (Rodrik, 2000).

Globalization forces generally cause small countries to have difficulties remaining competitive and retaining market share internationally. SIDS in particular should be focused on improving their economic specialization by enhancing the competitiveness of existing activities, and finding models of re-specialization should be policy objectives for many countries. On the other hand, technological progress provides countries with the opportunities to reduce certain handicaps and exploit new trading opportunities (Encontre, 1999).

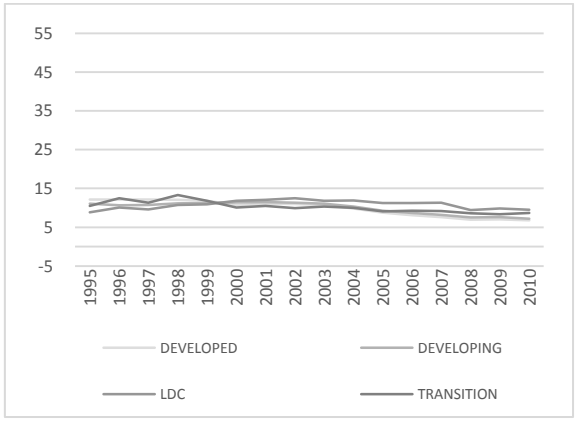
Raddatz (2007) documents a relatively larger impact but shorter persistence of commodity-price and interest rate shocks on the output of countries that are more open to trade. These findings are consistent with the idea that these countries are more exposed to fluctuations in international variables but also have better mechanisms to deal with them.

Globalization implies a global industrial readjusting. In the last decades, developed countries have shifted some labour-intensive industries of weak competitiveness to developing countries (Shangquan, 2000). The following graphs show trends in the composition of exports in all the countries – transition economies and developed countries included.

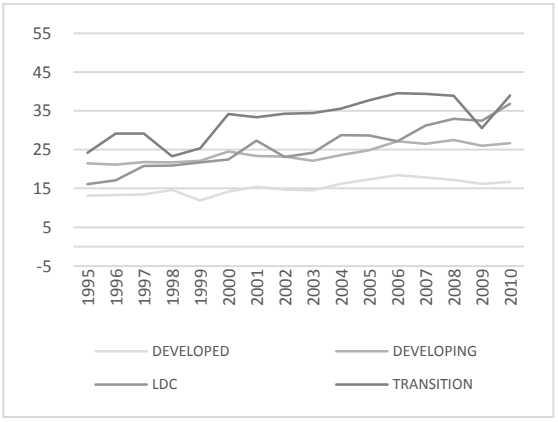
Average commodity exports to total exports (%)



Average manufactured exports to total exports (%)



Average labour-intensive and resource-based exports to total exports (%)



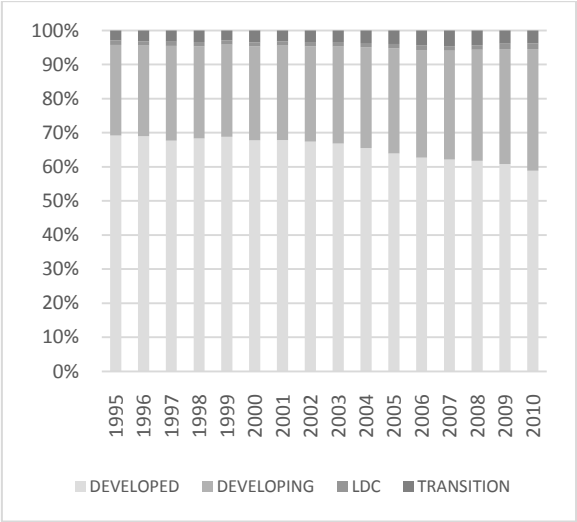
Average extractive industry exports to total exports (%)

Figure 13: Dependence on exports by group and good type

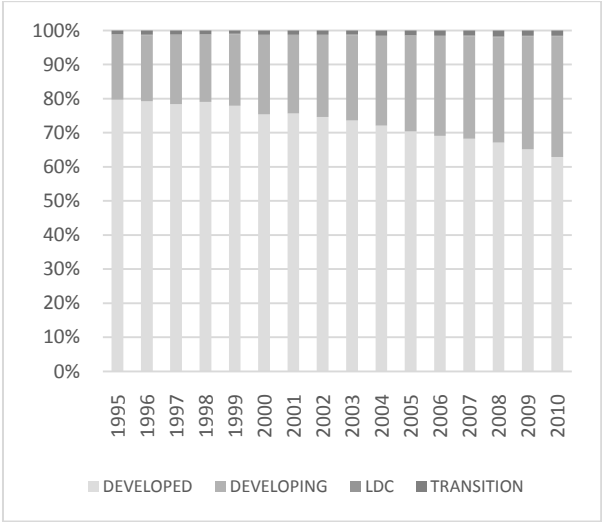
LDCs show a declining trend in the share of commodity exports to total exports, going from 42.51% in 1995 down to 33.36% in 2010. Despite their declining trend LDCs remain the most dependent on commodity exports, as shown in the figure before. Commodities expose the exporter to wide fluctuations in the export revenues because of their highly unstable prices.

If we look at the shares of groups to world market (in the figure below), we can see that developed countries represent the highest share of total exports in all the four categories. Nevertheless, developed countries show a declining trend in all categories. Developing countries

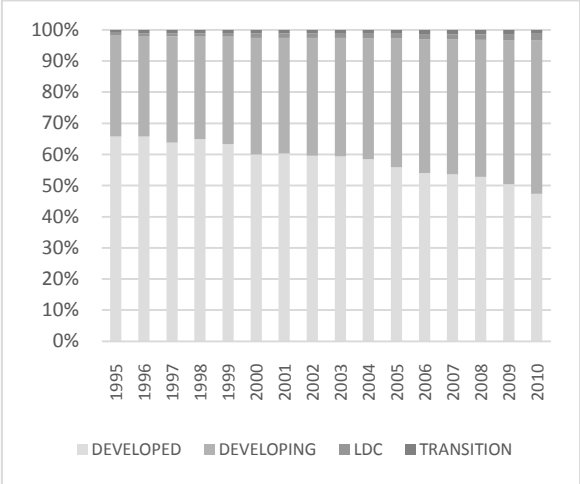
show an increasing trend in the average share of world exports that they represent. LICs, instead, represent a very low share of the world exports.



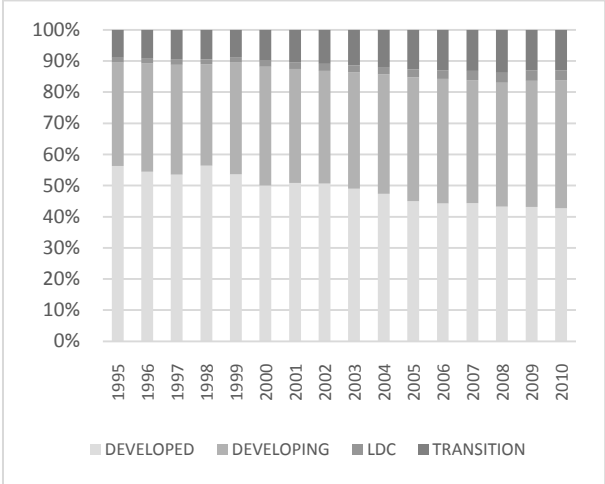
Average share of commodity exports to world commodity exports (%)



Average share of manufactured exports to world manufactured exports (%)



Average share of labour-intensive and resource-based exports to world LI-RB exports (%)



Average share of exports from extractive industry exports to world exports from extractive industry (%)

Figure 14: Average share of exported good to world exports by country group and by type of good

Openness to international trade correlates with several country characteristics, such as geographical location, insularity, landlocked-ness, country size and income. Large economies, for instance, trade more with themselves, small economies trade more with other countries, thus a small country is likely to show a higher value of openness-to-GDP ratio.

We constructed an index of *openness gap* from the expected level of openness, given country's characteristics. The index controls for influences of natural and demographical aspects. It is a

better measure than the traditional sum of exports and imports over GDP for cross-country comparison.

We ran a regression in order to compare trade openness across countries[17] – taking into account countries characteristics. We estimated the following regression:

$$O_i = \alpha_i + \beta_1 Y_i + \beta_2 Pop_i + \beta_3 LL_i + \beta_4 I_i$$

Where:
Y_i is the per capita GDP at purchasing power parity.
Pop_i is the population (country size is measured by country's population).
LL_i and I_i are dummies for landlocked-ness and insularity.
The following table shows regression results:

	Log(Openness)
Log(GDPpc PPP)	0.09784***
Log(Population)	-0.12663***
Landlocked	0.07172***
Island	-0.06672***
Constant	5.49598***
Observations	2432
R-squared	0.2826

Table 8: Openness to trade. Regression results

The estimation results indicate that GDP per capita is positively related to trade openness. A larger population instead corresponds to a lower openness.

Landlocked-ness is associated with a higher average value compared to the other countries. Insularity, instead, with a lower average value with respect to the group of other countries.

Regression residuals can be used to evaluate countries' openness. Positive residuals indicate that the country trades more than it can be expected, given its income level, its size and geographic characteristics. Negative values of residuals indicate that the country trades less than it can be expected (UNCTAD/WTO, 2012).

Exports

A trade-related economic shock can adversely affect economic growth by reducing a country's export revenues. If exports are an important component of GDP, a fall in exports and therefore in export revenues will lead to a decline in economic growth. Exposure to trade-related shocks can also be on account of imports. Price and supply shocks to major imports can lead to disruptions in the national economy that will hamper or reduce economic growth.

For an economic perspective, a country's exposure to external economic shocks generally depends on its reliance on exports because export earnings finance imports and contribute

[17] Transitions countries included.

directly to investment and growth. The size of the impact depends also on the mix of goods and services traded, the concentration of exports and imports (UNDP, 2011).

Concentration of exports

Concentration measures the degree of market concentration. We use the standardized Herfindahl-Hirschmann index published by UNCTAD. Values vary between 0 and 1, with 0 corresponding to absence of concentration (maximum diversification), 1 corresponding to maximum concentration. In formula:

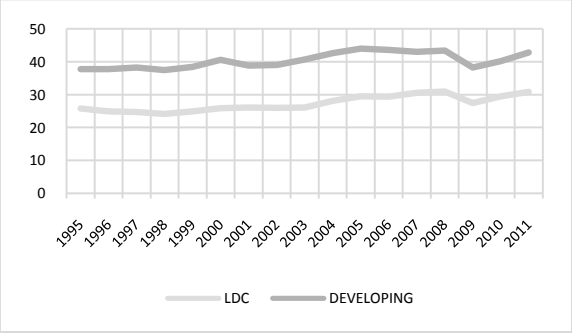
$$H_i = \frac{\sqrt{\sum_{j=1}^{n}\left(\frac{x_{ij}}{X_i}\right)^2} - \sqrt{\frac{1}{n}}}{1 - \sqrt{\frac{1}{n}}}$$

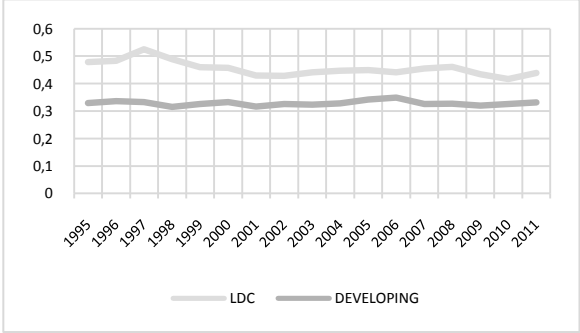
Where:
H_i is the value of concentration index for product i;
x_{ij} is the value of export for country j and product i;
$X_i = \sum_{i=1}^{n} x_{ij}$
n is the number of individual markets (countries) over the period considered.

$$H_i = \frac{\sqrt{\sum_{j=1}^{n}\left(\frac{m_{ij}}{M_i}\right)^2} - \sqrt{\frac{1}{n}}}{1 - \sqrt{\frac{1}{n}}}$$

Where:
H_i is the value of concentration index for product i;
x_{ij} is the value of imports for country j and product i;
$M_i = \sum_{i=1}^{n} m_{ij}$
n is the number of individual markets (countries) over the period considered.

Data reveal a slightly increasing trend in the importance of exports and imports over GDP in developing countries. The following graphs show the average percentage of exports over GDP and the average concentration of exports in developing countries and LDCs.





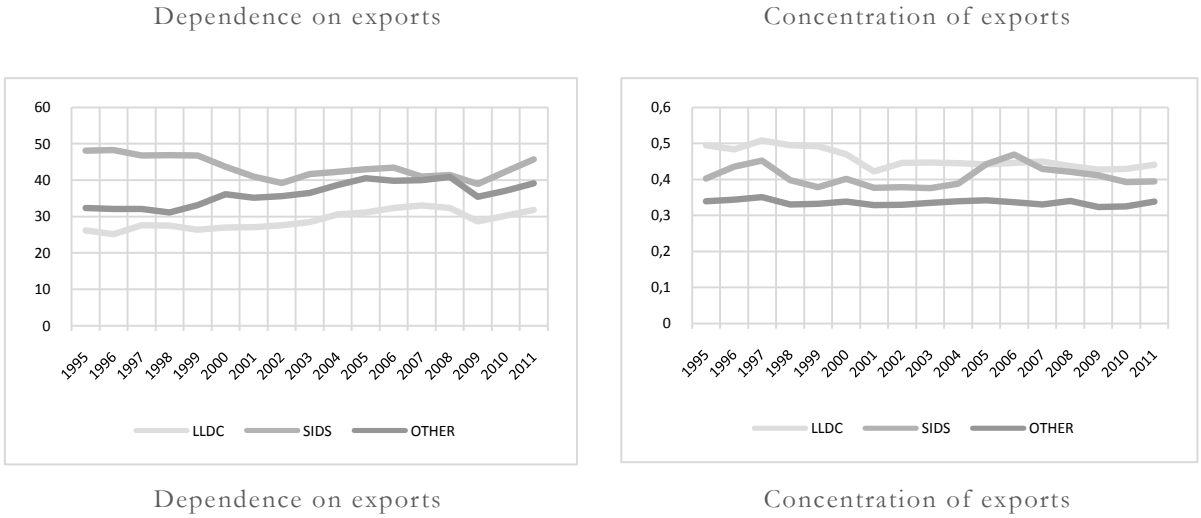


Figure 15: Dependence on exports and Concentration of exports by group

SIDSs tend to be more dependent on exports than the other developing countries. LDCs are less dependent on exports, but they depend on a fewer mix of goods – their concentration is higher than the concentration index of the other developing countries. LLDCs show a slightly decreasing trend in the export concentration. This pattern sustain Guillaumont's theory that LLDCs face higher costs than SIDSs in trading.

Volatility of exports

Exports' volatility is a proxy for the risk of shocks in the export revenues. For economies highly dependent on exports, the volatility in both export earnings and economic growth associated with economic shocks makes them extremely vulnerable (UNDP, 2011).

We used the Hodrick-Prescott Filter to get the cycle from the time series between 1995 and 2007 for each country. We then computed the variation coefficient of the cycle series and got the absolute value of variation coefficient. In formula:

$$|CV(X)| = \frac{\left(\sigma_{Xcycle}\right)_{1995-2007}}{\left(\mu_{Xcycle}\right)_{1995-2007}}$$

Dependence on strategic exports

As we saw before, LDCs trade more than the others in labour-intensive and resource-based goods and commodities. They show also an increasing trend in the exports of products from extractive industry. The following graph shows the average dependence on strategic exports in SIDSs LDCs and the other developing countries in 2007.

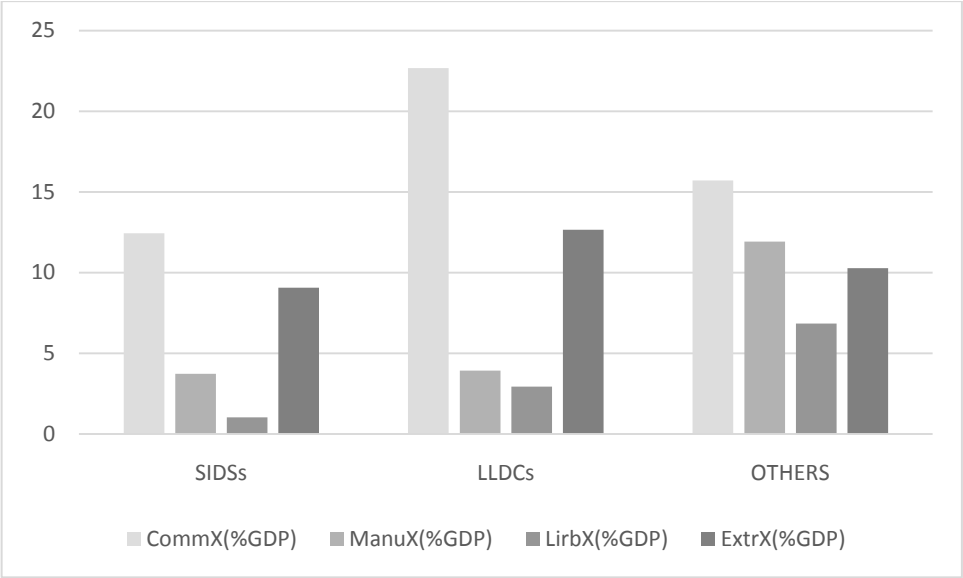


Figure 16: Average dependence on strategic exports

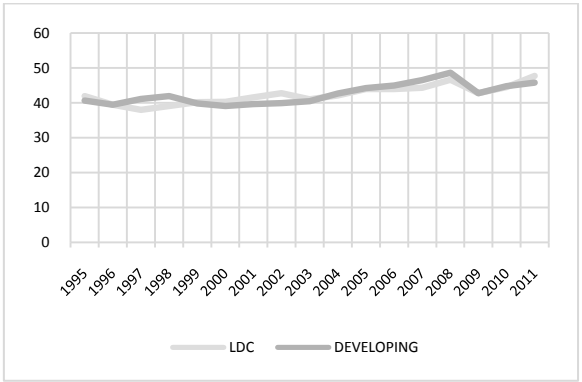
LLDCs are highly dependent on commodity exports with an average share over GDP equal to 22.67%. In general, commodities and products from extractive industries are the most important categories in the exports of developing countries.

