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Assessing and measuring economic resilience in low-income countries illustrative cases Nepal and DR Congo

Lucien Momeka, Ruhangamuza

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Thesis presented by

LUCIEN MOMEKA RUHANGAMUZA

Supervisor(s)

MARY VAN OVERBEKE (UCL)

Tutor(s)

FRANÇOIS WOITRIN (UNamur)

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Département des Sciences économiques/UNamur • Rempart de la Vierge 8 • 5000 Namur
Ecole d'économie de Louvain/UCL • Place Montesquieu 3 • 1348 Louvain-la-Neuve

EPIGRAPH

Resilience, a nourishing new tool that gives itself a future without being confined to the past.

Nabil Alami (2018)

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At the end of this thesis, it is imperative for us to fulfill a social duty, to thank wholeheartedly all who have contributed in one way or another to the accomplishment of this work.

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ABSTRACT

Considering two countries that are the subject of a comparative study (DR Congo and Nepal), we have defined a number of criteria on the basis of which eighteen indicators divided into five dimensions (commercial, socio-economic, fiscal, financial and spherical) have proved important for measuring and assessing the economic resilience of low-income countries. The min-max standardization technique allowed us to derive standardized coefficients between 0 and 1 on the basis of which we performed arithmetic average operations in order to identify sub-indices related to each dimension. Thus, five sub-indices were determined and their geometric average allowed us to determine the economic resilience index. Also, the min-max technique as well as the principal component analysis allowed us to determine the dimension that contributes more to the variability of our data. At the end of our analyses, it turns out that the economy of Nepal over the period from 2003 to 2017 is more resilient than that of DR Congo. This resilience capacity is largely explained by the trade dimension for these two countries.

Keywords: Economic resilience, composite index, sub-index

RESUME

Considérant deux pays faisant l'objet d'une étude comparative (RD Congo et Népal), nous avons défini un certain nombre de critères sur base desquels dix-huit indicateurs répartis en cinq dimensions (Commerciale, socio-économique, fiscale, financière et sphérique) se sont avérés importants pour mesurer et évaluer la résilience économique des pays à faible revenu. La technique de normalisation min-max nous a permis de dégager des coefficients normalisés compris entre 0 et 1 sur base desquels nous avons effectué des opérations de moyennes arithmétiques pour dégager les sous-indices liés à chaque dimension. Ainsi, cinq sous-indices ont été déterminés et leurs moyenne géométrique nous a permis de dégager l'indice de résilience économique. Aussi, la technique min-max ainsi que l'analyse en composante principale nous a permis de déterminer la dimension qui contribue le plus à la variabilité de nos données. Au bout de nos analyses, il s'avère donc que l'économie du Népal sur la période allant de 2003 à 2017 est plus résiliente que celle de la RD Congo. Cette résilience est en grande partie expliquée par la dimension commerciale pour ces deux pays.

Mots clés : Résilience économique, sous-indice, indice composite.

ACRONYMS AND ABBREVIATION

CEPII: Research and expertise on the global economy

CO_2: Carbon dioxide

COMTRADE: Commodity Trade

DAC: Development Assistance Committee

DR Congo: Democratic Republic of Congo

FDI: Foreign Direct Investment

GDI: Gender Development Index

GDP: Gross Domestic Product

HFA: Hyogo Framework for Action

HIPC: Heavily Indebted Poor Countries

IDA: International Development Association

IMF: International Monetary Fund

LEB: Life Expectancy at Birth

NICT: New Information and Telecommunication Technologies

NVRI: Net Vulnerability-Resilience Index

ODA: Official Development Assistance

OECD: Organization for Economic Co-operation and Development

P4R: Program for Result Financing

PCA: Principal Components Analysis

SITC: Standard International Classification

STATA: Software for Statistics and Data science

UNCDP: United Nations Common Development Plan

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INTRODUCTION

Because the economic resilience literature is too limited for low-income countries, the overall goal of our thesis is to describe the key variables to be considered in assessing and measuring the economic resilience in low-income countries. Specifically, this thesis aims on one hand, to develop a procedure for computing the economic resilience index in low-income countries. On the other hand, it provides a methodological framework needed to identify the dimension or the indicator that makes the economy more resilient in low-income countries in order to derive economic policy implications and thus provide recommendations for improving the resilience capacity for these countries.

With the exception of some fragile and conflict-affected countries, low-income countries experienced strong and sustained economic growth until 2014 despite the global financial crisis in 2008 (IMF, 2014). This positive trend hit a roadblock in 2014, with drop in global commodity prices. Commodity exporters experienced a marked drop in export revenues, soon reflected in budgetary difficulties and a fall-off in growth. With commodity prices set to remain low for the foreseeable future, macroeconomic development in the low-income countries continue to be heavily influenced by how countries are responding to the new world shocks, which makes the economies of low-income countries more exposed to shocks and less reassuring about their sustainability (IMF, 2015).

However, Countries and more particularly low-income countries are subject to a wide variety of economic shocks, sovereign debt crises, commodity price fluctuations or volatility in the world economy. These shocks can increase risk and uncertainty for households, investors and governments, and when sufficiently large, can trigger crises and throw economies off their growth path and then lead to long-lasting periods of stagnation (Sánchez et al. 2015). From a policy perspective it is therefore important to understand the major factors that condition a country's resilience to face the adverse economic shocks. And so, a first question comes to mind: ***What are the effective indicators for assessing and measuring the level of economic resilience in low-income economies?***

There is no consensus on the measurement of economic resilience. For instance, the choice of variables, the aggregation procedure and the way to assign weights to variables differs among composite indices of economic resilience in the literature (equal weight for Briguglio et al., 2009;

Guillaumont, 2010 versus unequal weights for Adrianto & Matsuda, 2004). In addition, studies on resilience do not generally refer explicitly to sustainable development even though some of them use this aspect. For illustrative purposes, in many works like those of Atkins et al. (2000) and Briguglio et al. (2009), the economic dimensions have been emphasized, but the other dimensions like the social; the environmental are implicit or even lacking.

Nonetheless, in the literature several variables are developed to assess and measure economic resilience and many of them relate to developed and emerging countries. Taking into account the theoretical and empirical lessons of the various scientific works proving the need for the low-income countries to strengthen their economic structures in order to be able to resist from the different shocks, we will consider indicators of trade dimension, socio-economic dimension, fiscal dimension, financial dimension and political dimension for assessing and measuring the economic resilience of low-income countries.

We use the term low-income country (34 countries) to refer to those countries that have a low per capita income ($995 or less) (World Bank 2018). Unlike the DR Congo (located in Central Africa with 2,345,000 km² and an estimated population of 81,339,988 inhabitants), Nepal (147,181 Km² is 16 times smaller than the DR Congo and with an estimated population of 29,304,998 inhabitants) is a landlocked Himalayan country in south Asia. Nevertheless, in the illustrative case we assess and measure economic resilience in these two low-income countries and not geographically close. One country is considered a large country (DR Congo) and the other as a small (Nepal). Thus, a comparative study is made between these two states in terms of their economic resilience capacity. ***Hence the question: which of the DR Congo and Nepal Republic is more economically resilient?***

Furthermore, in this work, we use the process of calculating a composite index of economic resilience based on the philosophy of sustainable development in order to identify the variable/indicator (or dimension) that contribute to make the low-income economies more resilient (here, we consider two countries namely the DR Congo and Nepal). Hence the question: ***In which economic dimension are the strengths of each country (DR Congo and Nepal) in terms of resilience?***

Having already all the data relating to the chosen variables for the two countries which constitute illustrative cases of our study, we will re-scaling all the variables based on the min-max

normalization technique before to evaluate the composite resilience index for both countries by applying arithmetic operations based on the simple arithmetic average and geometric average. The principal component analysis will also allow us to describe the variable that contributes more to make the economy more resilient.

The last fifteen years ago (2003-2017) is the time limit of our analyzes in the sense that this period corresponds of course to the years in which several low-income countries have experienced sufficient performance in terms of economic growth supposed to have improved their economic resilience capacity.

Contributing to a new methodology for assessing and measuring economic resilience in low-income countries is the principal motivation by addressing the present thematic. ***Personally***, this research allows me to have important theoretical and methodological tools for assessing and measuring economic resilience and especially for low-income countries. On the ***Theoretical level***, it is to highlight the questions on the evaluation of economic resilience and especially for low-income countries. To this end, no economic theory has succeeded in removing the indeterminacy surrounding this issue of economic resilience in particular the appropriate methodology to measure it in terms of index.

Regarding the ***operational interest***, in the context of this study, it is really a question of knowing the state of the economy for the Democratic Republic of Congo as well as that for the Nepal Republic, namely whether they are resilient and at what levels. Also, we believed that by approaching this study, we put at the disposal of the future researchers a working instrument which can help them to carry out diversified studies in the economic resilience field. At the end, researchers can use it as a solution track related to their problem and scientific research relating to the economic resilience of low-income countries.

In addition to the introduction and conclusion, our thesis is structured around four chapters. The first chapter, after having laid down the necessary theoretical bases, details the work forming the empirical basis of our study. The second chapter is dedicated to the methodological approach adopted in order to quantify the economic resilience index. The results of our analysis are presented in the third chapter which is also the part dedicated to the interpretation of the results. Finally the fourth chapter is devoted to the principal findings and the implications of our results in terms of economic policies.

First Chapter. LITTERATURE REVIEW

In this chapter, we present theoretically key concepts related to our topic, in particular the basic notion of resilience as well as other concepts (such as economic shock and composite index) needed in order to be able to apprehend the theoretical framework of our study. Just after the theoretical review we detail extensively the empirical lessons drawn from the existing literature on the assessment and measurement of economic resilience in low-income countries.

Section 1. THEORITICAL FRAMEWORK

In this section, we discuss about the different theoretical foundations related to our subject. First, we will present the concept of economic shock before raising the subject of economic resilience which represents the key issue of our work. Finally, it is important at the end of this section to introduce a little bit the concept related to composite index that will allow us in the third chapter of this thesis to better quantify the economic resilience and at the same time to be able to conduct the comparative study between low-income countries and more precisely Nepal and DR Congo, the two illustrative cases in our thesis.

1.1.1. Economic shock

An economic shock is an unexpected or unpredictable event that affects an economy, either positively or negatively. It refers technically to an unpredictable change in exogenous factors (L*ütkepohi 2008).* Shocks can be of three kinds: shocks caused by internal factors such as political crisis, social unrest, which may downturns in the national economy; shocks caused by economic shocks affecting a particular sector/industries that constitute an important component of the region's export base (prices fluctuations) and other external shocks (a natural disaster, closure of a military base, movement of an important firm out of the area, etc.).