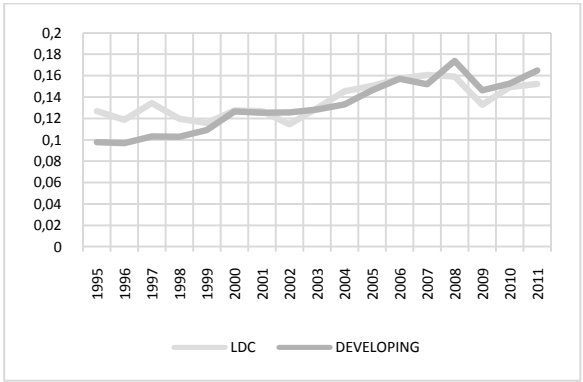
Imports

Exposure to trade-related shocks can also be on account of imports. Price and supply shocks to major imports can lead to disruptions in the national economy that will hamper or reduce economic growth.

Concentration of imports

Concentration measures the degree of market concentration for imports. As in the case of exports, we use the standardized Herfindahl-Hirschmann index published by UNCTAD. Values vary between 0 and 1, with 0 corresponding to absence of concentration (maximum diversification), 1 corresponding to maximum concentration. The following graphs show trend in the dependence on imports and the concentration of imports in developing countries and LDCs.





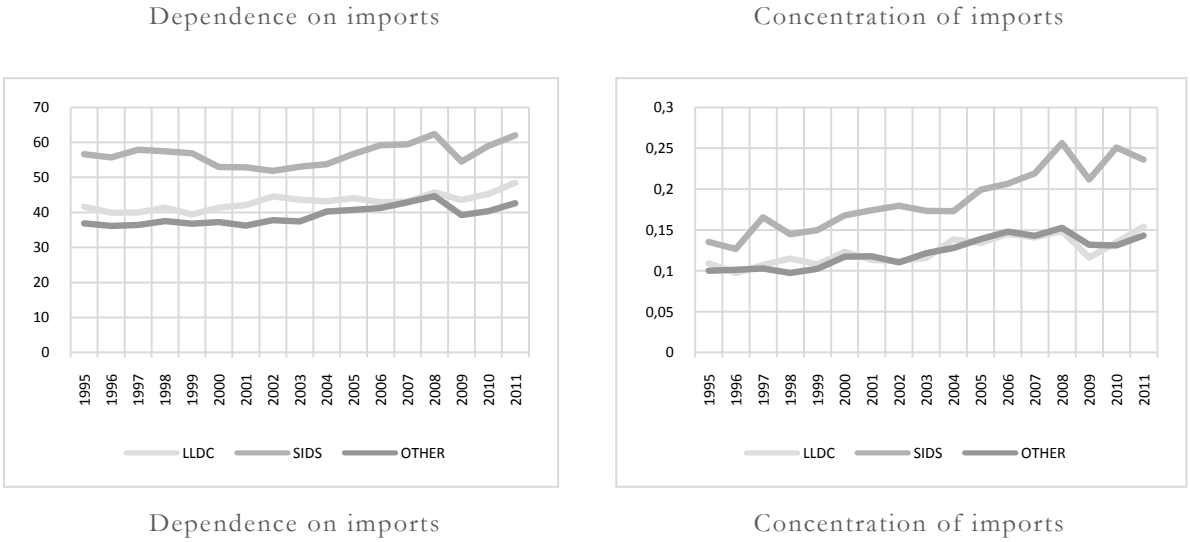


Figure 17: Dependence on imports and concentration of imports by group

Imports lie around 40-45% for both developing and LDCs. Concentration in imports show an increasing trend, going to 0.098 in 1995 to 0.152 in 2007 for developing countries, and from 0.13 in 1995 to 0.15 in 2007 for LDCs. When we look at the concentration by geographic category, we see that SIDSs show an increasing trend, and in general, their concentration has been always above the others since 1995.

SIDSs are also more dependent on imports than LLDcs.

Volatility of imports

As in the case of exports, volatility is a proxy for the risk of shocks in the imports that might come from price, quantity or exchange rate, as data are in current US$.

We used the Hodrick-Prescott Filter to get the cycle from the time series between 1995 and 2007 for each country. We then computed the variation coefficient of the cycle series and got the absolute value of variation coefficient. In formula:

$$|CV(M)| = \frac{\left(\sigma_{Mcycle}\right)_{1995-2007}}{\left(\mu_{Mcycle}\right)_{1995-2007}}$$

Dependence on strategic imports

Some imports are *strategic*. Dependence on strategic imports is a source of vulnerability because country cannot substitute such goods or services; consequently, it is exposed to price or volume fluctuations and to exchange rate fluctuations.

Food imports are important in developing countries because they affect households' wealth and purchasing power. Fuel imports are strategic because they represent an input for production and for mobility. Access to modern energy is essential for the provision of clean water, sanitation and

healthcare and for the provision of reliable and efficient lighting, heating, cooking, mechanical power, and transport and telecommunications services.

Energy and food are the main strategic because they satisfy the basic need for economic activity and life. The following graph shows the average values of imports of energy as percentage of energy use, imports of food and imports of fuel as percentage of households' consumption in 2007.

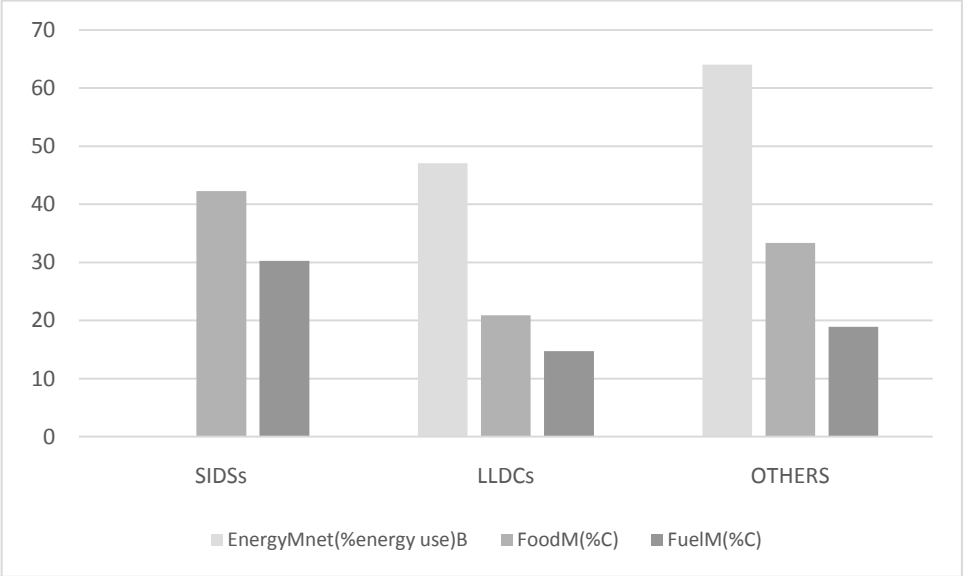


Figure 18: Dependence on strategic imports

Data on energy imports as share of energy use were not available for SIDS.

We ca see that SIDSs are highly dependent on food imports. LLDCs are less dependent than the other developing countries on energy imports; this might be because LLDCs are more dependent than the others are on exports of goods from extractive industry, which are related to energy.

2.3.2 International finance

Since the second half of 90s, private capital flows have become an important source of investment for many developing countries. Developing countries often do not have resources to fund their development and look at foreign capitals in the form of aid and investments.

Foreign Direct Investment

Even if private capitals tend to concentrate more on emerging economies, low-income countries are experiencing an increasing inflow of capitals (UNDP, 2011). Such situation exposes countries to financial shocks due to sharp declines in capital inflows.

Literature on the role of foreign direct investment (FDI) on economic growth shows contradictory results. The effect of FDI remains ambiguous. Domestic conditions in host countries are likely to make the difference in terms of positive effects of FDI inflows. FDI are

not sufficient to generate growth. Macroeconomic stability and high quality institutions are key for generating development from FDI (Alguacil, Cuadros, & Orts, 2011).

Domestic conditions like good governance are important for attracting FDI too. Democratic governments are associated with low country risk and debt risk. Debt risk is similar to the risk faced by multinationals investing abroad (Jensen, 2003). Generally speaking, capital inflows reduce the cost of capital, they might complicate macroeconomic management. A lower cost of capital stimulate investment and consumption, but large capital inflows put upward pressure on the exchange rate, making exports less competitive.

Capital inflows might be volatile and affect macro-financial stability with sudden reversal flows, like in the case of Indonesia in 2008 with SBI holdings by non-residents, and Korea with the reversal of bank's short-term debt inflows (IMF, 2011).

FDIs are less volatile than many other types of private capital flows (such as PIs or short-term loans), yet they remain an important source through which developing countries are exposed to the impacts of economic and financial crises. Over the past two decades, many developing countries have become increasingly reliant on FDIs to finance new investments. Of course, investments in new capital are the primary driver of economic growth and job creation, and FDIs also contribute to economic growth by promoting productivity-enhancing technological transfers from advanced to developing countries. This increased reliance, though, means that any shock to FDIs directly impacts economic growth and job creation. The volatility of foreign direct investments is not just harmful in the short term (a reduction in foreign investment immediately registers as lower GDP or lower economic growth), but empirical studies have shown that highly volatile FDIs are associated with a lower growth trajectory in the long run (Guillaumont, 2010).

The following graph shows the evolution of dependence on FDI inflows by type of country.

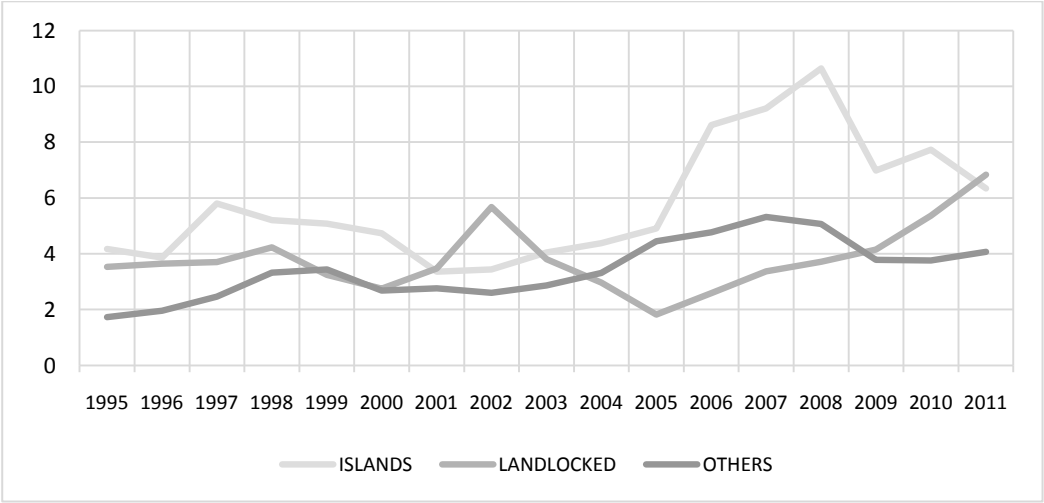


Figure 19: Dependence on FDI – FDI (%GDP)

Island countries experienced an increasing dependence on FDI inflows from 2005 up to 2008. Landlocked countries have started to increase their dependence on FDI in 2005 too, but the trend is still increasing.

Official development assistance and official aid

ODA is another important, yet volatile source of external finance that many developing countries depend on. High dependence on aid accentuates macroeconomic vulnerabilities because it leaves countries exposed to sharp fluctuations in the overall volume of aid as well as donor preferences for the purposes to which aid is put. The procyclicality of aid can exacerbate rather than mitigate the impact of financial and economic crises, and much evidence suggests that, on average, aid is indeed procyclical. Where aid is volatile or unpredictable, recipient governments are less able to plan expenditures effectively.

ODA flows have changed over the last years in relation to donors and beneficiaries, modalities and reasons for aid in general. Aid from DAC OECD donors has increased a lot; net ODA from DAC donors of the OECD increased from 53.9 billion of USD in 2000 to 128.7 billion of USD in 2010. Nevertheless, also non-OECD DAC donors have increased in the recent years highlighting the importance of the so called "South-South cooperation", which was equal to 15.3 billion of USD in 2008 (UNDP, 2011).

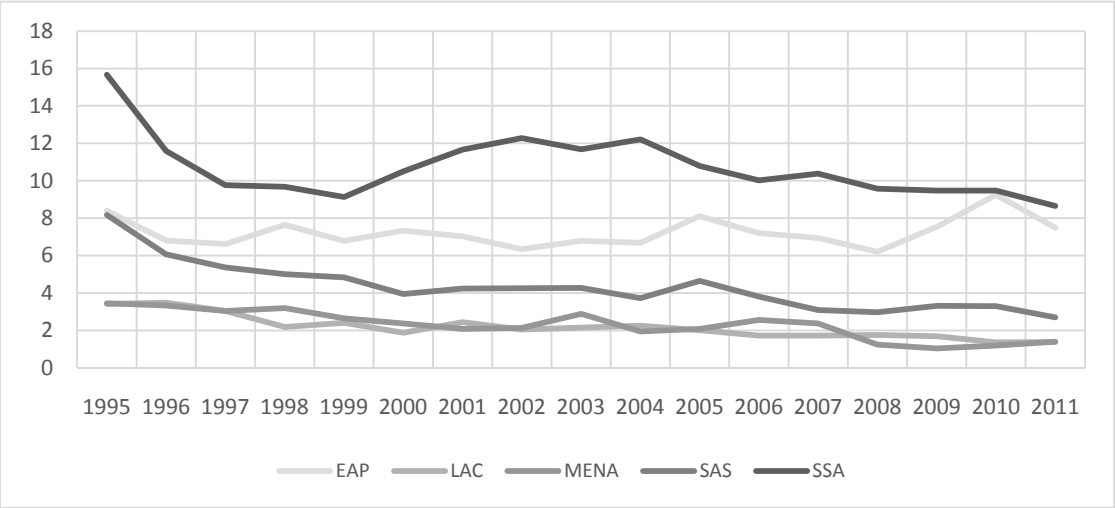
There is a strong debate on the benefits of international aid. Often aid is considered as useless because it is wasted and it represent unproductive public expenditure. Usually arguments against international aid use corruption and quality of institutions as a reason, nevertheless, the pattern of aid flows play a role. A non-democratic former colony, for example, gets almost twice as much aid as a democratic non-colony. "From the point of view of efficient aid, each of the "big three" donors—U.S., Japan, and France—has a different distortion: the U.S. has targeted about one-third of its total assistance to Egypt and Israel; France has given overwhelmingly to its former colonies; and Japan's aid is highly correlated with UN voting patterns (countries that vote in tandem with Japan receive more assistance). These countries' aid allocations may be very effective at promoting strategic interests, but the result is" (Alesina & Dollar, 2000).

On the other hand, aid is considered as an effective tool for reducing poverty, risk of conflict and assisting policy reforms, depending on the circumstances. Aid allocation is a political process in which donors' information and influence on government preferences in recipient countries make the difference (Collier & Dollar, 2004).

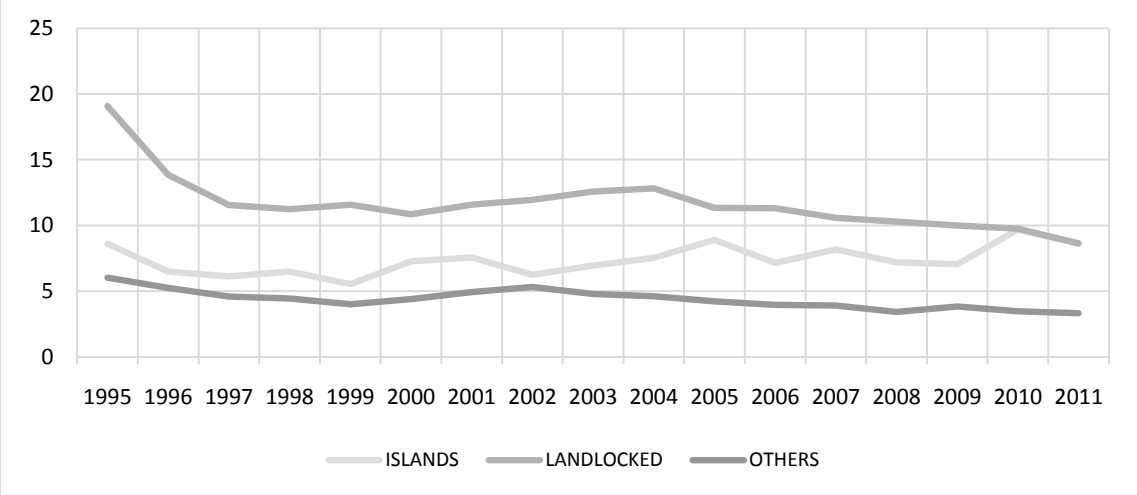
Part of the literature on international aid highlights the negative aspects of dependence on aid. Arguments against aid dependence refer mainly to the shift in government accountability to

donors. This is likely to promote corruption in the recipient country (McPherson & Gray, 2000). Good policies for reducing dependence on aid are based in investments. Strengthening policies and institutions that promote public and private investment increases the likelihood of exiting from heavy reliance on aid (Hailu & Shiferaw, 2012).

The following figure shows the evolution of dependence on aid by geographic region and by geographic aspects. Data refer to the Net official development assistance and official aid received as percentage of GDP.



Dependence on aid by geographic region[18]



Dependence on aid by geographic characteristics

Figure 20: Dependence on aid

[18] EAP East Asia and Pacific; LAC Latin America and Caribbean; MENA Middle East and North Africa; SAS South Asia; SSA Sub-Saharan Africa

Sub-Saharan Africa and East Asia and Pacific show the highest percentages of aid over GDP. The overall trend in aid dependence is decreasing. EAP countries received more aid, with respect to the past, between 2008 and 2010. If we look at the second graph, we can see that the declining trend is confirmed. Land-locked countries receive on average the highest share of aid, because they are mainly SSA countries.

Public external debt

Fiscal capacity determines whether a country can afford to take on additional debt to cope with or to counteract the impact of economic crises. If a country has adequate fiscal capacity, it can maintain public spending, even increase it by adopting fiscal stimulus packages and consequently be more resilient in the face of an economic or financial shock.

Even in the absence of any additional fiscal spending—for example, fiscal stimulus packages—in the aftermath of the crisis, governments might still suffer from limited fiscal capacity during economic crises. Fiscal accounts are highly procyclical in the developing world: tax revenues rise during periods of economic growth when incomes rise and fall during recessions when incomes fall, while government expenditures might rise during periods of growth, but do not fall during recessions. Therefore, fiscal capacity is automatically reduced during recessions even before government considers any additional post-crisis fiscal spending. Moreover, it becomes difficult or expensive to borrow the funds necessary to finance government spending during economic downturns, especially if the downturn is also associated with a financial crisis. Therefore, in order to strengthen coping capacity in the face of shocks, government needs to adopt policies that expand fiscal capacity.

The stock of external debt derives from domestic, but also from external factors, such as shock in the terms of trade for commodities, governance failures, conflicts, bad debt management etc. The problem of heavily indebted poor countries has shifted the attention on the debt sustainability issue.

We concentrate on the role of external debt in macroeconomic vulnerability, without considering the domestic public debt, for the moment, because of their differences in terms of behaviour and currency denomination.

IMF and the World Bank found evidence of different behaviour between domestic debt and external debt after external shocks, particularly in Low-income countries. "Like external debt, domestic debt increases sharply before debt distress; it however behaves differently from external debt after the onset of debt distress. […] But it is in the behaviour after the onset of repayment difficulties where domestic and external debt behave differently: domestic debt declines on

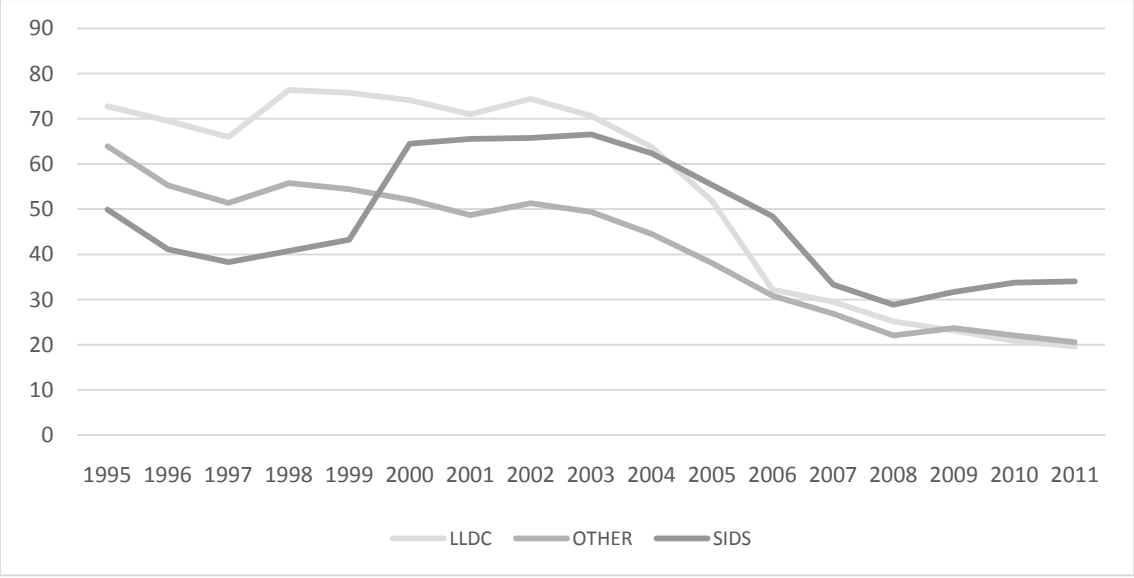
average by about one percentage point of GDP per year, whereas external debt increases by ten percentage points of GDP per year" (IMF & WB, 2010).

Moreover, a high level of external public debt hampers government's ability to cope with shocks because of the high risk of default due to exchange rate fluctuations and high interest rates, as external debt is usually denominated in foreign currency.

The high cost of servicing public external debt causes a substantial outflow of financial resources that cannot be used to stimulate the domestic economy.

External debt is usually denominated in foreign currency. A country can refer to foreign currency inflows (exports revenues, remittances, other financial inflows), foreign reserves and more foreign borrowing to repay external debt or to domestic revenues. In any case, a depreciation of domestic currency leads to an increase in outstanding foreign obligations, which increases the default risk.

The following figures show the average percentage of external debt public and publicly guaranteed over GDP; the average debt service on external debt public and publicly guaranteed, as percentage of GDP, by geographic group.



Average PPGED (%GDP)

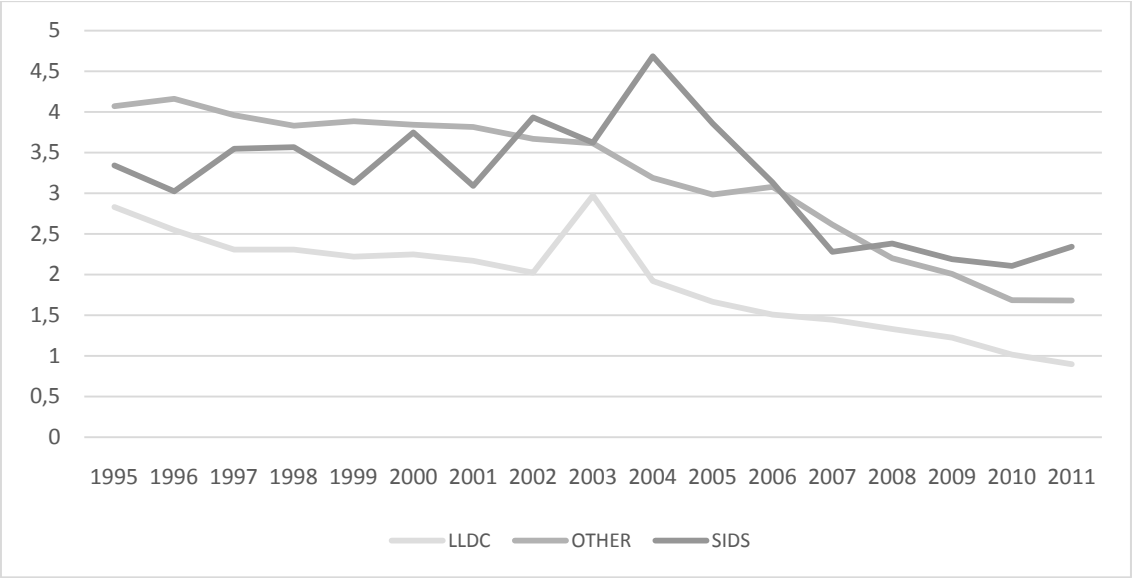


Figure 21: Trends in the External debt by group

There is a declining trend in the shares of PPGED, even if the public external debt in SIDSs has started to increase since 2008.

Debt service is the sum of principal repayments and interest actually paid; it is a proxy for debt sustainability. There is an increasing trend in the DSPPGED for SIDSs starting from 2010. On average, the overall trends in the debt service are decreasing.

Ch3. Methodology and Model

In this section, we provide the underlying rational and justification for using PLS approach to estimate macroeconomic vulnerability. Then, we illustrate several different models we tested and finally we present the results for the best model specification.

3.1 Methodology

3.1.1 Structural equation modeling (SEM) – A short history

The use of latent variable is not new in statistics. The idea that observable phenomena are influenced by underlying unobservable causes is part of individual cultural knowledge. Latent variables find wide application in everyday living, describing feelings, work efficiency, students' brightness and tons of other abstract concepts we usually deal with.

The scientific use of latent variables "provide a degree of abstraction that allows us to describe relations among a class of events or variables that share something in common. [..] In other words, latent variables permit us to generalize relationships" (Bollen, 2002, p. 606).

Although latent variables are widely used, there is not a general definition for a latent variable. Bollen (2002) lists a series of sets of definitions:

- Hypothetical variables definition. Hypothetical constructs derive from researchers' imaginations. According to such definition, latent variables are hypothetical constructs. Thus, they are abstract concepts arising from imagination.
- Unobservable/unmeasurable variables. Latent variables are variables that cannot be directly measured[19].
- Data reduction device. Such a definition describes latent variables as a tool to obtain parsimonious models describing the observed data. Latent variables become a synthesis of manifest variables.
- Local independence. This is one of the most important and widely used definitions. The basic idea is that one or more latent factor affect the same observed variables, creating a relationship among them. In other words, the correlation among a set of manifest variables might be due to one or more latent variable that affect these manifest variables.
- Expected value. The latent variable is the "true score". The true score is the expected value of the observed variable for a particular individual. Of course, this definition considers the latent variable as the result of a hypothetical infinitely repeated experiment.

[19] Karl Joreskog (1982) agrees with this definition.

- Non-deterministic function of observed variables. The latent variable is a variable that cannot be expressed as a function of manifest variables only. It means we cannot exactly determine the manifest variable; the latent variable is a nondeterministic function of the manifest variables. We can estimate latent variable, but we cannot make an exact prediction based on its observed variables.
- Sample realization. Arises from social sciences and psychology. Individuals' properties, such as intelligence, depression, happiness, inspire this concept of latent variable. Psychology and sociology hypothesize relations among individuals' properties; for instance, depression reduces self-esteem. Self-esteem and depression are latent variables. "A latent random (or nonrandom) variable is a random (on nonrandom) variable for which there is no sample realization for at least some observations in a given sample." (Bollen, 2002, p. 612) Such a definition is relative, because the same variable may be latent just in some samples, and observed in other samples.

SEM include several statistical methodologies to assess a set of causal relations among latent variables (structural model). Observed indicators, called *manifest variables*, measure the latent variables through the assessment of parameters that link each latent variable to its own manifest variables (the measurement model).

SEM parameters may be estimated through two different approaches:

- Covariance-based (CVB) approach estimates covariance between manifest variables;
- Component-based (CPB) approach estimates common latent components.

The SEM approach starts in the 70s with scholars Herman Wold, Karl G. Jöreskog and Dan Sörbom (Jöreskog & Wold, 1982).

Jöreskog and Sörbom developed the LISREL software.[20] LISREL stands for LInear Structural RELations and is one of the most powerful software for covariance analysis.

Herman Wold developed partial Least Squares SEM as an alternative to covariance-based SEM (LISREL-type models).[21] PLS-PM is a component-based approach where the causality is meant in terms of linear conditional expectations. Wold introduced the PLS SEM as *soft modeling* technique in order to underline the different methodology with respect to LISREL SEM. Soft modeling refers to the ability of PLS to exhibit greater flexibility in handling problems when it is difficult to

[20] See (Bollen, 1989) for history of LISREL (covariance-based) SEM

[21] See (Jöreskog & Wold, 1982) fo a comparison between LISREL and PLS SEM

meet hard assumptions of more traditional multivariate statistics (Esposito Vinzi, Chin, Henseler, & Wang, 2010).

3.1.2 Covariance-based SEM

The general forms of SEMs (also called LISREL *models*) incorporate most of the models listed before. It is common in general SEM to distinguish between two sub-models: the structural model that relates latent variables, and the measurement model that relates each latent variable with its own manifest variables. The measurement model is necessary in order to assess the latent construct behind the manifest variables. Once we get an estimation of the latent variables, we can go on estimating relations among latent variables. In order to describe the equations of a general CB SEM, we use here notation as in Bollen (2002):

$$\eta = \alpha_\eta + \mathrm{B}\eta + \Gamma\xi + \varsigma$$

$$Y = \alpha_Y + \Lambda_Y\eta + \varepsilon$$

$$X = \alpha_X + \Lambda_X\xi + \delta$$

The first equation is the *structural model* (or latent variable model), where η is a vector of latent endogenous variables; B is a matrix of regression coefficients of the impact of the endogenous latent variable on each other. ξ is the vector of latent exogenous variables, and Γ is a matrix of regression coefficients of the latent exogenous variables' impact on the latent endogenous variables. α_η is a vector of equation intercepts, and ς is the vector of latent disturbances.

The second and third equations are the *measurement models*. Y and X are vectors of observed variable – for endogenous and exogenous latent variables respectively. Λ_Y and Λ_X are matrices of factor loadings that relate Y to η (endogenous latent variables vector) to ξ (exogenous latent variables vector).

We can say, in general, that CB SEM helps in testing theories and developing sensometric theories, but it does not focus on explaining variance and prediction.

3.1.3 Component-based SEM

Partial least squares (PLS) is a type of regression-based methods designed for analyzing high dimensional data in a low-structure environment. Herman Wold proposed such methodology in the sixties. The basic idea was to introduce "soft models and soft data" with a strong focus on prediction. Wold considered the informational and distributional demands of LISREL, EQS etc. as unrealistic. Moreover, he claimed that estimation and description had been put into focus, at the expense of prediction. Wold was a sustainer of the recursive modelling, where every single

equation could be used for prediction and every parameter had a predictive interpretation, against the simultaneous equation modelling. For the latter type of model, Wold developed the so-called Fix-Point estimation method. Such a method is based on a predictive reinterpretation of the models, where the parameters are estimated iteratively by simple regressions – using least squares as overall predictive criterion. In 1966 this approach was extended to principal components and factor analysis. Parameters are divided into subsets so that keeping fixed any one of the subsets at predetermined values, the remaining set of parameters would solve the regression problem. Roles would be reversed and the regressions are to be continued until consecutive values for the parameters differ less than a prefixed value (Esposito Vinzi, Chin, Henseler, & Wang, 2010).

PLS-PM is a component-based estimation procedure. The iterative algorithm separately solves out the blocks of measurement models and then estimates the path coefficients in the structural model. The following figure shows the PLS-PM estimation method:

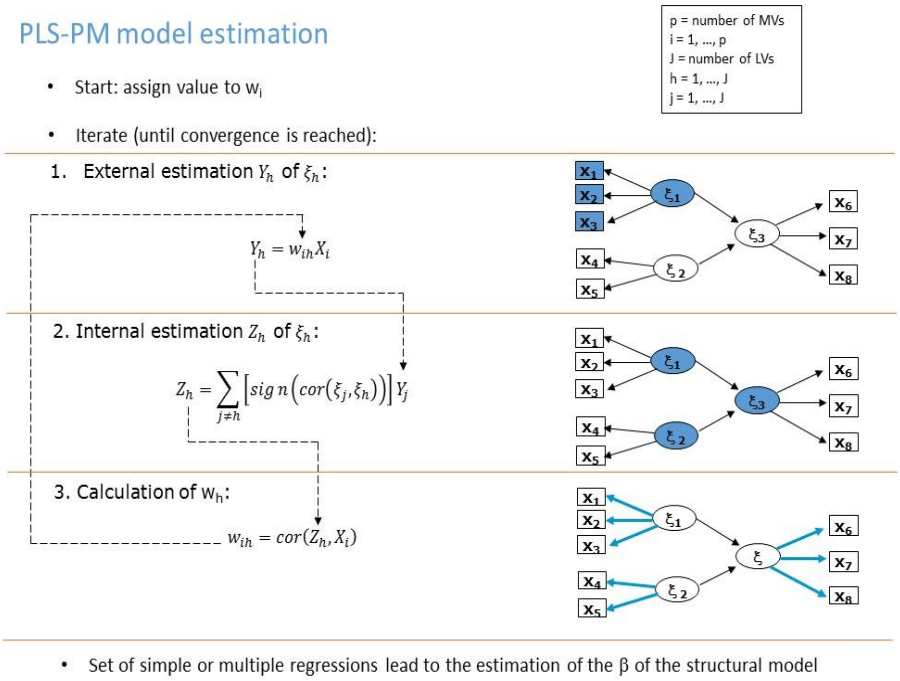


Figure 22: PLS-PM model estimation

PLS-PM is composed by two sub models: the structural model and the measurement model.

The **structural model** can be expressed as follow[22]:

$$\xi_j = \beta_{0j} + \sum_{q=\xi_q}^{\xi_j} \beta_{qj} \xi_q + \varsigma_j$$

[22] We use notations like in the (Esposito Vinzi, Chin, Henseler, & Wang, 2010)

Where:

ξ_j $(j = 1, \dots, J)$ is the endogenous latent variable; β_{qj} is the path coefficient that relates the qth exogenous latent variable to the jth endogenous latent variable; ς_j is the residual.

The **measurement model** depends on the direction of the relation between the latent variable and the manifest variables. Three different types of measurement models are available:

- The *reflective model* (or outwards directed model, or "Mode A"), in which manifest variables depend on the latent variable.
- The *formative model* (or inwards directed model, or "Mode B"), where the latent variable depends on manifest variables.
- The *MIMIC model*, a mixture of the reflective and formative models.

In **the reflective model**, manifest variables are consequences of the latent variable, and are the endogenous variables in the measurement model. As a consequence, changes in one manifest variable imply changes in the others. Each block of manifest variables relating to a single latent variable is assumed to be homogenous and unidimensional.

Each manifest variable is related to its latent variable by a simple linear regression:

$$x_{pq} = \lambda_{p0} + \lambda_{pq}\,\xi_q + \epsilon_{pq}$$

Where:

λ_{pq} is the loading associated to the pth manifest variable in the qth block; ϵ_{pq} is the residual assumed to have zero mean and being uncorrelated with the latent variable.

In the **formative model**, manifest variables represent a different dimension of the underlying concept (the latent variable). There are no homogeneity nor unidimensionality assumptions in the formative model. Manifest variable do not need to covary and internal consistency is not an issue. (Esposito Vinzi, Chin, Henseler, & Wang, 2010)

The measurement model can be written as follow:

$$\xi_q = \sum_{p=1}^{P_q} \omega_{pq}\, x_{pq} + \delta_q$$

Where:

ω_{pq} is the coefficient that links each manifest variable to the corresponding latent variable; δ_q is the error and represents the share of the latent variable that is not accounted by the block of manifest variables.