The shocks are not mutually exclusive; a country or regional economy may experience more than one simultaneously. Not all shocks cast an economy substantially off its prior growth path. When a shock occurs that does not cause the country or the region to be thrown off its prior growth path (to experience an economic downturn), we consider it as the region "shock-resistant". If the region or the country is adversely affected by the shock and it returns to its prior growth path within a relatively short period of time, we consider it "resilient". If it does not, we consider it "non-resilient" (Hill et al. 2012).

1.1.2. The term resilience

More than a metaphor and less than a theory, the resilience is a conceptual framework (Swanstrom 2008). The first known use of the term "resilience" in science was by Webster in the field of classical physics in 1824. Resilience initially was defined as the ability of a material to return to its initial condition in terms of size and shape after deformation due to a compressive shock (which exert pressure on a phenomenon in order to reduce its harmful impact)[1]. Today, the term resilience means to rebound or to leap back (Reggiani 2013).

According to Foster (2007), there are several conclusions about attributes of resilience. First, resilience applies not only to a system as a whole, but to individual system elements, such as the infrastructure, the information, the physical environment, the civic organizations, the governance and the economic systems. Second, a system that is resilient on one element may not necessarily be resilient on another. Third, resilience can be developed in terms of understanding and measurement, depending largely on the framework in which the concept is being considered.

Fourth, resilience leads to exploring a perfectly associated framework (vulnerability) that is more concerned with the sensitivity of the system or one of its components to external pressures. Vulnerability is not seen as the state opposed to resilience. A system can be resilient in some dimensions and at the same time vulnerable in others even though the resilience of one dimension may imply less vulnerability for the other dimension of the system (Seeliger & Turok 2013).

1.1.2.1. Resilience Versus stability, sustainability, prevention and vulnerability

Some concepts like stability, sustainability, prevention or vulnerability are not to be confused with resilience (Brinkmann et al. 2017).

A. Resilience versus stability

There's a difference between the two concepts. In fact, the resilience of a system is not to be equated with its stability (in the sense of a low degree of volatility) (Rose 2009). Even a system that undergoes considerable short-term fluctuation as the result of a shock can prove to be resilient if, following a phase of instability; it reaches a new equilibrium with performance comparable to that displayed before the shock.

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[1] Merriam-Webster Dictionary and McDargh (2013) http://www.eileenmcdargh.com/blog/2013/11/toughtimes-demand/ Accessed January 26, 2019.

B. Resilience versus sustainability

These two concepts differ with respect to their temporal dimension. Sustainability considerations from ecology to economics are defined on the basis of very long time horizons, typically encompassing several generations. Sustainable systems have the prospect of fulfilling their functions even after the passage of decades (or centuries). Sustainability is also often a reaction to gradual changes. Observations of resilience are undertaken over a shorter period of time. The systemic disruption under consideration is of a shorter-term and more abrupt nature, and the question of processing the shock, if necessary, refers at most to the medium term. As compared to resilience, sustainability is the more comprehensive concept; resilience represents a necessary but not sufficient condition for sustainability.

C. Resilience and prevention

As far back as the word's origin, the consideration of resilience does not take into account statements regarding the probability of sudden adverse events, but rather addresses the effects and processing of such events. This understanding permeates applications in all disciplines. Consequently, analyses of resilience should be conceptually distinguished from issues of crisis origin or prevention. At the core of resilience strategy is not the prevention of crises, but rather the attempt to cope with a crisis one which is unavoidable, or one whose probability can be influenced only to a limited degree as well as possible. This includes also proactive measures in the run-up to a possible crisis. However, these are not oriented toward averting the crisis, but rather toward coping with it more effectively through preparatory measures.

D. Resilience versus vulnerability

It is quite difficult for many of the scientists to establish the difference between resilience and vulnerability. Indeed, these two terms too should not be equated. Vulnerability is the broader term, encompassing the extent to which a system is exposed to crisis (Rose 2009), and is thus minimized through successful crisis-prevention measures. By contrast, the degree to which resilience has been achieved can be assessed only with respect to a crisis. A system in which crisis-prevention measures have been successfully carried out reduces its vulnerability. However, it does not necessarily thereby improve its resilience (for the case in which the now-less-probable crisis event nevertheless takes place).

Table below shows a comparison between vulnerability and resilience on different scales. The contrast suggests that resilience is more concerned with the capacity to recover from a disaster within a short time and with no outside assistance, while vulnerability is the property of resisting the stress caused by a natural hazard.

Table 1. Difference between vulnerability and resilience at different levels

Vulnerability	Resilience
Resistance	Recovery
Force bound	Time bound
Safety	Bounce back
Mitigation	Adaptation
Institutional	Community-based
System	Network
Engineering	Culture
Risk assessment	Vulnerability and capacity
Outcome	Process
Standards	Institution

Source: Manyena (2006), The concept of resilience revisited, p 445.

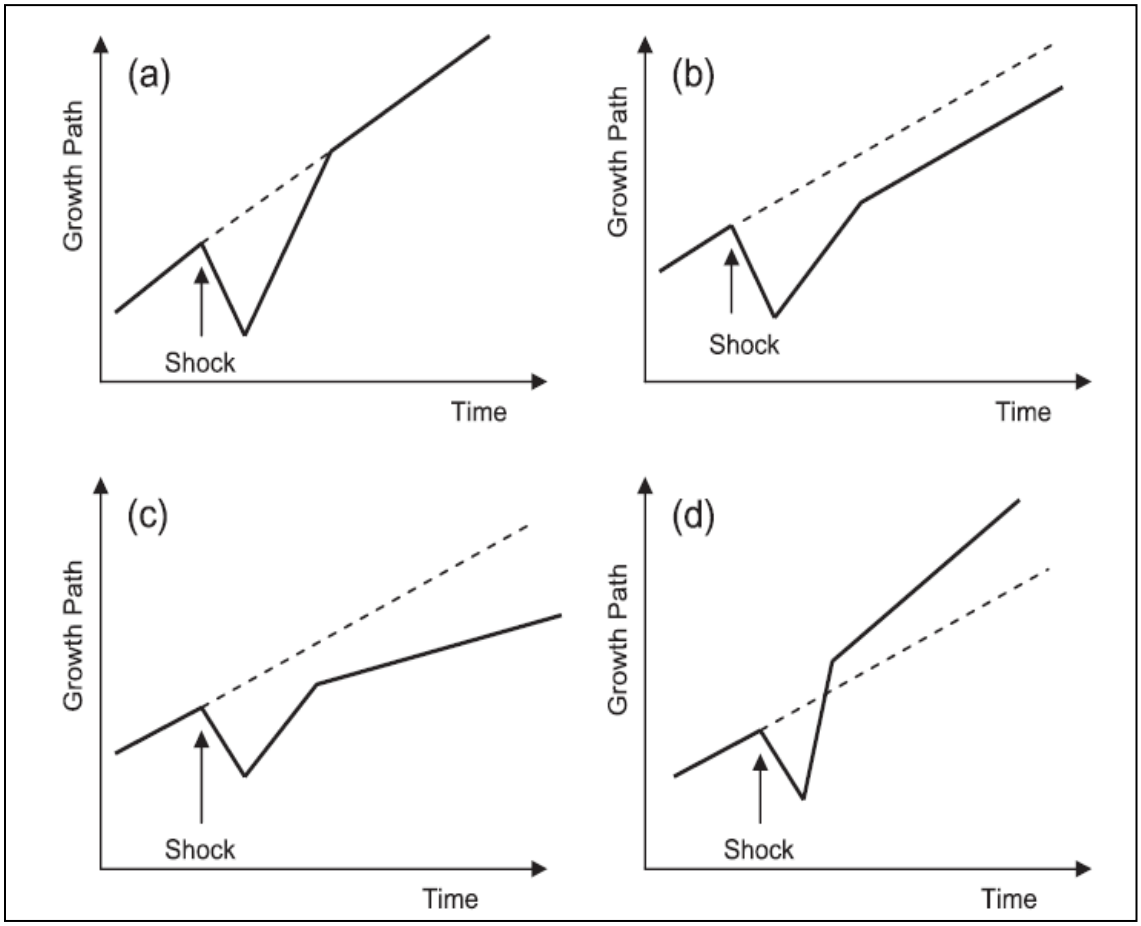
1.1.2.2. Towards Economic Resilience

For a long time, economic resilience did not receive the level of scientific attention as it is attracting today. Martin (2012) provides an interesting review of work on resilience from an economic viewpoint; in particular he describes how resilience was regarded in the broader economic literature as a fuzzy concept. In literature, the term Economic Resilience has been used in at least three senses relating to the ability to recover quickly from a shock; to withstand the effect of a shock and to avoid the shock altogether (Briguglio et al. 2006).

Today, the relative resilience of different economies would be measured in terms of their susceptibility to being moved off their equilibrium paths and their response times of recovery to equilibrium. It is difficult to reconcile the notion of resilience with the idea of economic evolution. The implication is that the more resilient is a country or a regional economy, the less it would change over time, even in the face of various shocks (Simmiea & Martin 2010). As we can see in Figure 1(a) below, a shock or disturbance moves an economy off its equilibrium growth path, but the assumption is that self correcting forces and adjustments eventually bring it back onto that path. This is not the case for other figures (1(b), 1(c) and 1(d)) even if each case shows

a certain degree of resilience but the resilience capacity in the three last cases (1(b), 1(c) and 1(d)) is less than the capacity resilience in the first case (1(a)).

Figures 1. Stylized responses of a regional economy to a major shock[2]



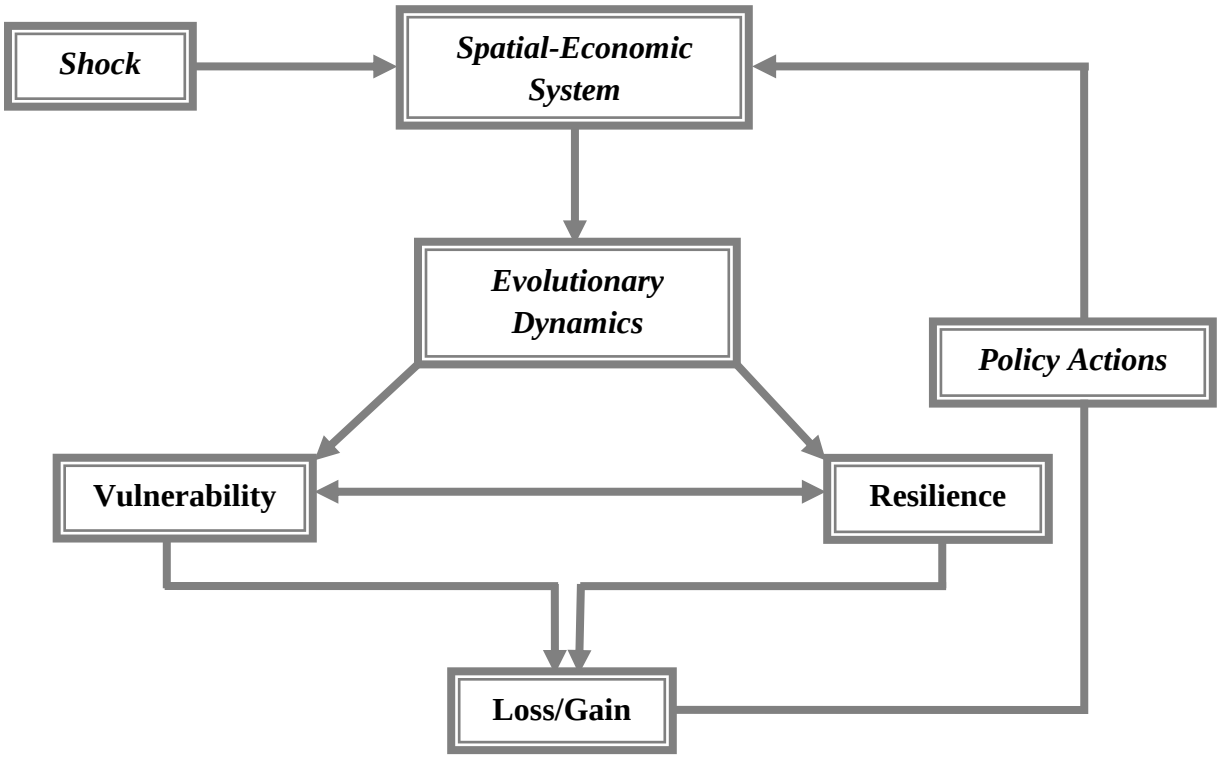
Source: Simmiea & Martin (2010), The economic resilience of regions: Towards an evolutionary approach, p 3.

However, being two concepts which are not mutually exclusive, it is less consistent to talk about economic resilience without addressing the point about economic vulnerability. Several authors consider economic vulnerability to be a pre-shocks characteristic and economic resilience the outcome of a post-shocks response (Cutter et al. 2008). Thus, economic resilience is often seen as a way to reduce economic vulnerability and a more resilient economic system is seen as a system with less vulnerable economic sub-systems (Pendall et al. 2012).

[2] (a) Return of region to its pre-existing steady growth path following the shock;
(b) and (c) region fails to resume former steady growth path after the shock, but settles on inferior path;
(d) Region recovers from shock and assumes an improved growth path.

The link and difference between these two concepts appears to be ambiguous and is not well defined in the economic literature. The figure below shows the inter-connections between economic systems, economic vulnerability and economic resilience, through their evolutionary dynamics and exposure to shocks. The shock plays a central role; when a shock hits the economic system, either in its entirety or one of its parts, it causes an economic loss or gain that is more or less pronounced according to the economic vulnerability and economic resilience characteristics of the system considered as a whole.

Figures 2. A methodological framework linking economic resilience and economic vulnerability



Source: Modica & Reggiani (2014), Spatial economic resilience, p 230.

The loss/gain changes the original structure of the economic system and result in a new equilibrium. The new equilibrium is the motivation for the introduction of "adaptive" strategies by policy makers (e.g., policy measures aimed at mitigating an economic loss, etc.). A good preventative action would be policy to enhance resilience (or to reduce vulnerability). However, this action would also affect the spatial-economic system. Thus, vulnerability and resilience might be regarded as concepts that play a key role in modifications to the spatial economic system's structure.

1.1.3. The composite indexes

The resilience concept is perceived as a network of dependent relationships among the variables and among dimensions. A composite index is an aggregation of a set of individual indicators that gives evidence for a multifaceted problem using mathematical or computational methods. The justification for a composite index lies in its fitness for the phenomenon to be measured and its simplicity (Pedrazza & Katsinis, 2018). The resulting big picture of composite indexes is easier to interpret than a battery of many separate indicators. Nevertheless, economic resilience index as a composite index reduce the multifaceted reality to a single value. In this work, we will calculate this composite index through some mathematical techniques in order to be able to quantify the economic resilience of low-income countries by using a group of variables.

1.1.3.1. Criteria for rejecting a variable to compute a composite index

Many authors provide guidelines or manuals regarding desirable properties of statistics and indices (see for example Farrugia 2007; IMF 2003; OECD 2008). Briguglio (2003) proposed criteria for rejecting component variables when constructing a composite index. These criteria include variables that are not relevant, are beg the question, and are redundant. As part of our work, these criteria are scrutinized with more attention.

A. Irrelevance variables

Variables (or indicators) that are not relevant to the phenomenon called to be measured should obviously be excluded. But there are instances where non-relevance of a variable is not immediately obvious. For example, in an economic vulnerability index, which is aimed at measuring the causes of economic vulnerability (capturing features of an economy that render it exposed to external shocks), GDP volatility or export volatility should not feature as components of the index. The reason for this exclusion is the fact that volatility can be a manifestation not only of vulnerability but also of some other causes (As for instance, an inherently highly vulnerable economy may not be volatile if it builds ***economic resilience***, and conversely an economy which is not high vulnerable may be volatile if its ***economic governance*** is weak).

B. Begging the question

This means assuming beforehand what is intended to be proved. For example, introducing country size as a component of the index when the objective is to test whether the small countries

(For example: Nepal) are more vulnerable than large countries (For example: DR Congo) is not acceptable, because this situation would bias the results. This is one more reason for not take into account the variable “size of country” in our thesis.

C. Redundancy

A set of variables that are highly correlated could replicate each other or capture the same tendencies. In practice, decisions to know which variables to exclude on the basis of this argument are not easy to take, among other things, this situation can require a correlation coefficient threshold, above which the variables would be considered as too correlated and therefore possibly capturing the same phenomenon.

However, highly correlated variables may be representing by different factors that convey more or less the same message. Testing for statistical correlation and retaining only those indices which are not highly correlated with each other may result in rejecting something which should be accepted. For this reason, the redundancy problem requires that statistical analysis should be complemented by a qualitative analysis of the variable itself. The fact of being selective in the choice of variable components may also be desirable for other reasons, such as parsimony.

1.1.3.2. Criteria for adopting a variable to compute a composite index

Briguglio (2003) in his study identified positive attributes of variables used to construct a composite index especially in the economic sphere, namely the simplicity, the transparency, the reproducibility, the comparability and the affordability. These are the essential qualities that a variable can have in order to compute a composite index and avoid any bias that may be involved in the calculation. We believe that we can take into account these criteria in order to select variables and build our index (economic resilience index) in the low-income countries.

A. Simplicity

The main advantage of simplicity is the fact that the variable is easy to understand by stakeholders, decision-makers and other users. The simplicity allows to correctly interpreting the variable and facilitates the work of making proposals in terms of economic policies. A variable with this quality (simplicity) must contribute effectively to the construction of the composite index (here it is the economic resilience index), which is also an essential element that makes the interpretation of a phenomenon simple and understandable.

B. Transparency

This attribute requires that the methodology used should be clearly explained by the institution or the persons who implemented the variable and that the data used by the author of the variable should be available to those who wish to assess the variable. That is one more reason to have a methodological basis well provided in a study in order to build a composite index.

C. *Reproducibility*

This attribute requires transparency, in that it should permit replication of the variable by users or assessors of the variable, including stakeholders and policymakers, for the purposes of evaluation and validation. It's just an attribute that demonstrates the need to have a variable that does not give some doubt about its estimate.

D. Comparability

A variable which is intended to measure an incidence across different subjects (such as countries) should, of course, be suitable for such comparisons. In the case of the resilience index, which is intended to compare economic resilience across countries, the variables selected as components of this index should be available across countries and should be measured in a homogenous manner. Preferably, the data should be collected as a matter of routine in line with the information required for a particular country. This may explain why cross-country economic indices are easier to construct than environmental indices and as internationally comparable economic statistics are easier to obtain than internationally comparable environmental statistics.

E. *Affordability*

This attribute implies that the procedure used must not be excessively time-consuming and the data needed must be relatively easy to obtain and to process. In this regard there is usually a trade-off between what is purely theoretical and what is practical. A variable known in advance that the data will be difficult to obtain is not worth it.

Two additional attributes can be added with respect to the composite indices proposed in a study, namely ***as wide coverage of states*** as possible and the ***usefulness*** of the adopted variable given that the purpose of some studies is to enable policy makers to identify priorities for building resilience. The choice of variables used in this thesis is based on these criteria

1.1.4. Computation of economic resilience index: Aggregation and weighting issues

Composite economic resilience index can be weighted or non-weighted averages of standardized variables. This index use aggregation processes that follow different fundamental principles and computation techniques, it all depends on what the author wants to demonstrate and how he intends to do it. Two main methods are used to integrate the variables and sub-indexes into a single value (economic resilience index).

First, regression models are estimated to calculate weights among variables. This method is followed by Atkins et al. (2000) to capture the sources of economic resilience. The regression explains the dependent variable gross domestic product using explanatory variables that refer to different sources of economic resilience. Adrianto & Matsuda (2004) also refer to a model to explain economic exposure as part of their composite resilience index. The two disadvantages of using a regression model can be summed up by the fact that this model is more complex for this kind of estimates and the integration of potential estimate errors from data that can be directly ready for use without additional estimates.

Second, an average of the various variables can be used directly. Adrianto & Matsuda (2004) compute weighted averages that associate the economic exposure sub-index with two other sub-indexes (economic vulnerability and economic resilience). Briguglio and Galea (2004) follow the same computation principle. Nevertheless, Briguglio (1995) recognizes the subjectivity or arbitrary characteristics of an ad hoc weighting: “alternative weighting schemes would not solve the problem of subjective choice”. The author acknowledges that there is no evidence of the higher validity of weighted variables compared with non-weighted variables. Non-weighted variables would not change the message conveyed through a composite resilience index in comparison with weighted variables.

Moreover, it would be difficult to determine whether fluctuations in the value of a composite index are due to an effective evolution of the resilience state or to changes in the weighting system, because there is no absolute proof that such an econometric procedure can provide time-invariant weights. For the same reasons, assigning weights to indicators based on expert elicitation does not solve problem, either. Consequently, most of the composite resilience indexes use a non-weighted average to integrate their components (Angeon & Bates 2015).

Kaly et al. (2004) argue that "simple averages across indicators can be used because they can be easily understood, and more complex models do not appear to offer any advantages to expression or utility of the index". For this reason, composite resilience index commonly calculate the simple averages of variables, provided that they are standardized. Standardization/normalization is required to permit international comparisons because composite indexes per se aggregate variables with different measurement scales. To manage outliers, even if procedure is not typical, the composite indexes use the extrema values of variables in standardization technique. Nevertheless, as noted by Nardo et al. (2005), more complex methodologies could be used to synthesize data, such as multivariate models and factor analysis.