The assumption is that $E(\xi_q | x_{pq}) = \sum_{p=1}^{P_q} \omega_{pq}\ x_{pq}$

Apart from measurement type, the standardized latent variable scores $(\hat{\xi}_q)$ are computed as linear combination of its manifest variables. Weights derive from convergence of the algorithm and transformed to produce the standardized latent variable scores:

$$\hat{\xi}_q = \sum_{p=1}^{P_q} w_{pq}\ x_{pq}$$

Where:

x_{pq} are centred variables and w_{pq} are the outer weights.

In PLS-PM the iterative procedure permits to estimate the outer weights and the latent variable scores. Estimation is partial (that is why *partial* least squares) because the procedure solves blocks once at a time by means of alternating single and multiple linear regressions.

3.1.4 PLS-PM SEM vs CBSEM

Rather than being competitive, the use of PLS could be considered as complementary to CBSEM, because it can be better suited depending on the specific empirical context and objectives of the analysis. In this paragraph we list the most important reasons for using PLS.

Degree of emphasis on covariance explanation

CBSEM researchers usually rely on the goodness of fit indices without considering the full suite of information that should also be used to evaluate the adequacy of the model being considered (Chin, 1998).

Nevertheless, the goodness of fit measures relate only to how well the parameters estimates match the sample covariances. Models with good fit indices may still be not good according to other measures such as the R-square and factor loadings. CBSEM algorithm considers the specified model as true and finds the best fitting parameters estimates.

Moreover, model misspecification can have a strong impact in CBSEM; path coefficients can be quite different if a relevant path is left out. That is why CBSEM are suggested for confirmatory analysis only; they require a strong theoretical and substantive background knowledge. PLS estimates instead are limited to the immediate blocks to which a construct is structurally connected.

Soft distributional assumptions

PLS is based on predictor specification. PLS approach does not make hard assumptions of specific joint multivariate distribution and independence of observations – as covariance-based maximum likelihood estimation does. Because of that, traditional parametric-based tests for significance would not be appropriate. Given its distribution-free approach, evaluation of PLS models should apply prediction-oriented measures that are also non parametric. Usually the R-square for dependent latent variable and bootcross validation are among the most used approaches to assess predictiveness, while resampling procedures such as jack knifing and bootstrapping are used to examine the stability of estimates.

Exploratory in nature

PLS is appropriate for exploratory studies where theoretical knowledge is relatively poor. CBSEM employ a full information maximum likelihood estimation that yields consistent parameter estimates under the assumption that the specified model is a true model. Nevertheless, weak or inappropriate measures for latent variables or misspecified structural models can bias estimations. Since PLS is a limited-information component-based approach, it tends to be less affected by misspecifications and inappropriate measures.

High model complexity as criterion

Models approximate reality. Because of that, models are always incomplete. As a consequence it is important to evaluate how and to what degree the model is true. SEM evaluation criteria focus on the falsity of model, rather to its completeness. CBSEM algorithm is very complex; it requires inverting matrices, and it makes it hard managing large models. Moreover, as the number of items increases (*i.e.* as model complexity increases), the chance of getting poor model fits increases too. Therefore, it is likely to make wrong evaluations because of CBSEM focus on falsity. Component-based methods are useful if one focuses on the complex interrelations among a large set of factors – that could be difficult to capture using CBSEM.

Sample size requirement

Sample size requirements of the PLS algorithm are smaller than requirements of CBSEM algorithm. In order to verify whether the sample size is sufficient to insure accuracy and statistical power, one should identify the dependent variable (at either measurement level or structural level) that has the highest number of predictors. Esposito Vinzi and colleagues (2010), make a good example that shows the difference between CBSEM and PLS in managing large numbers of constructs. Let us assume we have 100 constructs each with 100 reflective indicators. Estimating such a model with CBSEM requires calculating the covariances between the 10000 indicators. This means a lower triangular matrix of 50005000 variances and covariances. Since measurement

models are reflective, each dependent variable has only one predictor (the latent variable). The PLS only performs a series of simple OLS regressions. As a consequence, the sample size can be relatively small compared to the complexity of the model – within the PLS framework.

Accuracy of parameters estimation

One of the critiques to PLS is that estimates are not efficient or potentially biased compared to CBSEM estimates. Critics start from the assumption that PLS estimated scores are inconsistent relative to CBSEM approach because PLS components are aggregates of the observed variables and include measurement errors. The difference between the "true" parameter and the estimates will decrease when both the number of indicators per construct and the sample size increase. This is the so-called "consistency at large" problem. Critiques are true, but what if the underlying population model is not covariance-based? Estimated biases were calculated on the covariance-based ML estimation that assumes the underlying model is "true" and the generated data are covariance-based. Maximum likelihood estimation (which is frequently used in covariance structure analysis) is only efficient and unbiased when the assumption of multivariate normality is met. Schneeweiss (1990) argued that PLS can be a consistent estimator as long as we ask the question of which population parameters we are trying to estimate.

PLS can also be used for testing the adequacy of indicators as predictors and for suggesting potential relations among blocks of indicators.

Formative measurement

CBSEM only allows for reflective measurement models; manifest variables are assumed as affected by the latent variable. In order to understand whether a block of manifest variables reflects or forms a latent construct, one should check how and if the change of one of the MVs affects the other MVs. If a change in one of the MVs is coupled with a change of all the other MVs in a similar manner, then a causality and unidimensonality is verified; the reflective way is good. Alternatively, if a change in one of the MVs does not affect the other MVs, then items suggest multidimensionality, and the model may be formative. If there is multidimensionality, the resulting CBSEM estimates would be invalid.

A LV with formative indicators must be connected to at least one other LV to yield meaningful information, because the multiple regression weights that PLS estimates are intended to overlap with neighboring LV blocks. Without structural links, the weights would be identical. Instead, reflective measurement models form the single best score to best predict its own measures (*i.e.* the first principal component).

High order molar and molecular construct scores

High order latent variables are useful for managing levels of abstraction that goes over the first order used in basic models. There are two types of higher order constructs: the molecular second order construct, where arrows go from the second order construct to the first order constructs. The molar second order construct, where arrows go from first order constructs to the second order construct.

CBSEM are limited to the second order molecular construct. PLS allows for managing either molecular or molar second order constructs.

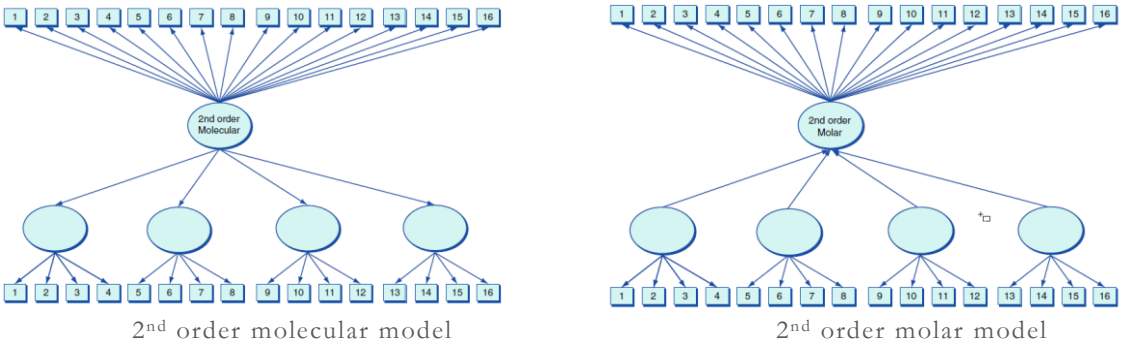


Figure 23: Types of second order structural models. *Source: (Esposito Vinzi, Chin, Henseler, & Wang, 2010)*

3.2 MEVI – Measurement models

In this section, we describe the specification of the Macroeconomic vulnerability index (MEVI). The MEVI integrates the Macroeconomic Vulnerability Assessment Framework (MEVAF) developed by Anuradha Seth, Amr Ragab and Ambra Altimari within the MEVAF project at UNDP[23]. We use a methodology that has never been used before in the assessment of economic vulnerability; the multilevel PLSPM structural equation modelling to construct a systemic model that allows us to analyse the overall interactions among all the manifest variables, in order to derive a measure of the *actual* total vulnerability.

Such methodology better suits the innovative definition of vulnerability that we propose. We propose a new concept of economic vulnerability and resilience as abstract concepts that we cannot directly observe. Vulnerability is the status that results from the complex interaction of factors that increase the exposure to exogenous shocks, and factors that increase the coping capacities.

We define a superblock latent variable, the *vulnerability*, as a macro-variable. We decompose the macro-variable into 11 possible sub-systems (latent variables) that, in turn, group 36 manifest variables. Such innovative approach allows us to capture the direct and indirect effects of the 11 sub-systems on the macro-systemic vulnerability.

[23] UNDP/Poverty Reduction Group Guidance Note: Macroeconomic Vulnerability Assessment Framework: A Practical Guide, Jan 2014, being printed

Structural equation models can be divided into two parts; the measurement models and the structural model. The measurement model connects a group of observable variables (manifest variables) to one latent variable.

Measurement model specification is not easy. Lot of tests need to be implemented. Sometimes it is necessary to transform variables in order to satisfy model requirements. Verifying what the latent constructs are measuring is necessary in every single step in order to be sure about what the latent variable indicates. We tested tens of different specifications to find the final specification that is coherent with theoretical meaning of latent variables.

We started with a set of MVs to test several model specifications. We constructed a large database getting data from World Bank, UNCTAD and the International Disaster Database EM-DAT[24]. We attempted to cover all the areas that scholars consider as potential source or consequence of economic vulnerability.

The following table lists all the MVs we use in the model. For a detailed explanation about definition, source and reference year of every single variable, see the Annex A.

MAIN AREA	VARIABLE NAME
GEOGRAPHICAL ASPECTS	Country surface (log)
	Country population (log)
	Population affected by natural disasters (%)
	Average economic damage from natural disasters (%GDP)
	Natural disasters per year
	Geographic distance
	Cost to export (% Average world cost to export)
SOCIO-ECONOMIC ASPECTS	Public expenditure (%GDP)
	Domestic investment (%GDP)
	Industry value added (% Total Added Value)
	Service value added (% Total Added Value)
	Primary school enrollment (net)
	Primary completion rate
	Progression to secondary school
	Secondary school enrollment (net)
	Tertiary school enrollment (gross)
	Control of Corruption (0-100 rank)
	Government effectiveness(0-100 rank)
	Political Stability and Absence of Violence/Terrorism (0-100 rank)
	Rule of Law (0-100 rank)
	Regulatory Quality (0-100 rank)
	Voice and Accountability (0-100 rank)
	Poverty gap
	Poverty headcount
	Real GNI per capita (log)
	Household real consumption per capita
INTERNATIONAL	Public external debt (%GDP)

[24] EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université catholique de Louvain – Brussels – Belgium.

FINANCE	Net flows on public long-term external debt (%GDP)
	Debt service on public external debt (%GDP)
	Foreign Direct Investment inflows (%GDP)
	Official Development Assistance and Official Aid (%GDP)
INTERNATIONAL TRADE	Openness gap
	Instability of total exports
	Instability of imports
	Export concentration
	Import concentration
	Commodity exports (%GDP)
	Manufacturing exports (%GDP)
	Exports from extractive industry (%GDP)
	Imports of energy (%energy use)
	Imports of food (% consumption)
	Imports of fuel (% consumption)

Table 9: Manifest variables used in the model

We normalize all variables according to the min-max procedure in order to get them on the same 0-100 scale. We use two formulas:

$$\#1:\ x_{normalized} = (x - min)/(max - min) * 100$$

$$\#2:\ x_{normalized} = (max - x)/(max - min) * 100$$

3.2.1 Measurement models - Evaluation methods

In this section, we describe the steps needed to reach the final specification of the MEVI we present in this work. After summarising the most common ways for evaluating measurement models, we go through the different specifications that have led us to the final version of the MEVI.

As for covariance-based SEM, applying the PLS algorithm requires a deep model evaluation. The evaluations follows two steps, as the PLS SEM have two models, the measurement model and the structural model.

Measurement models specify the relations between MVs and their LV. A measurement model can be either reflective or formative, or both. Theoretical considerations help in choosing whether a measurement model should be reflective or formative. Nevertheless, many construct are actually a combination of formative and reflective models (MIMIC). Bollen and Ting (2000) proposed a test for construct specification. The basic idea is that formative MVs do not necessarily correlate, whereas reflective MVs do. Thus, a measurement model cannot be reflective if there is little or no correlation among MVs.

Measurement model evaluation differs according to the type of model. Each MV represent a measurement subject to an error. The measurement error can be split into a random part and a systematic part. The random part includes all factors that influence a construct measurement's

results unsystematically. The systematic error, instead, occurs at each repetition and at the same level.

The literature provides several procedures for evaluating measurement models in the PLS approach.

The **content validity** shows to what extent MVs belong to the domain of the LV. Principal Component Analysis can be useful for evaluating it.

Uni-dimensionality should also be verified by looking at eigenvalues. Only the first eigenvalue should be higher than the critical value – in reflective models.

Content validity and uni-dimensionality cannot be used as criterion for evaluating formative measurement models. Formative LVs emerge from a block of MVs that may not be correlated, nor be uni-dimensional. In such cases, theoretical considerations should be provided supporting the specification.

Indicator reliability shows which part of an indicator's variance can be explained by the underlying latent variable. Usually loadings and cross-loadings matrix supports this evaluation. It shows the shared variance between LVs and MVs. Reflective models assume that MVs depends on the LV, thus one should expect that the LV shares more variance with its own MVs than with the other MVs. Loadings must be the highest values in the LV column. In formative models loading should be the highest values in the row. In formative models usually one should check which indicator contributes most substantially to the construct. Nevertheless, while indicators with a small loading are often eliminated within reflective measurement models, this cannot be done in formative models, because theoretical considerations have led the analyst to assign MVs to the LVs.

Construct reliability shows the extent to which a block of MVs measures the LV adequately verifying that the MVs assigned to the same LV reveal a strong mutual association. The composite reliability (it corresponds to the factor reliability in covariance-based SEM, Jöreskog's rho) can be used to test how well a LV is measured by its own MVs.

$$Composite\ reliability\ (\rho) = \frac{\left(\sum_i \lambda_{ij}\right)^2}{\left(\sum_i \lambda_{ij}\right)^2 + \sum_i var\left(\varepsilon_{ij}\right)}$$

Where:

λ_i is the loading of the MV i, ε_i is the measurement error of i, and j is the flow index across all the reflective measurement models. ρ varies between 0 and 1; values higher than 0.6 are acceptable.

Another common measure for composite reliability is the Cronbach's alpha. It shows how well a set of MVs measures a uni-dimensional LV.

$$Cronbach's\ alpha\ (\alpha) = \left(\frac{N}{N-1}\right) * \left(1 - \frac{\sum_{i=1}^{N} \sigma_i^2}{\sigma_i^2}\right)$$

Where:

N is the number of MVs assigned to the LV and σ_i^2 is the variance of MV i. As for the composite reliability, usually values higher than 0.5 are acceptable.

Since in formative models the LV is an effect, rather than a cause of MVs, internal consistency is irrelevant. Moreover, formative constructs are often multi-dimensional, thus they have a low alpha.

Convergent validity checks if measures that should be related are actually related. A common measure of convergent validity is the average variance extracted (AVE).

$$AVE = \frac{\sum_i \lambda_i^2}{\sum_i \lambda_i^2 + \sum_i var(\varepsilon_i)}$$

Where:

λ_i^2 is the variance of MV i, and ε_i is the measurement error of i. AVE measures the variance of MVs captured by the LV, divided by the total variance. Values above 0.5 are considered sufficient.

Discriminant validity checks whether measures that should not be related are actually not related. The shared variance between the LV and its own MVs should be larger than the shared variance with other LVs.

Convergent and discriminant validity are not good measures for formative models.

3.2.2 Measurement models - Specification

As said before, we estimate each latent variable through its own manifest variables. We define a superblock latent variable, the *vulnerability*, as a macro-variable. We decompose the macro-variable into 11 possible sub-systems (latent variables) that, in turn, group 36 manifest variables. Such innovative approach allows us to capture the direct and indirect effects of the 11 sub-systems on the macro-systemic vulnerability.

The following table shows the new measurement models specification.

LATENT VARIABLE	MANIFEST VARIABLES	TYPE PF MEASUREMENT MODEL
Smallness	Ln(surface) Ln(population)	Reflective
Remoteness	Geographic distance Cost to exports (%world average cost)	Formative

Resistance to natural disasters	Average population affected by natural disasters (%) Average number of disasters occurred per year	Formative
Governance	Control of corruption Government effectiveness Political stability and absence of violence/terrorism Regulatory quality Rule of law Voice and accountability	Reflective
Human capital	School enrollment, primary School enrollment, secondary School enrollment, tertiary Primary school completion rate Progression to secondary school	Reflective
Poverty	Poverty rate (2$) Poverty gap (2$) Ln(GNI per capita) Per capita real households' consumption ODA (% GDP)	Reflective
Exposure to shocks in the imports	CV(imports)*Dependence on imports Imports concentration*Dependence on imports Net imports of energy (%energy use) Fuel imports (% households consumption)	Formative
Exposure to shocks in the exports	CV(exports)*Dependence on exports Exports concentration*Dependence on exports Commodity exports (% GDP) Exports from extractive industry (% GDP)	Formative
Investment capacity	Domestic investment (% GDP) FDI (% GDP)	Formative
Productive structure	Industrial value added (% total value added) Services value added (% total value added)	Reflective
Public external debt	Public external debt stock (% GDP) Debt service on public external debt (% GDP)	Formative
Vulnerability (Superbock variable)	Ln(surface) Ln(population) Geographic distance Cost to exports (%world average cost) Average population affected by natural disasters (%) Average number of disasters occurred per year Control of corruption Government effectiveness Political stability and absence of violence/terrorism Regulatory quality Rule of law Voice and accountability School enrollment, primary School enrollment, secondary School enrollment, tertiary Primary school completion rate Progression to secondary school Poverty rate (2$) Poverty gap (2$) Ln(GNI per capita) Per capita real households' consumption ODA (% GDP) CV(imports)*Dependence on imports	Mixed

	Imports concentration*Dependence on imports Net imports of energy (%energy use) Fuel imports (% households consumption) CV(exports)*Dependence on exports Exports concentration*Dependence on exports Commodity exports (% GDP) Exports from extractive industry (% GDP) Domestic investment (% GDP) FDI (% GDP) Industrial value added (% total value added) Services value added (% total value added) Public external debt stock (% GDP) Debt service on public external debt (% GDP)	

Table 10: Specification of the measurement models

We used formula #1 for all the variables except for surface, population, GNI per capita, Households' real consumption per capita, Services value added, Manufactured exports that we normalize using formula #2.