Section 2.EMPIRICAL FRAMEWORK

In this section we try to build an empirical basis by summarizing the works of different researchers. These summaries are done based on four themes (economic resilience studies, resilience between regions according to a certain degree of shocks, some methodological basis, and Net Vulnerability-Resilience Index) that constitute the different points used in this section.

1.2.1. Economic resilience studies

In the paper presented by Cai, Lam, Qiang, Zou, Correll & Mihunov (2018) on *A synthesis of disaster resilience measurement methods and indices*, the authors synthesis study aimed to derive commonalities and new knowledge from the fragmented body of literature on resilience measurement. Through analyzing 174 articles collected for the period 2005–2017 and based on the simple description of the samples, the authors found that, 39.7% of the articles used qualitative methods and a similar percentage of articles (39.1%) used quantitative methods. Also, the most frequently used indicators in resilience measurement are income, employment, education, age, and previous disaster experience.

For us, we assume that a qualitative study only, although it has certain advantages, may depart from certain realities. The best way for us to perfect this study is to adopt the quantitative aspect while keeping an eye on the qualitative analysis. Also, the choice of variables will be made with the idea that all variables can be selected whatever the field in which they concern, only they must relate to the economic resilience in low-income countries and they respect the selection criteria proposed in the literature.

1.2.2. Resilience between different regions according to a certain degree of shock

Hill, Clair, Wial, Wolman, Atkins, Blumenthal, Ficenec & Friedhoff (2012) have conducted a study on the *Economic Shocks and Regional Economic Resilience*. Using a data base consisting of annual metropolitan level employment data for 361 MSAs in USA from 1970-2006, the authors identified nearly 1500 shocks to regional economies. In nearly half of these cases (47%), the affected region was "shock-resistant" and it did not suffer a serious economic downturn as a result of the shock. Regions suffering a downturn as a result of a shock were "resilient" 65% of the time. Regions that were adversely affected by a shock were less likely to be resilient if the shock was a national economic downturn alone (to which 55% of adversely affected regions were resilient) than if it were a national industry shock alone (80% resilient) or a local industry shock alone (77% resilient). The average length of time to resilience for a region after having suffered a shock-induced downturn was 2.9 years.

However, even if the most resilient regions can be vulnerable to different shocks, it is the resilience that will ensure that a shock can last up for a long time or disappear just after its appearance. For example, in the event of a shock to the global production of goods, several countries may suffer the same degree of shock (vulnerable to the same degree) but the response capacity to deal with these shocks differs from one country to another and it depends on the economic and social structure of each country. Hence the need to conduct the study that can compare resilience capabilities between states. We do this in our study by elucidating the key variables that may be the basis of this resilience capacity but for low-income countries only.

In the table 2 below presented, we reviewed briefly eighteen papers and articles, extracting from the main characteristics, tools used, and interpretation of economic resilience, with the aim of providing a complete overview to suggest new research questions and directions for the others research questions[3] as presented by Modica & Reggiani (2014) in their article entitled Spatial Economic Resilience: Overview and Perspectives. This table describes the different shocks, the context, the aim, the framework, the measure for resilience of each case studied in these 18 scientific works.

[3] The papers and working papers were selected using Google Scholar and the Scopus database. We restricted our search to papers containing the words "economic resilience', or 'regional economic resilience' in their titles, abstracts or key words.

Table 2. Main characteristics of the economics resilient literature[4]

Authors, year	Shock	Context	Aim[5]	Framework[6]	Tool	Measure for resilience	Case study
Adger 2000	Institutional shock	Livelihood system	Adjustment	Static	Qualitative analysis	Inequality of income property rights	Mangrove conversion in Vietnam
Ashby et al. 2008	2008–2010 downturn	Economic development	Adaptability	Static	Methodological framework	Environment Infrastructure Socio-economic	6 urban areas around the world
Bristow 2010	Economic downturns	Regional Development	Adaptability Recovery	Static	Cultural political economy approach	Measures of competiveness	Methodological approach
Bruneau et al 2003	Earthquake	Economic development	Resistance	Static	Performance measures index on the quality of Infrastructures	Socio-economic Technical Organizational	Methodological approach
Cellini and Torrisi 2014	Economic downturns	Output	Resistance	Static	SURE, RCM, MA,, MSA, CGEM	Regional heterogeneity of estimated parameters	Italian Region in 1890-2009
Chan et al. 2014	Flood	Economic development	Adaptability	Static	Indices	Built environment institutional Natural environment Socio-economic Technology	Tan-sui river basin in Taiwan
Coles and Buckle 2004	Disasters	Recovery activities	Recovery	Static	Qualitative analysis	Operational Planning Policy	Lewes district, UK in 2000
Cutter et al. 2008	Disasters	Recovery activities	Recovery	Static	Composite indicator	Community Ecological Infrastructure Institutional Socio-economic	Southeastern United states

[4] The analytical context changes according to the different economic objectives which range from regional accountability, job market analysis, business analysis and living standards and quality of life.

[5] Resilience might be analyzed to measure the economic success of a region/area in terms of: i) adjustment, ii) adaptation, iii) convergence, or iv) equilibrium; or according to Martin's (2012) categories: i) renewal, ii) reorientation, iii) recovery, or iv) resistance.

[6] The aspects account respectively for: a) the degree of regeneration along a regional growth path, b) the degree of adaptation in response to shock of the object under study; c) capacity in terms of speed and degree of recovery from shocks, and d) the extent of sensitivity to the shock. Framework refers to the treatment of time and space which has important impacts on the way the economic process that characterizes resilience is understood. The typical framework is static. Thus, time can be measured in moments of pre-shock, shock, and post-shock events, within the confines of the region/area. Alternatively, time can be seen as a constant process of transition in which space can be thought of as the result of a continuous flow of actions.

Davies 2011	2008–2010 downturn	Employment	Adaptability Adjustment Recovery Resistance	Static Dynamic	Regression analysis Semi-structured interviews	Regional strength and weakness Sectorial structure	Europe in 2008–2010
Dhawan and Jeske 2006	Energy price shocks	Output	Resistance	Static Dynamic	Counter-factual analysis	Counter-factual growth rate	USA 1970-2005
Di Caro 2013	Economic downturns	Employment	Resistance	Static	SURE VECM	Regional heterogeneity of estimated parameters	Italian regions in 1970-2010
Duval et al. 2007	Common unobserved shocks	Employment	Recovery	Static	Pooled regression analysis (dynamics)	Labor and product market regulations	20 OECD Countries in 1982–2003
Graziano 2013	Socio-economic shocks	Socio-economic development	Recovery	Static	Indices	Economic Enterprise Household Infrastructure Innovation Local economy	Italian local systems in 2007-2011
Hill et al. 2011	Economic downturn Industry shock	Employment Output	Adjustment Recovery Resistance	Dynamic	Hazard models Logistic regression	Socio-economic	MSA, USA 1970-2007
Jordan et al. 2011	Disasters	Output	Recovery	Static	Qualitative comparative analysis	Disaster impact Infrastructure institutional Recovery strategy Socio-economic	Hurricane Katrina Indian Ocean Tsunami
Martin 2012	Economic downturns	Employment, output	Adaptability Adjustment Recovery Resistance	Static Dynamic	Ratio of decline Sensitivity indices Growth trends Structural composition of employment change	Economic index	British regions in 1970-2010
Ormerod 2010	Coal-Industry specific shocks	Employment in coal field areas	Recovery	Static	Regression analysis	Percentage change in employment growth	UK Local authority eras 1983-2002
Simmie and Martin 2010	Economic downturn	Employment	Adaptability	Static Dynamic	Growth trends Structural composition of employment change	Economic	Cambridge and Swansea, UK 1970-2008

1.2.3. Some methodological basis for assessing simultaneously vulnerability and resilience

Omar, Glen & Gian (2017) presented a paper entitled *A new resilience rating system for Countries and States* in which they opted for an analytical approach for calculating the economic resilience of nations and communities. They relied on the older risk evaluation method in to evaluate the resilience by making certain modifications like the substitution of the vulnerability by the intrinsic resilience of the country which is calculated with the method based on the data of Hyogo Framework for Action (HFA). The applicability of their methodology was tested on 37 countries (for most middle-income countries) by calculating the respective intrinsic resilience and resilience indexes of these 37 countries. For the authors, this approach provides new ways through which the hazard can be understood.

The Commonwealth Vulnerability Index, developed by Atkins et al. (2000), considers the incidence and intensity of several risks. This method consists of a two-step approach that includes the construction of both a vulnerability impact index and a resilience index. Their aggregated index is reminiscent of that of Briguglio & Galea (2004). In this Index, the impact of vulnerability is assessed using a weighted least squares regression that joins income, various sources of volatility (such as economic exposure), sensitivity to environmental events and hazards, remoteness and insularity. The various sources of volatility refer to the stochastic term in the definition of economic volatility. In this index, GDP is a proxy for resilience, whereas its standard deviation is a proxy of vulnerability.

In his paper titled *towards more resilient economies: The role of well-functioning economic structures*, Sondermann (2018) measures economic resilience by isolating common gross domestic product shocks across countries using VAR and panel models, then he abstract from the origin of the shock and just filter severe crises events by selecting the 10th percentile of the gross domestic product distribution of a sample of OECD countries over 35 years. In addition the author estimates whether the reaction to shocks and the likelihood of entering into a severe recession depends on the quality of national economic structures. Furthermore, he takes the evidence gathered on structural variables and links them to observable macro variables. He found robust evidence that strong and flexible institutions increase the resilience towards adverse shocks. He concluded that the financial and sovereign debt crisis has exposed the limited

(rigidities in labor markets, limited competition in product markets, framework conditions) economic resilience of several OECD and specifically most euro area economies.

Blancard & Hoareau (2016) in their paper entitled are *small island developing states more economically vulnerable than others? An empirical approach using composite indicator and data envelopment analysis*. The main concern is on the determination of weights used to aggregate the seven sub-indicators compounding the economic vulnerability. They need to substitute the *ad hoc* weighting system adopted in the UNCDP by a less arbitrary endogenous one. Thus, they follow the model of Hatefi and Torabi (2010) generating a set of common weights shared by all countries. They found that the small island countries' economies still remains fragile compared to the other developing countries groupings but the magnitude of the economic vulnerability has decreased. Their simulation stated especially that insular economies are now more vulnerable than low-income countries. They explain these facts by a structural effect concerning the design of the common weights system.

The methodological lines adopted do not necessarily have to be the same for all studies; it depends on what the author seeks to explain and the field of study in which his work relates, the budget at his disposal to conduct the study, and so on. As far as we are concerned, we set up our own methodology approach that we consider appropriate for assessing and measuring the economic resilience of low-income countries.

1.2.4. Net Vulnerability-Resilience Index

Over the past decade a new approach to measuring economic resilience (NVRI) incorporating the sustainable development aspect into the choice of 43 variables grouped in 5 dimensions (Economic, social, environmental, political and peripheral) has emerged. Angeon & Bates (2015) analyze the NVRI related to mathematical algorithm (The B2A Algorithm) on graph theory. They found that NVRI follows a slightly ascending trend over the last decade, which allowing authors to conclude that there has been little worldwide improvement in the state of VR. They also found that the confidence intervals had a narrow spread, which revealed stability in the state of VR through time and space. Differences among the four groups of countries concerned the speed of NVRI evolution. In particular, the Least Developed Countries register the slowest average annual growth rate of the NVRI (0.47%), which is two times less than the other groups (0.73% for the Most Developed Countries, 0.84% for the Average Developed Countries and 0.73% for the Small

Island Developing States). In a sample of 95 states selected by Angeon & Bates, DR Congo and Nepal had not been taken into account.

In the economic literature, Singapore is considered as a “good pupil” because of its resilience, though it is a small island which could be discriminated a priori because of intrinsic factors of vulnerability. Bates et al. (2014) want to check if Vulnerability-Resilience index conceived from a sustainable perspective confirms the greater resilience of Singapore that forges the Singapore paradox. Their analysis using the graph theory focuses on data that span from the last decade (2000–2009). The application of the Net Vulnerability-Resilience Index (NVRI) confirms that Singapore has a resilience capacity higher than its vulnerability propensity. The strengths of Singapore are rooted in the governance and this country takes advantage of a good insertion in the global trade as shown in the peripheral dimension (35.66%). The weaknesses of Singapore are mainly rooted in the environmental dimension, the only dimension for which the propensity of vulnerability (34.86%) surpasses the low resilience capacity (4.83%).

The consideration of sustainable development in analyzes is of great importance and above all we are called to bequeath to future generations economic structures whose sustainability is ensured. We can produce as much, but it is our responsibility to treat our environmental structures in the strict respect of development standards and not just any, it is sustainable development.

1.2.5. Implications of the resilience framework

The resilience framework may be useful to support decision making, especially for setting directions and justifying choice of priorities for resilience building. In particular, the analysis could help to disseminate information on and draw attention to issues relating to resilience building, encourage quantitative estimation of resilience-building and promote the idea of integrated action in this regard. In general, the framework can be optimized for better governance, economic, social, financial and environmental in the fight against economic shocks and especially with shocks of external origin. The resilience framework developed by Briguglio et al. (2006) has inspired various studies and applied work on the topic of economic resilience.

A major policy implication associated with this framework is that in view of the high degree of economic vulnerability of states, resilience building is of major importance for the states and it therefore follows that it pays the states to embed resilience building measures in their plans and

strategies, by, amongst other things, promoting macroeconomic stability and market flexibility, while at the same time taking care not to take excessive risk. Embedding resilience in national plans and strategies also requires socio-economic development, environmental management and good political governance.

The framework has additional implications regarding the attraction of investment in the state, given that everything else remaining equal, in a country that is well-governed economically and enjoying political and social stability, domestic and foreign investments are more likely to be attracted, when compared to a badly governed and socially unstable country (Briguglio 2014). For example, Small states tend to be disadvantaged with regard to investment attraction due to their small domestic markets and poor natural resources endowments however good economic governance could to an extent make up for these inherent deficiencies.

PARTIAL CONCLUSION

In this chapter, we have established the state of literature on the key concepts of our study. However, most uses of the term “economic resilience” refer to this idea of the ability of a local socio-economic system to recover from a shock or disruption. Also, we have more or less defined the empirical basis by browsing a large number of scientific works related our topic. It is obvious that there are several issues of measuring and evaluating economic resilience. In our thesis, we opt for the normalization technique of our variables given their initial and extrema values. The re-scaling process is followed by a sequence of arithmetic operations and especially the geometric average to aggregate the sub-indices. This way of apprehending economic resilience for low-income countries is the true originality of our thesis.

Our way of processing the data may seem similar to the computation of the economic resilience index with the results from the graph constructed using the mathematical algorithm (Tarjan, B2A and so on). Given the fact that the economic structures of low-income countries differ, compared to the technique using the graph results, we introduce a new way of aggregating sub-indices in order to compute the composite resilience index. The structuring of the variables considered and chosen on the basis of certain criteria that seem to be entirely adapted to the situation of low-income countries is also an originality of this thesis. In the next chapter, we develop the methodological framework that can be validly adapted to the situation of low-income countries in order to assess and measure their economic resilience capacities.

Second Chapter. METHODOLOGICAL FRAMEWORK

This chapter highlights the coherence of the theoretical elements for structuring a complex network of variables in order to characterize the state of economic resilience in low-income countries and more particularly for the DR Congo and the Nepal. At first, while identifying a set of variables to be considered in a holistic approach to assess economic resilience in low-income countries, we present the sources of data and the essential materials used to process them. Second, we present arithmetic and statistical analysis techniques that allow us to measure the economic resilience index, and to identify the dimension that contributes much more to the economic resilience level in the two countries considered for illustrative purposes.

Section 1. THE VARIABLES RETAINED TO ASSESS ECONOMIC RESILIENCE IN LOW-INCOME COUNTRIES

Before assessing and measuring a composite index such as economic resilience, a theoretical framework must be followed to clearly define the meaningful basis for selection and the combination of variables used to compose the index and evaluate it (Montalbano, 2012). Resilience concept is perceived as a network of dependent relationships among the variables and among dimensions. However, as far as we are concerned in this thesis, we develop a brief analysis of the several indicators in order to be able to choose those that best characterize the economic resilience for low-income countries.

However, even though the selected variables are debatable, we have selected them by careful analysis of the theoretical and empirical underpinnings of measuring and evaluating the economic performance of some low-income countries in such a way that the aspects of sustainable development and the characteristics of the economic resilience of these countries are emerging. Thus, in accordance with criteria defined in point 1.1.3, eighteen indicators divided into five dimensions (trade, socio-economic, fiscal, financial and spherical) were carefully chosen (see appendix 1) in order to assess and measure the economic resilience in low-income countries.

The data come from the World Bank (National account data and Worldwide Governance Indicators), the International Monetary Fund (International financial Statistics; Government Finance Statistics; World Economic Outlook and Global Financial Stability Report), the United Nations (United Nations Development Programme; United Nations Population Division; United

Nations Educational, Scientific and Cultural Organization), the Organization for Economic Co-operation and Development, the Standard International Trade classification, the Carbon Dioxide Information Analysis Center, the International Telecommunication Union, and the national sources (Nepalese and Congolese institutions). The detailed sources related to each indicator are given in the Table N° 3.

2.1.1. The trade dimension

Since they express the level to which a country can be exposed or resilient to external shocks, trade indicators are very important in assessing the level of economic resilience for low-income economies. Thus, we consider the openness index, the export diversification index, the exports quality index as well as the remoteness compared to more dynamic markets.

2.1.1.1. The openness index

An open economy is one that interacts with other economies, which creates trade. The trade-to-GDP-ratio is the sum of exports and imports divided by GDP. This indicator measures a country's openness or integration in the world economy. It represents the combined weight of total trade in the economy; it is a measure of the dependence degree of domestic producers on foreign markets and their trade orientation (for exports) and the degree of reliance of domestic demand on foreign supply of goods and services (for imports).

However, there are different degrees of openness, depending on the country's restrictions on free trade. The opening of the economy to the world can be at the base of the advent of new technologies likely to improve the level of production of the country. Trade openness appears to be a very good indicator for assessing and measuring the economic resilience of low-income countries. According to the interpretation of the opening index, the higher is the index, the greater the influence of trade on domestic activities and the stronger the economy of this country, thus implying the strengthening of the economy in terms of resilience.

2.1.1.2. The export diversification

To measure the level of diversification, we create a dummy variable to define each product as "Traditional", "New", or "Non-traded." Traditional products are goods that were exported at the beginning of the sample, and non-traded goods have zero exports for the entire sample. Thus, for each country and product, the dummy values for traditional and non-traded remain constant

across all years of the sample. The aggregation of these dummies values is done by following the methodology used for the construction of the Theil Index giving an export diversification index without extreme values.

A country is less diversified when export revenues are driven by only a few sectors or trading partners, even though the country might be exporting many different goods or to many different trading partners. Countries with a more evenly balanced mix of exports or trading partners have a higher level of intensive diversification and this can strengthen their resilience abilities. Most low-income countries have concentrated export structures, whether it is a handful of commodities or a limited range of other products.

2.1.1.3. The Export quality

Export quality is estimated, using partner importer-reported data in the COMTRADE dataset (containing several observations at the SITC 4-digit level) on bilateral trade prices, values, quantities and a host of other information including data on preferential trade agreements and other gravity variables taken from CEPII. Data on income per capita are also taken into account. To derive the export quality index through aggregation, the international monetary fund uses the methodology developed in one of its working paper on *Export quality in Developing Counties*[7].

However, for almost three decades, the quality of exported products, particularly agricultural products, has been declining in low-income countries, both for commodity exporters and for diversified countries, which further reduces the ability of these countries to withstand external shocks (IMF 2015). Thereby, the quality of exports is a good indicator of the economic resilience of low-income countries as it allows foreign consumers to appreciate domestic products with the consequent reduction or increase in market shares of domestic firms.

2.1.1.4. The remoteness

This indicator is estimated based on logistics Performance Index reflecting the perceptions of a country's logistics. Respondents evaluate eight markets[8] based on six core (efficiency of customs clearance process, quality of trade and transport related infrastructure, ease of arranging

[7] The authors being Henn, Papageorgiou and Spatafora in 2013.

[8] For low-income coastal countries, the responds must select five most important export partner countries and three most important import partner countries. For low-income landlocked countries, the responds must select four most important export partner countries, two most important import partner countries and two landlocked countries.

competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time). The markets are chosen based on the most important export and import markets of the respondent's country, random selection, neighboring countries that connect them with international markets. Scores for the six areas are averaged across all respondents and aggregated to a single score using principal components analysis.

However, the crucial importance of international trade for low-income countries suggests their proximity to more dynamic markets is likely to generate beneficial growth effects, including regional linkages. The trade linkages are not easily available to more remote low-income countries. Armstrong & Read (2006) have managed to demonstrate that the location within a dynamic region has a positive effect on low-income economies in terms of economic resilience. Remoteness of dynamic regions increases the transportation cost (Atkins et al., 2000). Therefore, it is important to integrate this indicator for the assessment and the measurement of the economic resilience for low-income countries.