The following table shows the composite reliability values for the model specified (the superblock variable cannot be evaluated using the composite reliability values):

LATENT VARIABLE	TYPE	CRONBACH'S ALPHA	CRITICAL VALUE	EIGENVALUES
Smallness	R	0.891	437.537	791.689
				83.385
Remoteness	F	**0.350**	329.948	416.684
				243.211
Resistance to ND	F	**0.432**	293.929	418.709
				169.149
Governance	R	0.924	617.151	2715.414
				411.194
				317.324
				124.474
				83.618
				50.885
Human capital	R	0.902	531.008	1976.245
				246.583
				191.929
				137.541
				102.742
Public external debt	F	0.549	445.136	615.424
				274.849
Investment capacity	F	0.514	376.022	506.167
				245.877
Productive structure	R	0.745	449.415	715.930
				182.900
Exposure to shocks in the M	F	0.686	292.470	620.543
				287.330
				182.057
				79.951
Exposure to shocks in the X	F	0.512	359.000	661.239

				398.319
				205.629
				170.813
Poverty	R	0.897	605.873	2496.352
				282.609
				190.535
				34.886
				24.980

Table 11: Composite reliability

The low Cronbach's alpha for **Remoteness** does not represent a problem because the measurement model is formative.

Geographic distance has a low loading, but we decided to keep it, in order to have a complete measure of remoteness, due to both geographic distance and costs. The table shows the values of the factor loadings for Remoteness.

	Remoteness
Distance	**-0.118**
CtoX(%world)	**0.945**

Table 12: Remoteness. Loadings

Similar argument about **Resistance to natural disasters**. The Cronbach's alpha is lower than 0.5, but the model is formative and the loadings are high, as shown in the following table:

	Resistance to ND
Pop Affected	**0.729**
Dis per year	**0.868**

Table 13: Resistance to natural disasters. Loadings

3.3 MEVI – Structural model

In this section, we describe the structural part of the model. The structural model describes connections among latent variables. Since UN EVI is our main reference, we estimated the MEVI on a set of developing countries and LDCs only – as Guillaumont and Cairolle (2011) do.

We specified structural relations using a superblock variable as a response variable. A superblock LV concatenates the original blocks of MVs. Such structural specification belongs to the Hierarchical PLS Path Models (Jöreskog & Wold, 1982). The figure gives a graphical representation of the structural and measurement specification of MEVI-Sbk.

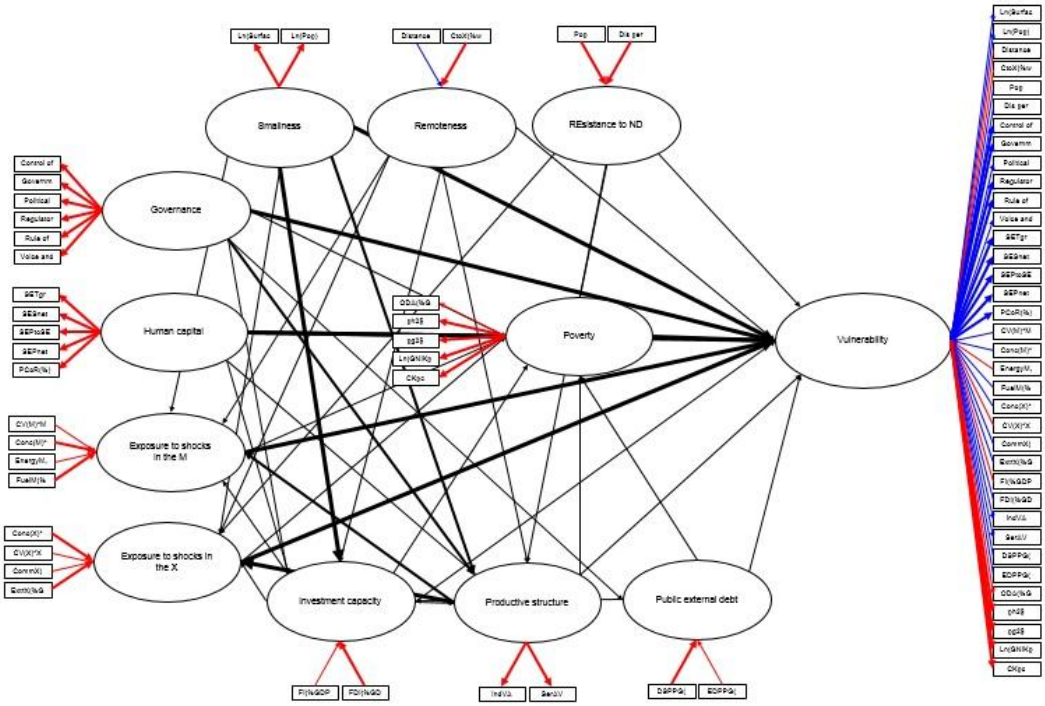


Figure 24: Structural model and measurement models

The main structural model links each LV to the Superblock variable (Vulnerability). Nevertheless, we specified other causal relations, as shown in the figure above, that affect the assessment of LVs' scores. As we explained in the Methodology section, PLS iterative algorithm separately solves out the blocks of measurement models and then estimates the path coefficients in the structural model. Thus, latent variable scores result from the iterative estimation.

The MEVI is the value of Vulnerability as predicted by the structural model. It is a regression of the single latent variables on the superblock vulnerability. We will call it the *primary* structural model. See the Annex C for details about the effects.

We defined relations among explanatory variables too. Thus, some explanatory LVs are endogenous, because they result from other LVs. We will refer to structural relations among explanatory variables as *secondary* structural model.

3.3.1 Primary structural model

The primary structural model refers to the direct relations of explanatory LVs to the single response superblock LV. The primary structural model is a multiple regression of the LVs to the superblock variable that we call *vulnerability*. The value of the MEVI corresponds to the predicted values of the *vulnerability*. The following figure offers a graphical representation of the primary model. Arrows in bold indicate significant coefficients.

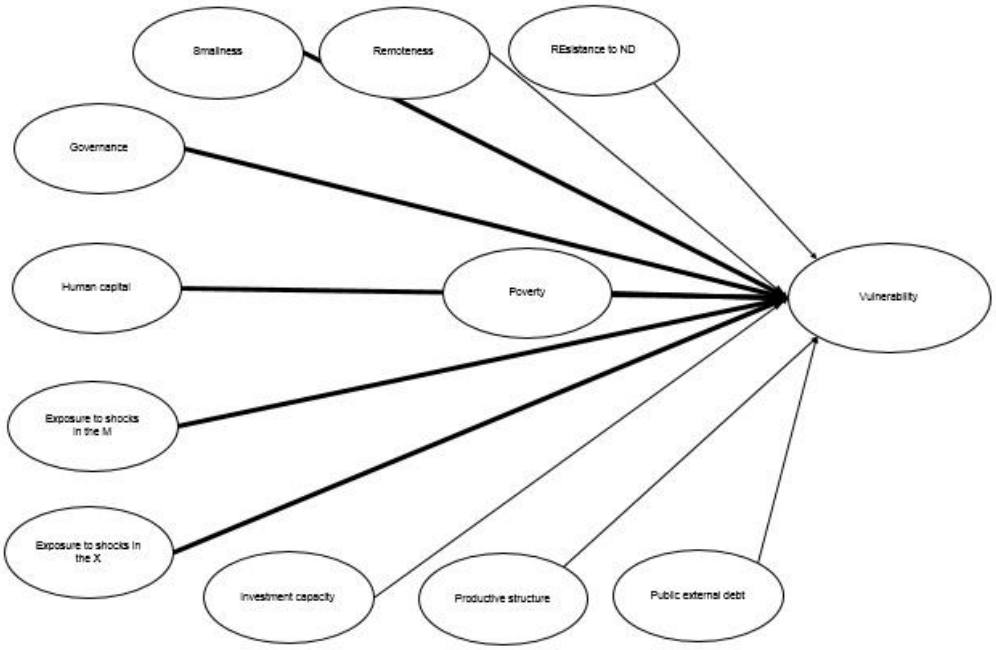


Figure 25: Primary structural model

The following table shows the results from the primary structural model. Variables in bold are statistically significant.

R^2	**F**	**Pr > F**	**R^2(Bootstrap)**	**Standard error**	**Critical ratio (CR)**	**Lower bound (95%)**	**Upper bound (95%)**
0.999	12738.573	0.000	0.999	0.000	2323.412	0.998	1.000
Latent variable			Value	Standard error	t	Pr > |t|	f^2
Smallness			**-0.131**	0.004	-32.014	**0.000**	11.917
Remoteness			0.004	0.003	1.078	0.284	0.014
Resistance to ND			0.002	0.003	0.616	0.540	0.004
Governance			**-0.404**	0.004	-108.089	**0.000**	135.850
Human capital			**-0.284**	0.005	-54.941	**0.000**	35.099
Public external debt			-0.003	0.003	-0.889	0.376	0.009
Investment capacity			-0.001	0.004	-0.227	0.821	0.001
Productive structure			0.003	0.004	0.667	0.506	0.005
Exposure to shocks in the M			**-0.033**	0.004	-9.183	**0.000**	0.981
Exposure to shocks in the X			**-0.014**	0.004	-3.806	**0.000**	0.168
Poverty			**0.397**	0.005	76.595	**0.000**	68.218

Table 14: Results from the primary stryctural model

The equation of the model is the following[25]:

$$Vul = -0.131Sml + 0.004Rmt + 0.002Rst - 0.404Gvn - 0.284HK - 0.003PED - 0.001ICa + 0.003PrSt - 0.033ExM - 0.014ExX + 0.397Pov$$

Where:

Vul is the vulnerability; *Sml* is the smallness; *Rmt* is the remoteness; *Rst* is the resistance to natural disasters; *Gvn* is the governance; *HK* is the human capital; *PED* is the public external debt; *Ica* is the investment capacity; *PrSt* is the productive structure; *ExM* is the exposure to shocks in the imports; *ExX* is the exposure to shocks in the exports; *Pov* is the poverty.

The following figure shows a graphical representation of the impact contribution of each explanatory LV on the vulnerability.

[25] Latent variable scores are shown in the Annex D.

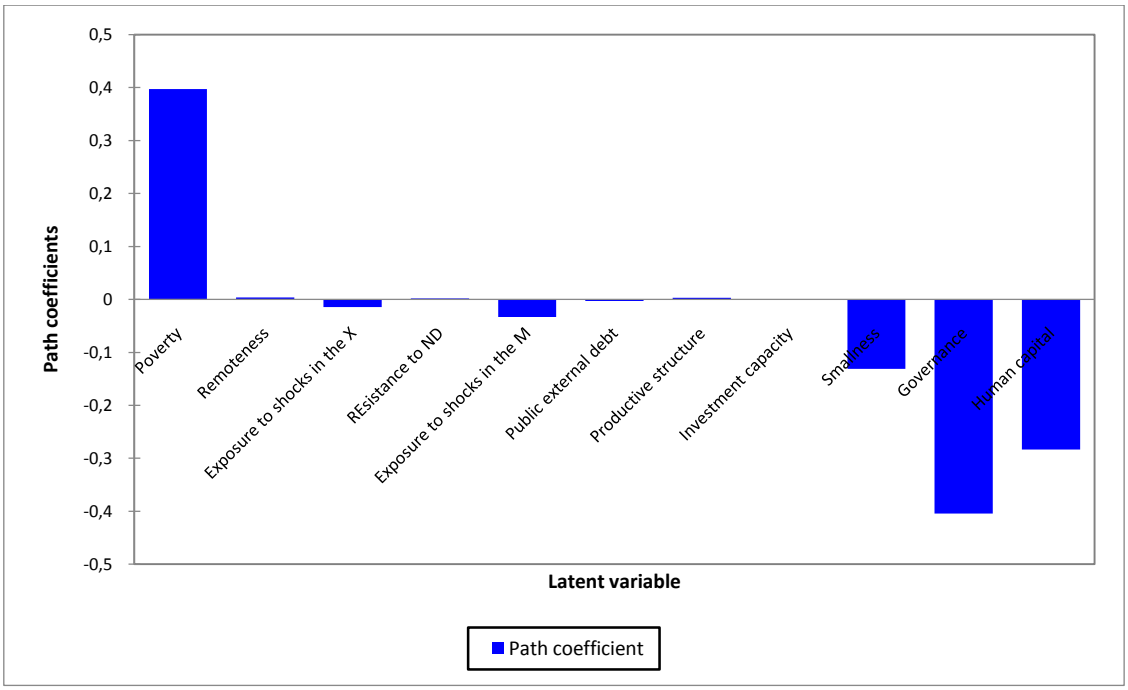


Figure 26: Impact and contribution of latent variables to Vulnerability. Direct effect

Smallness governance, human capital and exposure to shocks in the imports and exports reduce overall countries' vulnerability. Poverty, as expected, increases the vulnerability.

As said, we specified some structural relations among the explanatory latent variables. In the following section, we present results from the secondary structural model

3.3.2 Secondary structural model

The secondary structural model estimates causal relations among explanatory latent variables. Structural relations specified in the secondary model are the relations highlighted during the measurement model evaluations[26]. The following figure shows the secondary structural model we estimated.

[26] Measurement model evaluation requires the estimation of a structural model with all the possible correlations among the LVs.

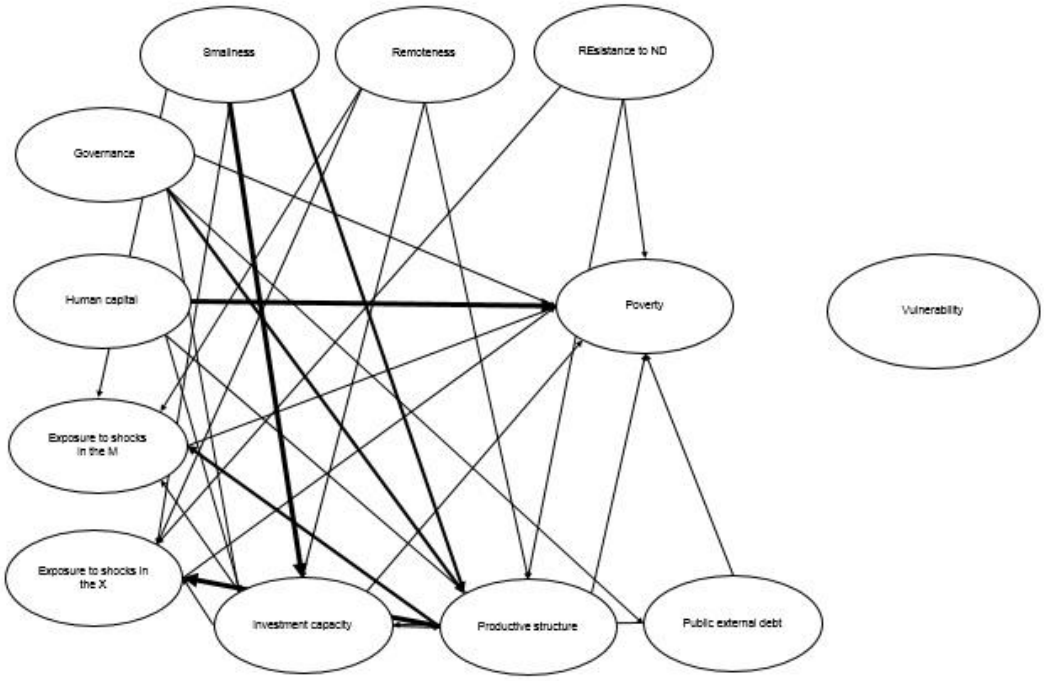


Figure 27: Secondary structural model

The secondary structural model captures the **direct** relations among explanatory LVs that determine the **indirect** effect of every single LV on the response superblock LV[27]. Arrows in bold highlight significant coefficients. The following table reports only the significant coefficients.

DEPENDENT VARIABLE	EXPLANATORY VARIABLE WITH SIGNIFICANT COEFFICIENT
Investment capacity	0.454*Smallness
Productive structure	0.279*Smallness 0.324*Governance
Exposure to shocks in the M	0.307*Productive structure
Exposure to shocks in the X	-0.678*Productive structure
Poverty	-0.687*Human capital

Table 15: direct relations between explanatory latent variables. Only significant coefficient are listed

Total effect on the vulnerability derives from the sum of direct and indirect effects of LVs on the superblock.

EXPLANATORY LV	TOTAL EFFECT ON VULNERABILITY
Smallness	0.167
Remoteness	-0.016
Resistance to ND	0.055
Governance	0.457
Human capital	0.553
Public external debt	0.041

[27] Direct and indirect effect tables in the Annex

Investment capacity	0.013
Productive structure	0.040
Exposure to shocks in the M	0.048
Exposure to shocks in the X	0.035
Poverty	-0.397

Table 16: Total effects of latent variables on the Vulnerability.

Values of the MEVI-Total effect are the combination of LVs scores and total effect coefficients[28]. The equation of the total effect MEVI is the following:

$$Vul = 0.167Sml - 0.0016Rmt + 0.055Rst + 0.457Gvn + 0.553HK + 0.041PED + 0.013ICa + 0.040PrSt + 0.048ExM + 0.035ExX - 0.397Pov$$

Where:

Vul is the vulnerability; *Sml* is the smallness; *Rmt* is the remoteness; *Rst* is the resistance to natural disasters; *Gvn* is the governance; *HK* is the human capital; *PED* is the public external debt; *Ica* is the investment capacity; *PrSt* is the productive structure; *ExM* is the exposure to shocks in the imports; *ExX* is the exposure to shocks in the exports; *Pov* is the poverty.