2.1.2. The socio-economic dimension

Socio-economic indicators are very important for assessing the economic resilience of low-income countries. For this dimension, some indicators like the gross domestic product, the FDI, the ODA and official aid received, the gender development index, the life expectancy at birth and the literacy rate seemed to us to be indispensable for assessing economic resilience of low-income countries.

2.1.2.1. The gross domestic product

Gross Domestic Product is a broad measurement of a nation's overall economic activity. It is the monetary value of all the finished goods and services produced within a country's borders in a specific time period, often annually. Gross domestic product includes all private and public consumption, government outlays, investments, additions to private inventories, paid-in construction costs and the foreign balance of trade. Apart this approach from measuring gross domestic product (speculated expenditure approach), there are also the production approach (sum of added values) as well as the revenue approach (sum of compensation of employees, gross operating surplus, gross mixed income, and taxes less subsidies on production and imports).

The level of gross domestic product reflects the ability of a country and especially the low-income countries to absorb or cope with different shocks. To measure the economic resilience for low-income countries, this indicator will enable us to identify the capacity that is needed to compare the economic performance of these countries in terms of economic resilience. A country that produces more (with high gross domestic product) will have a higher degree of economic resilience than one with a reduced productive capacity, all other things being equal. For this case to better make a comparative analysis, we consider the GDP per capita.

2.1.2.2. Foreign direct investment inflows (FDI)

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 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. The empirical evidence suggests a beneficial impact of foreign direct investment on developing host countries.

However, some work also points to some sources of potential risks: FDI can be reversed through financial transactions; there can be excessive FDI owing to adverse selection of investment and illicit sales, the leverage can limit the benefit of FDI. Also, a high share of FDI in a country's total capital inflows may reflect its institutions' weakness rather than their strength. In this thesis, we postulate that this indicator is likely to increase the productive capacity of the country and therefore it can be source of economic resilience. Hence, it is necessary for us to consider the FDI in assessing the level of economic resilience of low-income countries.

2.1.2.3. Net official development assistance and official aid received (ODA)

Net 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 on 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.

The objective of the ODA should be a rebalancing of the respective levels of development. Theoretically, these financial flows should be oriented towards the implementation of concrete and sustainable projects, essential infrastructures, actions against hunger, health, education, etc. ODA has been described as an "investment for the future" for rich countries, opening up new markets by reducing poverty and promoting sustainable development, and pursuing the foreign policy of the great world powers, forward a generous image of themselves (Guégan 2006). However, even though donor countries seem to benefit, we believe that these assistance further strengthen the economic resilience of low-income countries, and therefore ODAs and official aid received are good indicators for assessing and measuring the economic resilience of low-income countries. So the more a country benefits from these assistance, the more its economy becomes resilient, all other things being equal.

2.1.2.4. The gender development index

Gender Development Index is the ratio of female Human Development Index to male Human Development Index. The same goalposts as in the Human Development Index are used for transforming the indicators into a scale lying between zero and one. The only exception is life expectancy at birth where the goalposts are adjusted, to reflect the empirical finding that on average, women have a biological advantage over men, and live about 5 years longer.

In many low-income countries gender inequality is a pervasive feature. The gaps between male and female outcomes and opportunities are present in several dimensions: education, earnings, occupation and political representation, bargaining power inside the household, access to formal employment, access to managerial positions, or access to productive inputs. The gender development plays an important role in the country's level of production and therefore can be an indicator of the resilience of an economy, especially the low-income economies.

2.1.2.5. The life expectancy at birth

The life expectancy at birth is a statistical measure of the average time an organism is expected to live. The most commonly used measure of life expectancy is at birth (LEB), which can be defined in two ways. Cohort LEB is the mean length of life of an actual birth cohort (all individuals born a given year) and can be computed only for cohorts born many decades ago, so that all their members have died. Period LEB is the mean length of life of a hypothetical cohort assumed to be exposed, from birth through death, to the mortality rates observed at a given year.

Rapid increases in life expectancy at birth are causing a significant shift in the global age structure. Previous studies have demonstrated that resilience is generally positively correlated with cognitive function, physical health and self-reported health in low-income countries. And so, because of its importance, to assess the level of economic resilience in low-income countries we have taken the life expectancy at birth into account. Given the social and economic importance of this indicator, a country with a low level of life expectancy at birth is less economically resilient than one with high life expectancy at birth, all other things being equal.

2.1.2.6. The literacy rate

To measure the literacy rate, we divide the number of literates of a given age range by the corresponding age group population and multiply the result by 100. Most literacy gains improve human assets in terms of potential productivity in current activities and increasing access to new activities. In this indicator, livelihoods analysis comes close to the analysis of conventional vocational training.

Oxenham et al. (2002) report that across studies in low-income countries, there is virtual unanimity that people who had completed literacy courses tended to be more confident and more willing to take initiatives in developing their livelihood and contribute to strengthening the resilient capacity of their economies. There is therefore a need to take this indicator into account when assessing the resilience capacity of low-income economies. However, a country with a high literacy rate is more resilient than one with a low rate, all other things being equal.

2.1.3. The fiscal dimension

The revenues collected by the public authorities in terms of taxes are intended to finance the government expenditure and any deficit is likely to push the government to borrow and increasing the debt level of the country. The fiscal dimension through the tax revenue and the public debt plays an important role in assessing the level of economic resilience in low-income countries. Government expenditures are not considered because they are part of the GDP.

2.1.3.1. The tax revenue

Tax revenue refers to compulsory transfers to the central government for public purposes. To evaluate them, certain compulsory transfers such as fines, penalties, and most social security contributions are excluded. Refunds and corrections of erroneously collected tax revenue are

treated as negative revenue. Furthermore, tax revenues are very important to a nation and especially low-income countries; they leave much more maneuvers for the country to finance its expenses without resorting to any borrowing, which obviously is harmful to the economy in the medium and long terms.

Nevertheless, with a self-financing character of budget revenues in terms of taxes collected on the contribution of economic agents within the domestic territory, the state has a huge capacity to deal with some economic shocks in the immediate future and build its economy on a solid foundation by allowing it to be much more resilient. Thus, the more a country registers large revenues from tax, the more economic resilient it is, compared to the country that records less tax revenues, all other things being equal.

2.1.3.2. The public debt

The debt (categorized as internal and external debt) is a stock variable, measured at a specific point in time, and it is the accumulation of all prior government budget deficits (flow variable that equals the difference between government receipts and spending in a single year). Often, finance coming from indebtedness supports economic activity and innovation by promoting the economic resilience, but it can increase risks. Public debt may undermine the sustainability of growth in the medium and long term. However, whilst indebtedness does not necessarily imply financial distress, it is prudent to scrutinize high indebtedness of the countries.

Public debt are now at relatively low levels in the majority of in low-income countries helped by strong economic growth, low interest rates, and the provision of comprehensive external debt relief to some 34 countries under the Heavily Indebted Poor Countries/Multilateral Debt Relief Initiative. Some three-quarters of these countries are currently assessed as being at low or moderate risk of experiencing external debt distress under the joint Bank-Fund Debt Sustainability Framework. Nevertheless, debt levels have increased in recent years in a third of low-income countries and this can undermine their economic resilience. Highly indebted country may be less resilient to financial and economic shocks, all other things being equal.

2.1.4. Financial dimension

Deep and well-functioning financial sector in low-income countries can make the economy more resilient to idiosyncratic shocks by reducing borrowing constraints allowing economic agents to

smooth consumption and investment. In addition, the financial sector may not only strengthen monetary policy transmission and hence make monetary policy more effective in countering economic shocks but also speed up capital reallocation and reduce the persistence to economic shocks (Cespedes & Velasco, 2012). However, only those indicators relating to the traditional financial system that increasingly characterize the financial sector are considered in assessing and measuring economic resilience in low-income countries. So, we have the net current from abroad, the domestic credit to private sector and the non-performing loans.

2.1.4.1. Net current transfers from abroad

Current transfers comprise transfers of income between residents of the reporting country and the rest of the world that carry no provisions for repayment. The net current transfer from abroad is equal to the unrequited transfers of income from nonresidents to residents minus the unrequited transfers from residents to nonresidents. Thus, it is important to incorporate this indicator for the assessment and measurement of economic resilience for low-income countries. A country that registers this indicator at a high level will be more exposed to external shocks than the one for which this variable is at a low level, all other things being equal.

2.1.4.2. Domestic credit to private sector

Domestic credit to private sector refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of non equity securities, trade credits and other accounts receivable that establish a claim for repayment; these claims include credit to public enterprises. The financial corporation's include monetary authorities, deposit money banks, and other financial corporations including corporations that do not accept transferable deposits but do incur such liabilities as time and savings deposits, finance and leasing companies, money lenders, insurance corporations, pension funds, and foreign exchange companies.

Through its impact on consumption and investment, which are two major components of GDP, access to credit is a factor that can influence the level of economic resilience in low-income countries. It is therefore important for economic agents to have an access to credit in order to finance their consumption and/or investment. Thus, all other things being equal, this indicator will allow us to capture the degree of economic resilience in low-income countries. The fact that private agents have access to credit can make a country more economically resilient compared to the country whose this indicator is reduced.

2.1.4.3. Bank non-performing loans

Non-performing loans or NPLs are bank loans that are subject to late repayment or are unlikely to be repaid by the borrower. Bank non-performing loans to total gross loans are the value of nonperforming loans divided by the total value of the loan portfolio (including nonperforming loans before the deduction of specific loan-loss provisions). The loan amount recorded as non-performing should be the gross value of the loan as recorded on the balance sheet, not just the amount that is overdue. However, commercial loans are considered nonperforming if the debtor has made zero payments of interest or principal within 90 days, or is 90 days past due. For a consumer loan, 180 days past due classifies it as non-performing loans.

High levels of non-performing loans can weigh on the economic growth of the low-income countries as they reduce banks' profitability and their ability to lend, particularly to SMEs. Addressing the risks related to high stocks of non-performing loans is primarily the responsibility of affected banks and national authorities. Thus, non-performing loans are likely to have a negative impact on low-income economies and it is clear that this indicator is very important for assessing and measuring the economic resilience of low-income countries. All other things being equal, we consider that in the country, the higher is the non-performing loans, the higher the risk exposure of the banking sector, which affects the country's economic performance in terms of economic resilience.

2.1.5. Spherical dimension

Although there are no direct links to the economic sphere, the indicators listed below, given their link with sustainable development, are very important for assessing and measuring the economic resilience of low-income countries. Thus, in our thesis, the government effectiveness, the CO_2 emission, the access to New Information and Telecommunication Technologies (NICT) allows us together with the preceding indicators to well determine the level of the economic resilience of the low-income countries.

2.1.5.1. The government effectiveness

Government effectiveness reflects 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. The level of government effectiveness of a country, especially for low-income countries, may be a factor determining the degree of economic resilience, especially as it can be an attracted factor of foreign investment, which in turn can contribute to increase production and furthermore impact on the level of output volatility in the country. This evidence includes increasing revenue by offering favorable tax rates for individuals and corporations and creating a favorable regulatory environment to attract new investment.

2.1.5.2. The CO_2 emissions

Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. Carbon dioxide emissions are an environmental indicator, but they can have an economic impact and especially in the production of goods and services. Environmental pollution can be at the root of the deterioration of the productive conditions of a country. The CO_2 emissions can cause production shocks and thus prevent the economy from being resilient. It is therefore important to include this factor in the assessment and measurement of the economic resilience of low-income countries, although having particularities of the environmental dimension. The more a country emits CO_2, the more its economy is less and less resilient, all things being equal.

2.1.5.3. Access to NICT

This indicator is estimated from the number of internet users. Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital Televisions, and so on. The access to New Information and Communication Technologies can be the basis for improving a country's production conditions. However, all things being equal, we assume that, the higher is the value of this indicator, the more the country is resilient economically.

The table below on the classification of main variables repeats all the eighteen indicators (grouped in five dimensions) chosen in our thesis to assess and measure the economic resilience in low-income countries. A brief description of the all variables, the unit of measure used to capture each variable and the sources used to collect the different data for the case of the Nepal and the DR Congo are presented.

Table 3. Classification of the main variables (into five dimensions) used to assess and measure the economic resilience

Dimensions	Variables	Descriptions	Measures	Sources
Trade	Openness Index	Ratio of country's total trade, the sum of exports plus imports, to the country's GDP.	% of GDP	World Bank/ National accounts data.
	Export diversification index	Absolute deviation of the trade structure of a country from world structure.	From 0 (very high) to 7 (very low)	International Monetary Fund (Calculations from COMTRADE Dataset).
	Export quality Index	Found from partner importer-reported data from the COMTRADE Dataset.	From 0 (very low) to 1 (very high)	Standard International Trade classification (SITC).
	Remoteness	Logistics Performance Index surveys where the respondents evaluate the quality of trade and transport related infrastructure.	From 1 (very low) to 5 (very high)	World Bank/ National accounts data.
Socioeconomic	***GDP per capita***	Total value of all the goods and services produced by a country in a particular year, divided by the number of people.	Constant 2010 US dollars	World Bank/ National accounts data.
	Foreign direct investment	Net inflows of direct investment equity (equity capital, reinvestment of earnings, and other capital). It is the new investment inflows less disinvestment.	% of GDP	International Monetary Fund/ International Financial Statistics.
	Net official development assistance and official aid received	ODA consists of disbursements of loans made on concessional terms net of repayments of principal. Net official aid refers to aid flows net of repayments.	Constant 2015 US$ per inhabitant	Organization for Economic Co-operation and Development/ Development Assistance Committee.
	Gender development index	Ratio of the HDIs calculated separately for females and males.	From 0 (very low) to 1 (very high)	United Nations Development Programme/ Human Development Reports.
	Life expectancy at birth	Number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.	Year	United Nations Population Division.

	Literacy rate	Percentage of people who can both read and write with understanding a short simple statement about their everyday life.	% of people ages 15 and above	United Nations Educational, Scientific and Cultural Organization/ Institute for Statistics.
Fiscal	***Tax revenue***	Compulsory transfers to the central government for public purposes.	% of GDP	International Monetary Fund/ Government Finance Statistics, Yearbook and data files.
	Public debt	The historical public debt represents the gross government debt during different periods.	% of GDP	International Monetary Fund/ World Economic Outlook.
Financial	***Net secondary income (Net current transfers from abroad)***	Is equal to the unrequited transfers of income from nonresidents to residents minus the unrequited transfers from residents to nonresidents.	% of GDP	World Bank/ National accounts data.
	Domestic credit to private sector	Financial resources provided to the private sector by financial corporations.	% of GDP	International Monetary Fund/ International Financial Statistics and data files.
	Bank non performing loans	the value of nonperforming loans divided by the total value of the loan portfolio	% of total gross loans	International Monetary Fund/ Global Financial Stability Report.
Spherical	***Government effectiveness***	Lack of quality and credibility of public action and service.	-2.5 = low, 2.5 = high	World Bank/ Worldwide Governance Indicator (WGI).
	CO_2 emissions	Includes carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	Metric tons per capita	Carbon Dioxide Information Analysis Center,/ Environmental Sciences Division/ Oak Ridge Laboratory.
	Access to NICT	Internet users are individuals who have used the Internet (from any location).	% of population	International Telecommunication Union.

Source: Own conception from theoretical information and criteria defined in the point 1.1.3.

Section 2.MATERIALS AND ANALYSIS TECHNIQUES

In this thesis, the Excel spreadsheet software is used to establish our initial database and possibly to realize some analysis that does not necessarily require software strictly speaking. The STATA 13.0 software will finally allow us to make graphical presentations of our results and to perfect our analysis by conducting in particular the principal component analysis.

However, this section provides an overview of the different materials and techniques used in the set about processing and analyzing data in order to derive results on some of the salient points that this study must address. Thus, we present the manipulation of our database, the techniques used to calculate the economic resilience index as well as the principal component analysis.

2.2.1. Database

In this point, we will present how the database was compiled from the variables listed and presented in section 1 of the current chapter. We took the data of the eighteen variables divided into 5 dimensions over a period of 15 years (from 2003 to 2017). Some operations (missing data processing, Transformation of annually data into quarterly data in order to have a high number of observations and avoid some bias in our results) have been done to adapt our database to the different analyzes that we will conduct.

2.2.1.1. Missing data

Initially, for both countries (DR Congo and Nepal), which will be the focus of our analyzes to highlight our methodology for the evaluation and measurement of economic resilience in terms of index, we recorded nearly 23 missing data on the 270 (15 years multiplied by 18 variables) that counts our database for each of these countries (a missing data rate estimated at nearly 8.5% for each country). Given that the multivariate type analyzes do not admit a missing in terms of the data, we resorted to the function ipolate and epolate of the software STATA 13.0 (The commands being reproduced in appendix 6c) in order to carry out the operations of linear interpolation and extrapolation to complete our data bases.

However, we interpolate, if we give to x (considered as the independent variable) a value included in the cloud of points and we extrapolate if we give to x a value located at outside the cloud of points. As far as we are concerned, we have estimated the missing values for each country according to the variable GDP per capita (considered as y) which seems to be linearly

correlated with the variables missing some observations among others: Export diversification index (nearly 0.36% of all data); Export quality index (nearly 0.36% of all data); Remoteness (nearly 2.59% of all data), GDI (nearly 1.11% of all data), literacy rate (exactly 2.97% of all data) and the variable non-performing loan (nearly 1.11% of all data).

2.2.1.2. Quarterly data transformation

By conducting the principal component analysis, the stability of eigenvalues and eigenvectors increases as the ratio $\frac{n}{p}$ increases (where n is the number of observations and p the number of variables). Kocovsky et al. (2011) suggest that a $\frac{n}{p}$ ratio of 3.0 to 8.0 is required for the stability of the principal components. Regarding our database $n = 15\ and\ \ p = 18$ and therefore the ratio $\frac{15}{18} = 0.83$ is insufficient to conduct the principal component analysis. Since quarterly or monthly data are not available for all variables, the exigency with respect to the size of observations in order to carry out the analyses, led us to proceed with transformations of our data which are annual in quarterly data.

After transformation in quarterly data, we will have $(15years\ *4\ quarters\ per\ year) = 60\ observations$. So, the ratio will be $\frac{60}{18} = 3.3$, an acceptable threshold for conducting the principal component analysis. The transformations as we can see in the appendix 6d were made on the basis of the manipulations of some commands in STATA 13.0 which make the transformations by performing the interpolations and extrapolations of the annual data on quarterly periods. The purpose of interpolation and extrapolation is to search for an unknown high frequency series (Quarterly data), whose means, sums, first or last values correspond to a known low frequency range (annual data). In fact, these method should not impact the result and creates the quarterly data between two annual observations but the trend and the fluctuations are not modified, the result of the analyses should not be changed (Vinayagathasan 2014).

2.2.2. Computing the resilience index based on the set of variables

A composite index is an aggregation of a set of individual indicators that gives evidence for a multifaceted problem using mathematical or computational methods. The justification for a composite index lies in its fitness for the phenomenon to be measured and its simplicity (Nardo et al. 2005). In our database we have three categories of variables: Aggregates or numbers with no

maximum limits (4 variables), percentages whose extrema values are 0 and 100 (9 variables) and numbers with known extrema values that are not percentages (5 variables).

By referring to the methodology followed in the Tarjan Algorithm, three steps are required to calculate any composite index:

First step: Standardization: re-scaling variables between $[0 \quad 1]$

Similar to the re-scaling of life expectancy in the computation of the Human Development Index, we use the common "min–max" transformation. In this approach, the data is scaled to a fixed range, usually 0 to 1. The cost of having this bounded range in contrast to Z-score normalization is that we will end up with smaller standard deviations, which can suppress the effect of outliers (Raschka 2014). Thus, the variable x_i is standardized for any country j as follows:

$$x'_{ij} = \frac{(x_{ij} - \min(x_{ij}))}{\left(\max\left(x_{ij}\right) - \min\left(x_{ij}\right)\right)}$$

In a few cases, indicator and criteria point in opposite directions. For example, a high export diversification index or public debt or banks non-performing loans or carbon dioxide emissions (CO_2) means a low (rather than high) economic resilience. In these cases, the following alternative formula is used.

$$x'_{ij} = \frac{\left(\max\left(x_{ij}\right) - x_{ij}\right)}{\left(\max\left(x_{ij}\right) - \min\left(x_{ij}\right)\right)}$$

The maximum and minimum values (that will be useful for re-scaling observations) for each variable are given in Appendix 2.

Second step: Aggregating the variables

The aggregating procedure to find the sub-indices is implemented within the five dimensions through the indicator (x_i^R) associated to each one and considered as essential measurements of economic resilience in low-income countries. Using the simple arithmetic average (By hopping that there's no significant outliers in the data); we compute five aggregating indices related to each dimension. Let h be the evaluation and measurement dimensions of economic resilience for each low-income countries j.

$h = (Trade, Socio - économic, Fiscal, Financial\ and\ Spherical)$. We aggregate in fine the standardized observations using a simple arithmetic average operation to determine five sub-indices (R_{jh}) related to each dimension for each country.

$$R_{jh} = \frac{1}{\aleph x_{ijh}^{R}} \sum_{i=1}^{\aleph x_{ijh}^{R}} x_{ijh}^{R}$$

Where $\aleph x_{ijh}^{R}$ is the number of dimensions that is 5.