3.4 MEVI vs EVI

As already said, UN EVI is our main reference. We use values of EVI in 2007 in order to compare it to the MEVI. In this section we show rankings of the MEVI-Dir, MEVI-Tot and the EVI. We used values of MEVI and EVI in 2007 for 99 developing countries. We ranked countries according to EVI and MEVI, separately. Ranking values go from 1, indicating country with the lowest value of vulnerability, to 99, indicating the country with the highest value of vulnerability. Then we used the official classification for Developing and LDCs countries in 2007 in order to verify how the extent to which the two measures were able to identify LDCs.

The following table shows the values of the three indices and the ranking:

Country	Economic group	Geographic group	MEVI-Dir	MEVI-Tot	EVI	# EVI	#MEVI-Dir	#MEVI-Tot
Algeria	DEVELOPING	OTHER	0.051	-0.021	30.58	31	53	46
Angola	LDC	OTHER	0.381	-0.219	49.09	82	65	39
Argentina	DEVELOPING	OTHER	-0.463	0.699	27.22	22	33	67
Bahamas, The	DEVELOPING	SIDS	-2.311	3.098	47.16	72	1	98
Bangladesh	LDC	OTHER	1.327	-1.844	22.27	17	88	12
Belize	DEVELOPING	SIDS	-0.791	1.237	40.12	52	21	80
Benin	LDC	OTHER	0.776	-1.104	37.72	44	71	28
Bhutan	LDC	LLDC	-0.621	0.820	44.08	67	27	72

[28] Table with scores in the Annex

Bolivia	DEVELOPING	LLDC	-0.013	0.162	37.81	45	49	52
Botswana	DEVELOPING	LLDC	-1.260	1.508	48.15	80	10	85
Brazil	DEVELOPING	OTHER	-0.428	0.560	21.35	13	36	62
Burkina Faso	LDC	LLDC	1.315	-2.013	39.05	49	87	5
Burundi	LDC	LLDC	2.012	-2.679	56.66	91	98	1
Cambodia	LDC	OTHER	0.768	-0.982	47.57	74	70	30
Cameroon	DEVELOPING	OTHER	0.972	-1.491	28.97	27	75	20
Cape Verde	DEVELOPING	SIDS	-1.213	1.555	47.94	77	12	86
Central African Republic	LDC	LLDC	1.896	-2.558	42.71	61	97	3
Chad	LDC	LLDC	1.115	-1.158	57.30	92	80	27
Chile	DEVELOPING	OTHER	-1.655	2.073	35.02	40	6	92
China	DEVELOPING	OTHER	0.120	-0.445	21.70	15	58	35
Colombia	DEVELOPING	OTHER	-0.442	0.648	19.67	9	35	63
Costa Rica	DEVELOPING	OTHER	-1.123	1.349	35.50	42	15	81
Cote d'Ivoire	DEVELOPING	OTHER	1.399	-1.987	29.51	28	90	6
Djibouti	LDC	OTHER	-0.345	0.550	44.39	68	40	61
Dominican Republic	DEVELOPING	SIDS	-0.533	0.811	30.91	33	31	71
Ecuador	DEVELOPING	OTHER	0.001	0.136	33.93	37	50	51
Egypt, Arab Rep.	DEVELOPING	OTHER	-0.236	0.443	16.38	3	45	55
El Salvador	DEVELOPING	OTHER	-0.549	0.696	35.08	41	30	65
Eritrea	LDC	OTHER	1.531	-2.212	60.01	96	95	4
Ethiopia	LDC	LLDC	1.332	-1.845	28.41	25	89	11
Fiji	DEVELOPING	SIDS	-0.340	0.670	48.10	79	41	64
Gabon	DEVELOPING	OTHER	-0.192	0.474	44.60	69	46	56
Gambia, The	LDC	OTHER	0.370	-0.361	65.08	97	64	36
Ghana	DEVELOPING	OTHER	-0.061	-0.013	33.07	36	47	48
Guatemala	DEVELOPING	OTHER	0.081	-0.078	28.82	26	55	43
Guinea	LDC	OTHER	1.460	-1.908	27.20	21	93	10
Guyana	DEVELOPING	SIDS	-0.460	0.514	47.99	78	34	59
India	DEVELOPING	OTHER	0.336	-0.472	19.08	8	63	34
Indonesia	DEVELOPING	OTHER	0.264	-0.310	18.87	7	62	37
Jordan	DEVELOPING	OTHER	-1.069	1.597	24.30	20	17	89
Kenya	DEVELOPING	OTHER	0.981	-1.361	17.89	4	76	24
Korea, Rep.	DEVELOPING	OTHER	-1.843	2.460	18.65	5	3	95
Lao PDR	LDC	LLDC	0.631	-0.967	44.88	70	67	31
Lebanon	DEVELOPING	OTHER	-0.499	0.891	31.58	34	32	74
Lesotho	LDC	LLDC	0.458	-0.567	43.05	63	66	33
Libya	DEVELOPING	OTHER	0.162	-0.054	38.37	46	60	45
Madagascar	LDC	OTHER	1.092	-1.527	40.35	54	79	18
Malawi	LDC	LLDC	1.125	-1.529	51.46	84	81	17

Malaysia	DEVELOPING	OTHER	-1.175	1.494	20.78	12	13	83
Maldives	DEVELOPING	SIDS	-0.716	1.012	55.59	90	24	75
Mali	LDC	LLDC	0.953	-1.400	40.50	55	74	23
Mauritania	LDC	OTHER	0.797	-1.210	49.99	83	72	26
Mauritius	DEVELOPING	SIDS	-1.535	1.921	41.00	58	8	91
Mexico	DEVELOPING	OTHER	-0.620	0.718	19.71	10	28	68
Mongolia	DEVELOPING	LLDC	-0.782	1.055	52.78	86	23	77
Morocco	DEVELOPING	OTHER	-0.271	0.403	18.73	6	44	54
Mozambique	LDC	OTHER	1.407	-1.983	42.80	62	91	7
Namibia	DEVELOPING	OTHER	-0.399	0.526	42.04	60	37	60
Nepal	LDC	LLDC	1.128	-1.456	29.83	30	82	22
Nicaragua	DEVELOPING	OTHER	0.184	-0.174	35.70	43	61	40
Niger	LDC	LLDC	1.694	-2.577	40.75	56	96	2
Nigeria	DEVELOPING	OTHER	1.508	-1.951	40.25	53	94	8
Oman	DEVELOPING	OTHER	-0.825	1.014	39.80	51	20	76
Pakistan	DEVELOPING	OTHER	1.068	-1.532	22.45	18	77	15
Panama	DEVELOPING	OTHER	-1.025	1.557	32.58	35	18	87
Papua New Guinea	DEVELOPING	SIDS	-0.028	0.059	41.48	59	48	49
Paraguay	DEVELOPING	LLDC	0.084	-0.017	47.83	76	56	47
Peru	DEVELOPING	OTHER	-0.395	0.696	29.71	29	38	66
Philippines	DEVELOPING	OTHER	0.075	-0.106	23.37	19	54	41
Qatar	DEVELOPING	OTHER	-1.173	1.499	43.43	65	14	84
Rwanda	LDC	LLDC	1.132	-1.508	47.69	75	83	19
Samoa	LDC	SIDS	-1.620	2.150	59.18	94	7	93
Sao Tome and Principe	LDC	SIDS	-0.288	0.235	48.73	81	43	53
Saudi Arabia	DEVELOPING	OTHER	-0.367	0.512	30.79	32	39	58
Senegal	LDC	OTHER	0.724	-1.061	34.02	38	68	29
Sierra Leone	LDC	OTHER	1.266	-1.680	44.02	66	86	13
Solomon Islands	LDC	SIDS	0.036	0.122	59.95	95	52	50
South Africa	DEVELOPING	OTHER	-0.624	0.784	21.39	14	26	70
Sri Lanka	DEVELOPING	OTHER	-0.328	0.475	28.35	24	42	57
St. Kitts and Nevis	DEVELOPING	SIDS	-1.775	2.369	57.94	93	5	94
St. Lucia	DEVELOPING	SIDS	-1.852	2.547	53.50	88	2	97
St. Vincent and the Grenadines	DEVELOPING	SIDS	-1.816	2.533	51.96	85	4	96
Sudan	LDC	OTHER	1.418	-1.915	47.47	73	92	9
Swaziland	DEVELOPING	LLDC	0.022	-0.295	43.07	64	51	38
Tanzania	LDC	OTHER	1.081	-1.465	28.09	23	78	21
Thailand	DEVELOPING	OTHER	-0.599	0.735	15.80	2	29	69
Togo	LDC	OTHER	1.143	-1.530	40.77	57	84	16

Tonga	DEVELOPING	SIDS	-0.655	0.881	69.00	98	25	73
Trinidad and Tobago	DEVELOPING	SIDS	-1.105	1.360	38.81	47	16	82
Tunisia	DEVELOPING	OTHER	-0.787	1.147	22.21	16	22	78
Turkey	DEVELOPING	OTHER	-0.880	1.152	13.07	1	19	79
Uganda	LDC	LLDC	1.155	-1.649	38.94	48	85	14
Uruguay	DEVELOPING	OTHER	-1.440	1.888	39.80	50	9	90
Vanuatu	LDC	SIDS	-1.233	1.584	55.24	89	11	88
Venezuela, RB	DEVELOPING	OTHER	0.155	-0.084	34.59	39	59	42
Vietnam	DEVELOPING	OTHER	0.108	-0.059	20.24	11	57	44
Yemen, Rep.	LDC	OTHER	0.935	-1.314	45.66	71	73	25
Zambia	LDC	LLDC	0.730	-0.707	52.99	87	69	32

Table 17: Values of the Indices and rankings

Capturing the total effect is the advantage of using structural equation models. We will show two values of the MEVI, the first deriving from the direct effect only (MEVI-Dir), the second using the total effect (MEVI-Tot).

EVI and MEVI-Dir. The following scatter shows the ranking according to the UN EVI (horizontal axis) and the MEVI-Dir (vertical axis).

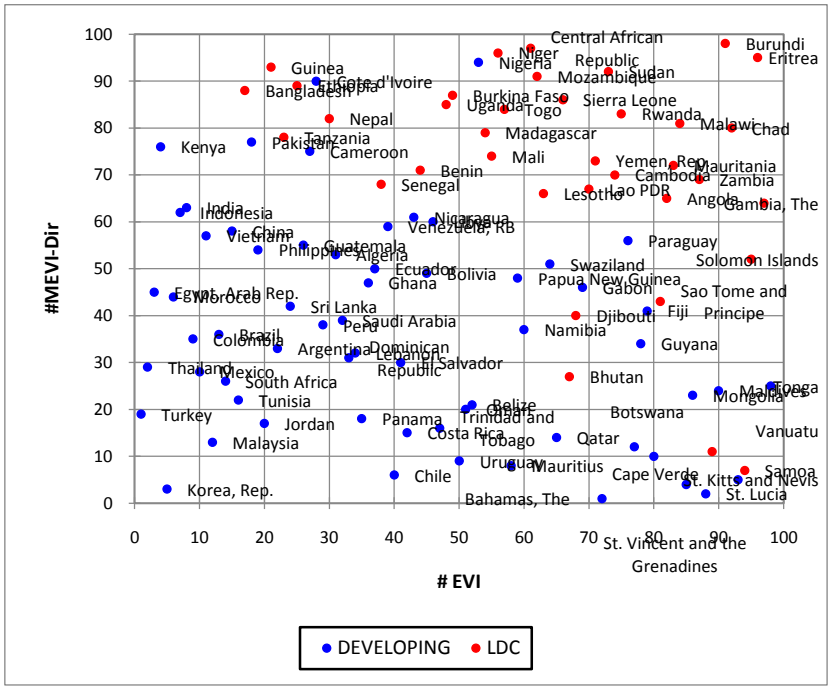


Figure 28: EVI and MEVI-Dir ranking comparison

Both, EVI and MEVI-Dir assign to LDCs a high vulnerability, that is why LDCs lie on the top-right part of the graph. Bhutan, Samoa, Vanuatu, Djibouti and Sao Tome and Principe are the only LDCs that lie below the value of 50 in the ranking of the MEVI-Dir. The EVI does not capture Burkina Faso, Benin, Senegal, Uganda, Nepal, Tanzania, Ethiopia, Guinea and Bangladesh.

EVI and MEVI-Tot. Things change considerably once we consider the total effect (sum of direct and indirect effect). The following scatter shows the ranking according to the UN EVI (horizontal axis) and the MEVI-Tot (vertical axis).

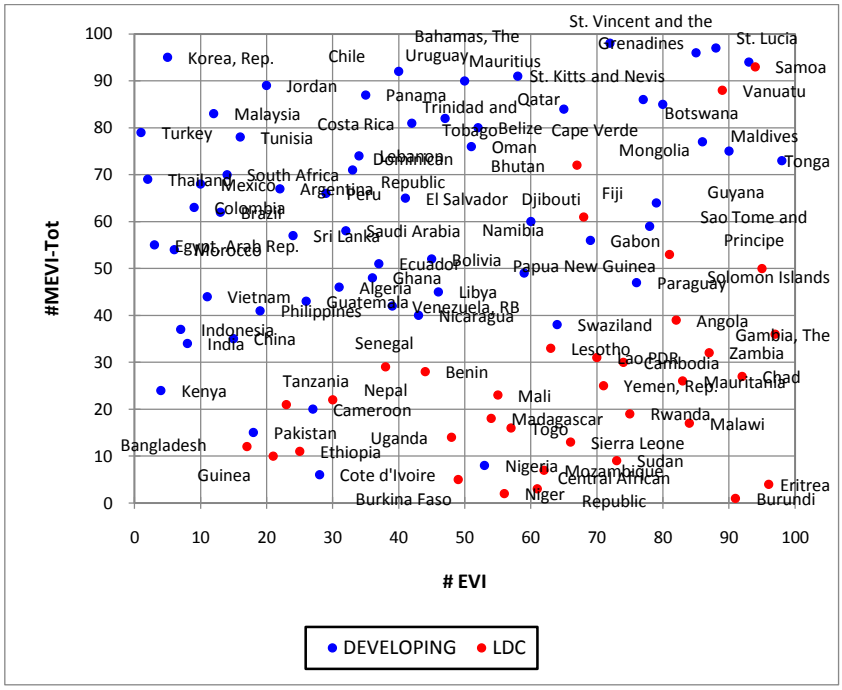


Figure 29: EVI and MEVI-Tot ranking comparison

LDCs now lie on the bottom-right part of the graph. MEVI-Tot assigns to the LDCs a low level of total vulnerability. Samoa, Vanuatu, Bhutan, Djibouti, Sao Tome and Principe and Solomon Islands are the only LDCs above the value of 50 in the ranking of the MEVI-Tot. The EVI does not capture Burkina Faso, Benin, Senegal, Uganda, Nepal, Tanzania, Ethiopia, Guinea and Bangladesh.

We tested the validity of EVI and MEVI with the growth rate of GDP in the period after the 2007 crisis. The following table shows correlations with GDP growth, the EVI, the MEVI-Dir and the MEVI-Tot.

ΔGDPg (09-07) is the difference between the GDP growth rate (annual %) in 2009 and 2007. GDPg_pc,PPP is the annual growth rate of GDP per capita, PPP (constant 2005 international $) in 2009. Values in bold are different from 0 with a significance level alpha=0.05.

Variables	*MEVI-Dir*	*MEVI-Tot*	*EVI*	*⊿GDPg (0907)*	*GDPg_pc,PPP (09)*
MEVI-Dir	**1**	**-0.996**	0.008	**0.368**	**0.379**
MEVI-Tot	**-0.996**	**1**	0.001	**-0.371**	**-0.369**
EVI	0.008	0.001	**1**	0.017	-0.160
⊿GDPg (09-07)	**0.368**	**-0.371**	0.017	**1**	**0.588**
GDPg_pc,PPP (09)	**0.379**	**-0.369**	-0.160	**0.588**	**1**

Table 18: Correlation matrix between EVI, MEVI-Dir, MEVI-Tot and GDP growth in the post-crisis period

MEVI-Tot is negatively correlated with the variation of GDP growth rate between 2007 and 2009. It means that countries that experienced a negative growth rate are the countries with higher vulnerability - according to the MEVI-Tot. The EVI has a positive but not significant correlation with the variation of GDP growth rate.

MEVI-Tot has a negative and significant correlation with the growth rate of the per-capita GDP in 2009. EVI has a negative, but non-significant correlation.

In summary, once we compare MEVI-Dir with MEVI-Tot we can see that direct effects have a positive relation with the growth rate in the post-shock period.

EVI is part of the criteria for identifying LDCs. However, it considers only a direct effect of the factors that increase exposure to shocks. It does not considers resilience. In general, we have seen in the scatter plots that both MEVI-Dir and MEVI-Tot discriminate LDCs better than the EVI.

MEVI-Tot overturns the concept of vulnerability by assigning to LDCs a low level of total vulnerability. This derives from considering the total effect of variables that increase the exposure to exogenous shocks and the variables that off-set it (resilience).

3.5 MEVI vs VRI

In chapter 2 we highlighted that VRI does not consider the instability of international trade. The MEVI uses the variation coefficients of both, exports and imports.

Foreign capitals are not take into account; the MEVI considers the dependence on ODA, among the MVs of the poverty, and the dependence on FDI, as manifest variable of Investment capacity.

Natural disasters do not play a role in the VRI, instead the MEVI considers the Proneness to natural disaster as latent variable whose manifest variables are average population affected and the average number on natural disasters occurred per year.

3.6 MEVI vs CVI

CVI tries to estimate country resilience using the GDP. The rationale behind such a choice refers to the necessity of facing high costs for emergency after a shock occurs.

However, we believe that resilience should reflect absorption capacity too. Measuring resilience by GDP only might limit, because it does not capture the system's capacity to react and the resources available for after-shock policies.

The MEVI considers several variables as resilience: human capital, governance, investment capacity, productive structure and external debt.

Moreover, the CVI estimates the impact of vulnerability on GDP volatility, while the MEVI considers the impact on country income and poverty levels.

Summary and conclusions

The large number of economic crises occurred during the last decades has brought economic literature to the stage where it is clear that we cannot successfully deal with poverty and underdevelopment unless we also deal with vulnerability. The emerging consensus in international policy circles is that building resilience is a necessary and effective pathway for sustaining development progress. This is especially resonant now since it has become apparent that vulnerability to financial and economic shocks is an impediment to sustained economic growth and human development in many developing countries. Such a situation makes it necessary to assess vulnerability. Nevertheless, the lack of consensus about definition and assessment of vulnerability and resilience exacerbates the already complex issue.

Current literature about macroeconomic vulnerability is divided into two main strands of research: early warning system and exposure to exogenous shocks. The first strand of research refer to IMF and World Bank in particular and is based on the *ex-ante* risk assessment; special focus on the endogenous factors that can increase the risk of crisis. The second strand of research refer to United Nations and Commonwealth Secretariat, and focuses on *ex-post* evaluation of aspects that amplified or reduced the negative impact of exogenous shocks, without focusing on the probability that a negative shock occurs. The purpose of second group of measures is giving suggestion for international aid allocation. They discriminate least developed countries from the other developing countries and highlight potential criticalities of small island developing states, considered as the most vulnerable countries.

We deeply analysed the three main indicators of economic vulnerability that refer to the second strand of research. We highlighted several criticalities, starting from the definition and the assessment of economic vulnerability.

- Briguglio's VRI estimates the overall risk of being negatively affected by exogenous shocks subtracting resilience from vulnerability. Vulnerability results from exposure to international trade shocks. Resilience derives from macroeconomic stability, microeconomic market efficiency, good governance and social development (Briguglio, Cordina, Farrugia, & Vella, 2009). We disapprove that VRI focuses on socks in international trade only; there is no role for international capital flows and natural disasters and poverty.
- Commonwealth's CVI combines a vulnerability impact index, which focuses on shocks coming from international trade and to natural disasters, and the GDP that is a proxy for resilience (Easter, 1999). We argue that resilience should reflect the capacity of countries to counteract shocks also through policies that address public resources to face emergencies, and the long-run

policies to reduce exposure and improving coping capacities. Thus GDP does is not sufficient to measure resilience.

- UN EVI proposed by Guillaumont (Guillaumont & Cairolle, 2011) combines the exposure index with the shock index. Geographical aspects, like location and size, and market specialization measures to construct the exposure index. Natural shock and trade shock indices capture the risk of shocks. As for the other indices, foreign capitals are not considered, even if they represent an important source of financing for developing countries. Resilience is not considered; Guillaumont focuses on international trade and natural disasters without considering that countries' coping capacities can mitigate the impact of shocks and reduce the time necessary to bounce back to pre-crisis situation.

We propose a new concept of economic vulnerability and resilience as abstract concepts that we cannot directly observe. Vulnerability is the status that results from the complex interaction of factors that increase the exposure to exogenous shocks, and factors that increase the coping capacities. Current measures fail in capturing the system effect, the complexity deriving from the interaction among all the sources of vulnerability and resilience.

In synthesis, we state that vulnerability has to be intended as country's structural characteristic. Variables like dependence on exports, country size etc. are the observable manifestations of such (unobservable) structural characteristic.

We use multilevel PLSPM structural equation modelling to construct a systemic model that allows us to analyse the overall interactions among all the manifest variables, in order to derive a measure of the *actual* total vulnerability.

We define a superblock latent variable, the *vulnerability*, as a macro-variable. We decompose the macro-variable into 11 possible sub-systems (latent variables) that, in turn, group 36 manifest variables. Such innovative approach allows us to capture the direct and indirect effects of the 11 sub-systems on the macro-systemic vulnerability.

We compare results with the UN EVI and we find diametrically opposite results. We find that until we consider the direct effects only (MEVI_Dir), the EVI and the MEVI-Dir give similar results. However, once we consider the total effects (direct plus indirect) in the MEVI-Tot, results change; countries that got a high score of EVI (*i.e.* high level of vulnerability), get a low score of the MEVI-Tot (*i.e.* low level of vulnerability).

Correlation analysis with the growth rate of real GDP in the post-crisis period show that the EVI has a positive correlation with the variation of GDP growth rate between 2007 and 2009, and a negative correlation with the GDP growth rate in 2009. Nevertheless, correlations are not different from zero (with a significance level alpha=0.05). The MEVI-Tot as a negative correlation with the variation of

GDP growth rate between 2007 and 2009, and a negative correlation with the GDP growth rate in 2009. Both correlations are significant (alpha=0.05).

In conclusion, the MEVI-Tot has a better capacity to identify actual vulnerability than the EVI.
These results confirm our hypothesis that vulnerability (and resilience) is like a disease that we can diagnose through by means of its manifestations that, in turn, can be either causes or consequences of being vulnerable.

Annex A. Variable definitions

Variable name	Indicator name	Definition	Source	Reference Year(s)
Country surface (log)	Surface area (sq. km)	Surface area is a country's total area, including areas under inland bodies of water and some coastal waterways.	WB-WDI	2007
Country population (log)	Population, total	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The values are midyear estimates.	WB-WDI	2007
Population affected by natural disasters	Total affected	Total affected are people that have been injured, affected and left homeless after a disaster are included in this category.	EM-DAT	1995-2007
Economic damage from natural disasters	Estimated damage	Estimated damage is the economic impact of a disaster usually consists of direct (e.g. damage to infrastructure, crops, housing) and indirect (e.g. loss of revenues, unemployment, market destabilisation) consequences on the local economy. In EM-DAT estimated damage are) given in US$ ('000). For each disaster, the registered figure corresponds to the damage value at the moment of the event, i.e. the figures are shown true to the year of the event.	EM-DAT	1995-2007
Natural disaster per year	Natural disasters	Natural disasters are: geophysical disasters (events originating from solid earth, like earthquake, volcano, dry mass movement); meteorological disasters (events caused by short-lived/small to meso scale atmospheric processes - in the spectrum from minutes to days, like storms); hydrological disasters (events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up, like floods, wet mass movements); climatological disasters (events caused by long-lived/meso to macro scale processes - in the spectrum from intra-seasonal to multi-decadal climate variability, like extreme temperature, drought, wildfire); biological disasters (disasters caused by the exposure of living organism to germs and toxic substances, like epidemic, insect infestations, animal stampede)	EM-DAT	1995-2007
Remoteness	**Distance from main world markets – adjusted for landlockedness**	Remoteness is measured as a weighted average of the distance to the main world markets. Weights are given by the minimum average distance to a significant fraction of the world market and choose the threshold of one third. The *minimum distance* is the minimum average distance to reach a given size of the world markets. It fits requirements, because it is an exogenous measure and weights differ for each country. (Guillaumont, 2007b)	CERDI	2007
Cost to export	**Cost to export (US$ per container)**	Cost measures the fees levied on a 20-foot container in U.S. dollars. The time and cost (excluding tariffs) necessary to complete every official procedure for exporting and importing the goods are recorded; however, the time and cost for sea transport are not included. All documents needed by the trader to export or import the goods across the border are also recorded. For exporting goods, procedures range from packing the goods into the container at the warehouse to their departure from the port of exit. For landlocked economies, these include procedures at the inland border post, since the port is located in the transit economy. Payment is made by letter of credit, and the time, cost and documents required for the issuance or advising of a letter of credit are taken into account. The ranking on the ease of trading across borders is the simple average of the percentile rankings on its component indicators. Only official costs are recorded.	WB-WDI	2007
Public expenditure	**Expense (% of GDP)**	Expense is cash payments for operating activities of the government in providing goods and services. It includes	WB-WDI	2007

		compensation of employees (such as wages and salaries), interest and subsidies, grants, social benefits, and other expenses such as rent and dividends.		
Domestic investment	**Gross fixed capital formation (current US$)**	Gross fixed capital formation (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.	WB-WDI	2007
Industry value added	**Value Added by Economic Activity**	Is the value added by industry (ISIC Rev.3 C-E) as percentage of total added value.	UN Statistics Division	2007
Services value added	**Value Added by Economic Activity**	The value added by service sector as percentage of value added (ISIC Rev.3 F-P).	WB-WDI	2007
School enrollment, primary	**Primary school enrollment (net).**	Primary education provides children with basic reading, writing, and mathematics skills along with an elementary understanding of such subjects as history, geography, natural science, social science, art, and music. Gross enrollment ratios indicate the capacity of each level of the education system, but a high ratio may reflect a substantial number of overage children enrolled in each grade because of repetition or late entry rather than a successful education system. The net enrollment rate excludes overage and underage students and more accurately captures the system's coverage and internal efficiency.		
School enrollment, secondary	**Secondary school enrollment (net)**	Secondary education completes the provision of basic education that began at the primary level, and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers.	WB-WDI	2007
School enrollment, tertiary	**Tertiary school enrollment (gross)**	Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level.	WB-WDI	2007
Primary completion rate	**Primary completion rate**	It measures the education system's performance. Completion rate is the percentage of students completing the last year of primary school. The variable captures whether an education system has the capacity to meet the needs of universal primary education – according to MDGs. It is important because official enrollments sometimes differ significantly from attendance. The WB calculates it by dividing the number of new entrants (enrollment minus repeaters) in the last grade of primary education, regardless of age, by the population at the entrance age for the last grade of primary education and multiplying the result by 100.	WB-WDI	2007
Progression to secondary school	**Progression to secondary school**	Progression measures the efficiency of education system. WB computes it by dividing the number of new entrants in the first grade of secondary education by the number of students who were enrolled in the final grade of primary education in the previous school year, and multiplying by 100. For both, completion rate and progression, the reference year reflects the school year for which the data are presented. In countries where the school year spans two calendar years (for example, from September 2006 to June 2007), the reference year refers to the year in which the school year ended.	WB-WDI	2007

Control of Corruption	**Control of Corruption**	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WB-WGI	2007
Government effectiveness	**Government effectiveness**	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WB-WGI	2007
Political Stability and Absence of Violence/Terrorism	**Political Stability and Absence of Violence/Terrorism**	Political Stability and Absence of Violence/Terrorism captures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WB-WGI	2007
Rule of Law	**Rule of Law**	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WB-WGI	2007
Regulatory Quality	**Regulatory Quality**	Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WB-WGI	2007
Voice and Accountability	**Voice and Accountability**	Voice and Accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WB-WGI	2007
Public external debt (%GDP)	**External debt stocks, public and publicly guaranteed (PPG) (DOD, current US$)**	Public and publicly guaranteed debt comprises long-term external obligations of public debtors, including the national government, political subdivisions (or an agency of either), and autonomous public bodies, and external obligations of private debtors that are guaranteed for repayment by a public entity.	WB-WDI	2007
Net flows on public long-term external debt (%GDP)	**Net flows on external debt, public and publicly guaranteed (PPG) (NFL, current US$)**	Net flows (or net lending or net disbursements) received by the borrower during the year are disbursements minus principal repayments. Long-term external debt is defined as debt that has an original or extended maturity of more than one year and that is owed to nonresidents by residents of an economy and repayable in currency, goods, or services.	WB-WDI	2007
Debt service on public external debt (%GDP)	**Debt service on external debt, public and publicly guaranteed (PPG) (TDS, current US$)**	Public and publicly guaranteed debt service is the sum of principal repayments and interest actually paid in currency, goods, or services on long-term obligations of public debtors and long-term private obligations guaranteed by a public entity.	WB-WDI	2007
Foreign Direct Invesment inflows	**Foreign direct investment, net inflows**	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than	WB-WDI	2007

(%GDP)	**(BoP, current US$)**	that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments.		
Official Development Assistance and Official Aid (%GDP)	**Net official development assistance and official aid received (current US$)**	Net official development assistance (ODA) consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries to promote economic development and welfare in countries and territories in the DAC list of ODA recipients. It includes loans with a grant element of at least 25 percent (calculated at a rate of discount of 10 percent). Net official aid refers to aid flows (net of repayments) from official donors to countries and territories in part II of the DAC list of recipients: more advanced countries of Central and Eastern Europe, the countries of the former Soviet Union, and certain advanced developing countries and territories. Official aid is provided under terms and conditions similar to those for ODA.	WB-WDI	2007
Openness gap		Openness gap measures the residuals from OLS regression of trade openness, measured as sum of exports and imports over GDP, versus country income, population, two dummies for landlockedness and isnularity		2007
Commodity exports (%GDP)	**Merchandise trade matrix - product groups, exports in thousands of dollars**	Commodity exports measures the share of commodity exports to GDP. Commodities are goods classified as *Primary commodities*, excluding fuels (SITC 0 + 1 + 2 + 4 + 68).	UNCTAD Stat	2007
Manufacturing exports (%GDP)	**Merchandise trade matrix - product groups, exports in thousands of dollars**	Manufacturing exports measures the share of commodity exports to total exports of goods and services. Manufactured goods are those classified as *Manufactured goods* (SITC 5 to 8 less 667 and 68).	UNCTAD Stat	2007
Exports from extractive industry (%GDP)	**Merchandise trade matrix - product groups, exports in thousands of dollars**	Exports from extractive industry measure the share of exports from extractive industry to total exports of goods and services. Extractive industry goods are Ores and metals (SITC 27 + 28 + 68); Pearls, precious stones and non-monetary gold (SITC 667 + 97); Fuels (SITC 3); Iron and steel (SITC 67).	UNCTAD Stat	2007
Instability of total exports		Instability of total exports measures the volatility of total exports of goods and services. It is a proxy for the risk of shocks in the exports revenues. It is the variation coefficient of total exports.		1995-2007
Instability of total imports		The variable measures the volatility of total imports of goods and services, as variation coefficient of the series. It is a proxy for the risk of shocks in the imports.		1995-2007
Export concentration	**Concentration and diversification indices of merchandise exports and imports by country**	Export concentration measures the degree of market concentration. We use the standardized Herfindahl-Hirschmann index published by UNCTAD. Values vary between 0 and 1, with 0 corresponding to absence of concentration (maximum diversification), 1 corresponding to maximum concentration.	UNCTAD Stat	2007
Import concentration	**Concentration and diversification indices of merchandise exports and imports by**	Import concentration measures the degree of market concentration. We use the standardized Herfindahl-Hirschmann index published by UNCTAD. Values vary between 0 and 1, with 0 corresponding to absence of concentration (maximum diversification), 1 corresponding to maximum concentration.	UNCTAD Stat	2007

	country			
Imports of energy (%energy use)	**Energy imports, net (% of energy use)**	Net energy imports are energy use less production, both measured in oil equivalents. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. Since some countries have high percentages in absolute terms, we bounded values to $\pm 100\%$. See the special section in the Annex for details.	WB-WDI	2007
Food imports (% consumption)	**Imports of food**	The variable measures Imports of food, basic (SITC 0 + 22 + 4) from the rest of the world.	UNCTAD Stat	2007
Imports of fuel (% consumption)	**Imports of fuel**	Imports of fuels (SITC 3) from the rest of the world.	UNCTAD Stat	2007
Real consumption per capita	**Household final consumption expenditure (current US$)**	Household final consumption expenditure is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses.	WB-WDI	2007
Real GNI per capita	**GNI per capita, PPP (constant 2005 international $)**	PPP GNI is gross national income (GNI) converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GNI as a U.S. dollar has in the United States. GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. Data are in constant 2005 international dollars.	WB-WDI	2007
Households real consumption per capita	**Household final consumption expenditure, PPP (constant 2005 international $)**	Household final consumption expenditure (formerly private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported separately by the country. Data are converted to constant 2005 international dollars using purchasing power parity rates. We divided by population.	WB-WDI	2007
Poverty gap	**Poverty gap at $2 a day (PPP) (%)**	Poverty gap is the mean shortfall from the poverty line (counting the nonpoor as having zero shortfall), expressed as a percentage of the poverty line. This measure reflects the depth of poverty as well as its incidence.	WB-WDI	2007
Poverty headcount	**Poverty headcount ratio at $2 a day (PPP) (% of population)**	Population below $2 a day is the percentage of the population living on less than $2.00 a day at 2005 international prices. As a result of revisions in PPP exchange rates, poverty rates for individual countries cannot be compared with poverty rates reported in earlier editions.	WB-WDI	2007

Annex B. Variables with bounded values

Net energy import sas percentage of energy use		
Country Name	EnergyMnet(%energy use)	Bound
Algeria	-346.535	-100
Angola	-791.114	-100

Azerbaijan	-330.682	-100
Bolivia	-188.773	-100
Colombia	-210.093	-100
Ecuador	-153.138	-100
Gabon	-652.623	-100
Libya	-518.44	-100
Nigeria	-115.946	-100
Oman	-244.064	-100
Qatar	-389.94	-100
Saudi Arabia	-284.745	-100
Sudan	-128.686	-100
Trinidad and Tobago	-110.267	-100
Venezuela, RB	-223.668	-100
Yemen, Rep.	-135.594	-100

Variation coefficients

Variation coefficient is likely to be high when the mean value is below zero – because it is the ratio between standard deviation and mean. The following is a list of variables bounded with values.

ODA		
Country Name	Abs[CV(ODA)]	Bound
Bolivia	1795.9	100
Bosnia and Herzegovina	1346.29	100
Ecuador	173.672	100
Mali	454.145	100
Sudan	138.224	100
Trinidad and Tobago	629.034	100

FDI		
Country Name	Abs[CV(FDI)]	Bound
Cape Verde	683.6807	100
Costa Rica	106.606	100
Croatia	1733.68	100
Djibouti	153.847	100
Guatemala	395.8649	100
Malawi	221.83	100
Tunisia	112.8911	100
Uganda	275.283	100
Zambia	159.5586	100

Exports		
Country Name	Abs[CV(X)]	Bound
Algeria	264.468	100
Croatia	1569.96	100
Fiji	105.9183	100
Samoa	101.814	100
Sierra Leone	576.244	100

Imports		
Country Name	Abs[CV(M)]	Bound
Cambodia	177.464	100
Croatia	106.133	100
Philippines	215.321	100
South Africa	957.395	100

Annex C. MEVI Structural – direct and indirect effects of LVs

Direct effects (Latent variable) / Dimension (1):

	Smallness	Remoteness	Resistance to ND	Governance	Human capital	Public external debt	Investment capacity	Productive structure	Exposure to shocks in the M	Exposure to shocks in the X	Poverty	Vulnerability
Smallness												
Remoteness	0.000											
REsistance to ND	0.000	0.000										
Governance	0.000	0.000	0.000									
Human capital	0.000	0.000	0.000	0.000								
Public external debt	0.000	0.000	0.000	0.167	0.000							
Investment capacity	0.454	-0.084	0.000	0.112	0.164	-0.071						
Productive structure	0.279	-0.130	-0.056	0.324	-0.128	0.000	0.178					
Exposure to shocks in the M	0.209	-0.137	0.000	0.000	0.000	0.000	0.211	0.307				
Exposure to shocks in the X	0.264	0.003	0.186	0.000	0.000	0.000	0.120	-0.678	0.000			
Poverty	0.000	0.000	-0.133	-0.079	-0.687	-0.099	0.025	-0.131	-0.037	-0.053		
Vulnerability	-0.131	0.004	0.002	-0.404	-0.284	-0.003	-0.001	0.003	-0.033	-0.014	0.397	

Indirect effects (Latent variable) / Dimension (1):

	Smallness	Remoteness	Resistance to ND	Governance	Human capital	Public external debt	Investment capacity	Productive structure	Exposure to shocks in the M	Exposure to shocks in the X	Poverty	Vulnerability
Smallness												
Remoteness	0.000											
REsistance to ND	0.000	0.000										
Governance	0.000	0.000	0.000									
Human capital	0.000	0.000	0.000	0.000								
Public external debt	0.000	0.000	0.000	0.000	0.000							
Investment capacity	0.000	0.000	0.000	-0.012	0.000	0.000						
Productive structure	0.081	-0.015	0.000	0.018	0.029	-0.013	0.000					
Exposure to shocks in the M	0.206	-0.062	-0.017	0.126	0.004	-0.019	0.055	0.000				
Exposure to shocks in the X	-0.190	0.088	0.038	-0.220	0.087	0.000	-0.121	0.000	0.000			
Poverty	-0.055	0.020	-0.004	-0.052	0.012	0.001	-0.033	0.024	0.000	0.000		
Vulnerability	0.299	-0.020	0.053	0.862	0.837	0.044	0.013	0.037	0.082	0.049	-0.794	

Total effects (Latent variable) / Dimension (1):

	Smallness	Remoteness	REsistance to ND	Governance	Human capital	Public external debt	Investment capacity	Productive structure	Exposure to shocks in the M	Exposure to shocks in the X	Poverty	Vulnerability
Smallness												
Remoteness	0.000											
REsistance to ND	0.000	0.000										
Governance	0.000	0.000	0.000									
Human capital	0.000	0.000	0.000	0.000								
Public external debt	0.000	0.000	0.000	0.167	0.000							
Investment capacity	0.454	-0.084	0.000	0.100	0.164	-0.071						
Productive structure	0.360	-0.145	-0.056	0.342	-0.099	-0.013	0.178					
Exposure to shocks in the M	0.415	-0.200	-0.017	0.126	0.004	-0.019	0.265	0.307				
Exposure to shocks in the X	0.075	0.092	0.224	-0.220	0.087	0.000	-0.001	-0.678	0.000			
Poverty	-0.055	0.020	-0.137	-0.131	-0.675	-0.098	-0.009	-0.107	-0.037	-0.053		
Vulnerability	0.167	-0.016	0.055	0.457	0.553	0.041	0.013	0.040	0.048	0.035	-0.397	

Annex D. Latent variable scores

	Smallness	Remoteness	Resistance to ND	Governance	Human capital	Public external debt	Investment capacity	Productive structure	Exposure to shocks in the M	Exposure to shocks in the X	Poverty	Vulnerability
Algeria	-1.034	1.023	0.309	-0.722	0.602	-0.508	-0.627	-1.534	-1.554	2.596	-0.561	0.062
Angola	-0.712	0.215	0.348	-1.505	0.749	2.886	-1.546	-2.283	-2.337	4.206	-0.290	0.389
Argentina	-1.100	-0.320	0.254	0.168	1.050	-0.173	-0.505	0.267	-0.883	-0.970	-0.719	-0.497
Bahamas, The	1.341	-0.166	0.711	2.359	1.504	0.510	0.639	2.355	2.573	-0.007	-1.698	-2.312
Bangladesh	-0.665	-0.203	-2.183	-1.036	-1.025	-0.489	-0.758	0.216	-0.584	-0.624	1.272	1.352
Belize	1.256	0.298	-0.190	0.312	0.786	3.339	0.743	1.112	-0.001	0.095	-0.680	-0.766
Benin	0.053	-0.217	0.455	0.148	-1.196	-0.692	-0.643	0.161	-0.090	-0.720	1.229	0.770
Bhutan	0.925	-0.059	0.870	0.678	0.477	-0.400	0.647	-1.272	0.190	0.489	-0.191	-0.597
Bolivia	-0.538	-0.314	0.131	-0.477	0.749	0.080	-0.726	-0.026	-1.103	0.131	-0.249	-0.019
Botswana	0.000	0.597	0.699	1.667	0.500	-0.587	-0.014	-0.274	0.061	1.244	-1.080	-1.249
Brazil	-1.749	-0.909	-0.273	0.502	0.643	-0.015	-0.601	0.974	-0.826	-1.044	-0.790	-0.446
Burkina Faso	-0.281	1.281	0.511	0.046	-2.377	-0.762	-0.976	-0.040	-0.325	-0.730	1.494	1.301
Burundi	0.419	1.122	0.513	-1.433	-1.907	-1.586	-0.944	-0.295	-0.199	-0.954	2.310	2.013
Cambodia	-0.168	-0.321	-1.234	-1.030	-0.116	-1.061	0.639	-0.658	-0.691	0.758	0.724	0.675
Cameroon	-0.487	-0.165	0.573	-1.087	-1.632	-0.257	-1.080	-0.289	-0.226	-0.040	-0.009	0.957
Cape Verde	1.570	-0.413	0.650	1.448	0.333	-0.251	2.219	1.331	0.413	-0.186	-0.803	-1.220
Central African Republic	-0.195	4.313	0.571	-1.634	-1.778	0.365	-0.839	-1.154	-0.512	-0.646	1.678	1.904
Chad	-0.601	4.959	0.291	-1.797	0.749	-0.744	-1.202	-1.925	-1.482	3.126	1.261	1.104
Chile	-0.572	-1.237	0.349	2.355	1.051	-0.451	0.162	-0.133	0.012	0.748	-1.174	-1.624
China	-2.233	-0.969	-6.068	-0.132	0.653	-0.666	0.342	-0.874	-0.229	-0.769	-0.108	0.130
Colombia	-0.905	0.868	-0.169	0.192	0.986	0.240	-0.206	0.372	-1.403	-0.846	-0.669	-0.448
Costa Rica	0.413	-0.219	0.212	1.381	0.359	-0.197	0.222	0.801	-0.120	-0.058	-1.048	-1.139
Cote d'Ivoire	-0.376	0.764	0.731	-1.580	-1.687	-1.278	-1.074	-0.309	0.715	-0.179	0.620	1.401
Djibouti	1.014	-0.420	-0.230	-0.674	0.303	-0.657	3.468	1.835	2.596	-0.148	-0.797	-0.327
Dominican Republic	0.245	-0.482	0.317	-0.105	0.841	0.442	-0.178	0.704	-0.418	-0.739	-0.830	-0.527
Ecuador	-0.264	-0.159	0.351	-0.989	0.619	0.772	-0.982	0.045	-0.750	0.066	-0.709	-0.002

Egypt, Arab Rep.	-0.992	-0.083	0.700	-0.234	0.874	-0.016	0.476	-0.264	-0.420	-0.448	-0.588	-0.246
El Salvador	0.561	-0.836	-0.084	0.329	0.244	0.662	0.123	0.632	-0.323	-0.573	-0.728	-0.538
Eritrea	0.167	0.366	0.051	-1.461	-1.929	-1.557	-1.323	0.283	-0.418	-0.894	0.959	1.523
Ethiopia	-1.036	1.196	-0.394	-0.743	-1.192	-0.603	-0.728	-0.491	-0.353	-0.876	1.334	1.336
Fiji	1.063	-1.217	0.133	-0.091	0.813	-0.501	0.748	1.101	1.754	-0.433	0.114	-0.341
Gabon	0.261	0.411	0.836	-0.695	0.749	4.277	-0.474	-1.618	-2.152	0.385	-0.703	-0.227
Gambia, The	1.042	0.016	0.704	-0.275	-0.312	-0.133	0.571	0.904	-0.034	-0.516	0.741	0.378
Ghana	-0.353	-0.611	0.571	0.747	-0.383	-0.551	-0.112	-0.007	-0.284	-0.541	0.171	-0.049
Guatemala	-0.033	-0.142	0.313	-0.489	0.076	0.008	-0.655	0.469	-0.195	-0.955	-0.306	0.081
Guinea	-0.172	-0.553	0.629	-1.763	-1.254	-0.337	0.289	-1.015	-0.049	-0.007	0.932	1.490
Guyana	0.463	-0.989	-1.027	-0.065	0.373	-0.518	0.586	-0.338	1.392	-0.346	-0.687	-0.445
India	-1.934	-0.351	-3.573	0.351	0.565	-0.400	-0.285	0.051	-0.132	-0.873	0.946	0.358
Indonesia	-1.419	-0.762	-1.670	-0.201	0.622	0.292	-0.630	-1.023	-0.562	-0.837	0.381	0.279
Jordan	0.218	-0.414	0.727	0.765	1.254	0.568	1.807	1.025	1.323	-0.554	-0.853	-1.053
Kenya	-0.697	0.951	-1.446	-0.598	-0.784	-0.304	-0.636	0.463	-0.089	-0.828	1.025	1.001
Korea, Rep.	-0.314	-0.324	0.208	1.905	1.820	0.510	-0.754	0.385	0.456	-0.585	-1.487	-1.832
Lao PDR	-0.042	0.792	-0.098	-1.282	-0.628	-1.063	0.718	-0.801	-0.471	-0.381	-0.238	0.608
Lebanon	0.828	0.368	0.865	-0.524	0.438	3.306	1.467	1.659	1.350	-0.412	-1.099	-0.465
Lesotho	0.736	-0.656	0.025	0.076	-0.991	1.823	0.136	0.264	1.566	0.572	0.935	0.348
Libya	-0.536	1.117	0.904	-0.991	0.749	0.080	0.216	-2.511	-1.778	3.267	-0.270	0.144
Madagascar	-0.544	-0.295	0.006	0.337	-1.529	-0.929	1.152	0.255	0.091	-0.710	1.802	1.095
Malawi	-0.061	0.095	-1.740	-0.064	-0.980	-0.629	-0.355	0.155	-0.164	-0.468	2.020	1.131
Malaysia	-0.476	-0.869	0.155	1.209	0.937	0.427	-0.188	-0.648	0.672	0.208	-1.138	-1.232
Maldives	2.327	0.086	0.736	0.101	0.082	0.314	0.197	2.163	0.625	1.284	-0.791	-0.676
Mali	-0.633	0.623	0.384	0.241	-1.418	-0.688	-1.113	-0.607	-0.064	-0.074	1.407	0.946
Mauritania	-0.273	0.599	0.027	-0.491	-1.257	0.417	-0.105	-1.146	-0.214	0.272	0.518	0.791
Mauritius	1.517	-0.896	0.820	1.829	0.441	0.031	-0.151	1.107	0.597	0.026	-1.142	-1.527
Mexico	-1.261	-0.042	-0.782	0.430	0.643	0.167	-0.478	0.479	-0.882	-0.752	-1.181	-0.631
Mongolia	-0.319	0.836	-0.696	0.290	1.284	-0.771	0.948	-1.083	1.584	0.733	-0.703	-0.784
Morocco	-0.583	-0.199	0.602	0.144	0.243	0.643	-0.047	0.643	0.159	-0.538	-0.562	-0.253
Mozambique	-0.653	-0.529	-0.581	-0.026	-1.721	-1.063	-0.316	-0.213	-0.152	-0.214	2.054	1.398

Namibia	-0.106	0.174	0.220	1.183	0.152	0.510	0.354	0.169	-0.270	-0.461	0.235	-0.407
Nepal	-0.265	0.553	0.207	-0.739	-0.884	-0.545	-1.027	0.090	0.243	-1.014	1.341	1.150
Nicaragua	0.125	-0.257	-0.111	-0.593	0.012	0.542	0.129	0.557	0.441	-0.779	-0.079	0.177
Niger	-0.664	2.015	-0.495	-0.616	-2.599	-0.832	-0.587	-0.446	-0.178	-0.542	1.509	1.699
Nigeria	-1.132	-0.148	-0.120	-1.287	-0.916	-0.467	-0.815	-1.784	-0.720	1.571	1.465	1.559
Oman	0.090	-0.623	0.860	1.094	0.236	0.662	0.164	-1.275	-0.636	2.099	-0.728	-0.820
Pakistan	-1.120	-0.775	-0.618	-0.843	-1.196	-0.425	-0.500	0.352	-0.351	-0.906	0.549	1.082
Panama	0.372	-1.033	0.554	0.742	1.110	0.573	0.781	1.859	2.243	-0.396	-0.736	-1.020
Papua New Guinea	-0.225	-0.478	0.203	-0.769	0.405	0.753	-0.979	-2.240	0.993	0.828	-0.504	-0.022
Paraguay	-0.182	-0.651	0.517	-0.945	0.405	0.197	-1.100	-0.344	-0.076	-0.126	-0.529	0.084
Peru	-0.829	-1.087	-0.228	0.033	0.889	2.657	-0.140	0.174	-0.532	-0.502	-0.634	-0.373
Philippines	-0.732	-0.296	-2.257	-0.071	0.391	0.668	-0.704	0.118	0.067	-0.194	0.170	0.040
Qatar	1.101	-0.361	-0.169	1.229	1.022	0.240	0.508	-1.655	-1.582	1.447	-0.671	-1.173
Rwanda	0.392	2.076	0.247	-0.156	-1.115	-0.673	-0.832	-0.121	-0.766	-0.834	1.905	1.147
Samoa	1.886	-1.218	0.872	1.450	1.137	-0.602	-0.883	0.320	0.398	1.262	-1.093	-1.632
Sao Tome and Principe	2.184	-0.650	-0.084	-0.020	-0.793	-0.326	3.081	0.867	0.620	0.384	-0.523	-0.299
Saudi Arabia	-0.937	-0.140	0.778	0.173	0.594	0.240	0.053	-1.545	-1.388	1.947	-0.671	-0.353
Senegal	-0.155	-0.186	0.501	-0.018	-1.421	-0.534	-0.333	0.725	0.396	0.417	0.775	0.741
Sierra Leone	0.282	-0.106	0.579	-0.907	-1.196	-0.878	-0.673	-0.801	0.342	-0.821	1.501	1.260
Solomon Islands	1.072	-0.712	0.811	-0.583	0.064	-0.104	0.047	1.028	0.375	1.464	-0.025	0.003
South Africa	-0.941	-0.505	-0.348	1.192	0.617	-0.474	-0.724	0.874	-1.011	-0.844	-0.346	-0.680
Sri Lanka	-0.002	-0.800	0.086	0.218	0.490	-0.178	-0.593	0.413	0.098	-0.795	-0.274	-0.303
St. Kitts and Nevis	2.787	-1.046	0.463	2.019	0.912	0.568	3.192	1.235	-0.320	-0.338	-0.872	-1.742
St. Lucia	2.284	-0.606	0.838	2.037	0.896	0.793	3.344	1.959	4.029	-0.254	-0.865	-1.906
St. Vincent and the Grenadines	2.505	-0.842	0.835	1.948	1.184	0.966	2.163	1.484	1.058	0.178	-0.819	-1.802
Sudan	-1.034	0.902	-0.094	-1.735	-0.982	-0.845	0.649	-0.965	-1.270	-0.050	0.649	1.404
Swaziland	1.004	0.179	-1.859	-0.582	-0.442	-0.143	-1.124	-0.537	-0.179	-0.322	-0.539	0.011
Tanzania	-0.840	-0.105	-0.143	0.112	-1.073	-0.921	-0.168	-0.226	-0.031	-0.725	1.761	1.087
Thailand	-0.797	-0.543	-0.803	0.294	0.713	-0.308	-0.070	-0.189	0.714	0.302	-0.883	-0.565
Togo	0.323	-0.363	0.590	-1.231	-1.029	-1.664	-0.840	-0.761	1.667	-0.637	1.106	1.135
Tonga	2.356	-1.625	0.499	-0.046	0.244	-0.377	0.547	0.829	1.163	-0.819	-0.671	-0.663

Trinidad and Tobago	1.276	-0.727	0.823	0.861	0.365	0.662	-0.695	-0.924	0.781	0.922	-1.113	-1.052
Tunisia	-0.074	0.149	0.852	0.559	0.818	1.577	-0.300	0.497	-0.189	-0.467	-0.886	-0.782
Turkey	-0.915	0.414	-0.225	0.665	1.065	0.024	-0.427	0.784	-0.540	-0.957	-1.170	-0.879
Uganda	-0.429	2.022	0.051	-0.241	-1.482	-0.685	0.130	0.073	-0.322	-0.839	1.383	1.159
Uruguay	0.170	-0.840	0.604	1.721	1.025	0.510	-0.127	0.811	-0.251	-0.918	-1.136	-1.456
Vanuatu	1.477	0.306	0.068	0.993	0.683	-0.685	0.420	1.350	0.322	0.931	-1.074	-1.249
Venezuela, RB	-0.738	1.535	0.561	-1.456	0.787	0.023	-0.715	-0.791	-1.346	0.558	-0.878	0.140
Vietnam	-0.744	-0.609	-1.078	-0.232	0.627	-0.385	1.056	-0.704	0.717	-0.204	0.306	0.110
Yemen, Rep.	-0.538	-0.255	0.522	-1.100	-1.163	-0.721	-0.440	-0.312	0.064	1.151	0.270	0.954
Zambia	-0.496	0.710	-0.311	-0.170	0.380	-0.718	0.913	-0.329	-0.433	0.554	1.751	0.743

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