Third step: Composite index of economic resilience for low-income countries

As we want to compare countries with very different economics properties (in this study, DR Congo and Nepal), to determine the composite index of economic resilience we use a geometric mean, which indicates the central tendency or typical value of a set of numbers using the product of their values. The geometric average of our sub-indices related to different dimensions of economic resilience $\{R_{j,Trade}, R_{j,Socio-économic}, R_{j,Fiscal}, R_{j,Financial}\ and\ R_{j,Spherical}\}$ is given by:

$$R_j \epsilon [0 \quad 1] = \left(\prod_{h=1}^{n} R_{jh} \right)^{1/n} = \sqrt[n]{R_{j1}\, R_{j2} \cdots R_{j5}}$$

0 Refers to a low and 1 refers to a high resilience. However, we define certain thresholds by assuming that four deciles of the maximum value of index (1.00) correspond to one step completed by the country. Having already affected the first four deciles in step 1 ("Less resilient"), we divide the remaining six deciles between the "resilient level" stage and the "more resilient level" stage. Thus, we assume that the economy is less resilient if $0 \leq R_j < 0.40$; the economy is resilient if $0.40 \leq R_j < 0.80$; the economy is very resilient if $0.80 \leq R_j \leq 1.00$.

2.2.3. Principal Component Analysis (PCA)

The Principal Component Analysis also called Hotteling transform or Karhunen-leove Method is one of the most frequently used multivariate data analysis. It can be considered as a projection method which projects observations from a p-dimensional space with p variables to a k-dimensional space ($Where\ k < p$) so as to conserve the maximum amount of information[9].

[9] Information is measured here through the total variance of the scatter plots.

If for example, the information associated with the first 3 axes represents a sufficient percentage of the total variability of the scatter plot, the observations will be able to be represented on a 3 dimensional chart, thus making interpretation much easier[10]. The Principal Component Analysis involves a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible and each succeeding component accounts for as much of the remaining variability as possible[11].

2.2.3.1. Preliminary tests

It is absolutely necessary to be wary of the so-called singularity condition where a variable would be perfectly correlated with another variable or with a combination of several variables. This condition can be detected by calculating the "determinant" of the correlation matrix $|R|$. The determinant can take any value between 0.0 and 1.0. However, these two extreme values are problematic. Indeed, a determinant of 0.0 indicates that the matrix is singular, that is, there's at least one case of linear dependence in the matrix, or in other words, that a variable can be fully explained or predicted by a linear combination of other variables. As Jolliffe (2002) mentions, we should never perform a Principal Component Analysis on a correlation matrix whose determinant is smaller than 0.0001.

Conversely, a determinant equal to 1.0 is also a condition unsuitable for the PCA; it indicates that the correlation matrix is an identity matrix, that is to say a matrix containing only 0.0 values, except for the presence of the values 1.0 in the diagonal. There's a statistical test for which the null hypothesis consider that the sample comes from a population where the correlation matrix is an identity matrix. This is Bartlett's sphericity test. Obviously, we wish that this test is significant to allow us to reject the null hypothesis of identity. If Bartlett's test does not allow us to reject the null hypothesis, we are in the presence of a really extreme situation where the PCA is not justifiable. It must be said that the Bartlett test is sensitive to the size of the sample. The higher sample is the best one.

It is also important to ensure that individually, each variable is related to all others. When we are in the presence of a variable that does not correlated with any other, it is recommended to

[10] http://www.xlstat.com/en/products-solutions/feature/principal component analysis/ Accessed April 6, 2019.
[11] http://www.fon.hum.uva.nl/praat/manual/Principal component analysis/ Accessed April 6, 2019.

subtract this variable before proceeding to a PCA. Individual examination of variables is greatly facilitated by the calculation of Kaiser-Meyer-Olkin sampling adequacy measures. These indices are calculated for each of the variables as well as for the global matrix and can also take values between 0.0 and 1.0. To be conserved in a PCA, a variable must obtain a KMO measure exceeding 0.5. Kaiser (1974) suggested an interesting gradation using the following reference points: unacceptable (below 0.5), mediocre (between 0.5 and 0.6), average (between 0.6 and 0.7), well (between 0.7 and 0.8), very well between (0.8 and 0.9) and excellent (beyond 0.9).

2.2.3.2. Mathematical technique used in Principal Component Analysis

The mathematical technique used in PCA is called eigenanalysis (resolved using a square symmetric matrix with sums of squares and cross products). The eigenvector associated with the largest eigenvalue has the same direction as the first principal component. The eigenvector associated with the second largest eigenvalue determines the direction of the second principal component and so on. The sum of the eigenvalues equals the trace of the square matrix.

2.2.3.3. Characteristics of Principal Components

The first component extracted in a PCA accounts for a maximal amount of total variance in the observed variables. Under typical conditions, this means that the first component will be correlated with at least some of the observed variables. The second component extracted will have two important characteristics. First, it will account for a maximal amount of variance in the data set that was not accounted by the component 1. Under typical conditions, this means that the second component will be correlated with some of the observed variables that did not display strong correlations with component 1. The second characteristic is that it will be uncorrelated with the first component. However, the remaining components that are extracted in the analysis display the same two characteristics. Each component accounts for a maximal amount of variance in the observed variables that was not accounted for by the preceding components, and then it is uncorrelated with all of the preceding components (Hatcher & Stepanski, 1994).

2.2.3.4. Extraction of the principal components

The number of principal components that can be extracted from a correlation matrix is less than or equal to the number of variables in the matrix. However, the percentage of variance explained by each component decreases systematically as one progresses through the extraction process and

can become quite negligible once the most important components are extracted. This leads us to consider two criteria that will help us to extract the principal components namely the Kaiser's criterion and the cartel scree test.

A. Using Kaiser's criterion (1960)

We want to know how the total variance (which is 18.0 for each country) will be distributed among the different components that we want to extract. For this, we will calculate the eigenvalue of each component. We know that each variable has 1.0 units of variance. According to Kaiser (1960), the extraction of the principal components must therefore stop as soon as eigenvalue becomes less than 1.0.

B. Using the Cattell Scree Test (1966)

In 1966, Cattell proposed a graphical method for deciding the number of principal components to extract. The variance accumulation test commonly called "scree test" requires that a graph be drawn showing the size of the eigenvalues of the different components according to their extraction order. The term "scree" refers to a phenomenon geomechanical where there is an accumulation of rock deposits at the foot of a mountain, thus creating a small promontory at the place where the unevenness of the mountain turns abruptly into a softer slope. The criterion proposed by Cattell leads us to stop the extraction of components to where the change of slope occurs in the graph.

PARTIAL CONCLUSION

We have just made a methodological overview for the realization of our thesis. The data encompasses 18 variables related to the resilience index and that come from the different national databases as well as those from the international organizations. They are treated specifically with the use of the spreadsheet Excel and the software STATA 13.0. First, we will use the min-max standardization technique in order to be able to re-scaling our observations. Next, for all years, on the basis of simple arithmetic average operations we will compute associated sub-indices to each dimension before calculating the composite index of economic resilience based on the geometric mean of the sub-indices. Finally, we will conduct principal component analyzes to identify the dimension that best accounts for the variability of economic resilience in the two illustrative cases (Nepal and RD Congo).

Third Chapter. MEASUREMENT OF ECONOMIC RESILIENCE IN NEPAL AND DR CONGO

In this chapter we analyze our data on economic resilience in low-income countries by making a comparison between DR Congo and Nepal in a dynamic perspective. Before calculating the economic resilience index, we analytically present the indicators that allow us to assess and measure the economic resilience for both illustrative cases. A little further we synthesize the information from these many indicators using the Principal Component Analysis.

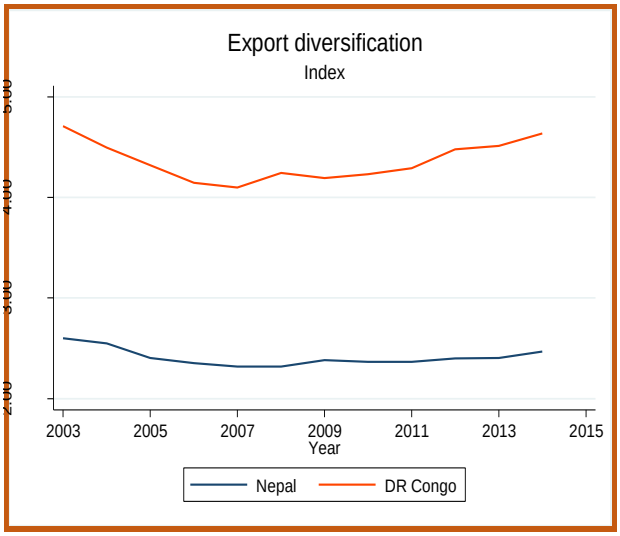
Section 1.ANALYTICAL PRESENTATION OF DATA

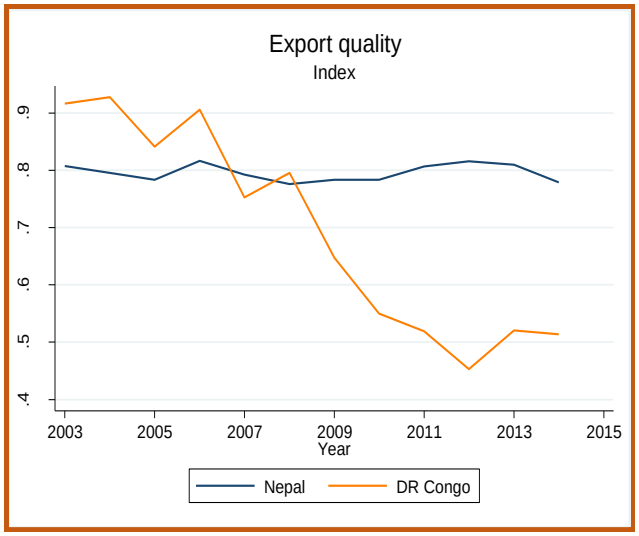
To measure the economic resilience of low-income countries, we list a number of indicators that we divide into trade, socio-economic, fiscal and financial dimensions. In addition to these four dimensions, another dimension bringing together indicators related to governance, CO_2 emissions and the access to NICT is added to make a total of five dimensions.

3.1.1. Trade indicators

The following graphs give an idea about the evolution of the commercial components in DR Congo and Nepal. Thereby, firstly we present the export diversification degree (including variety of products as well as variety among trading partners) and the quality of export before to analyze secondly the degree of openness of these two economies (DR Congo and Nepal) and their remoteness to more dynamics markets.

Figures 3. Export diversification and quality for DR Congo and Nepal

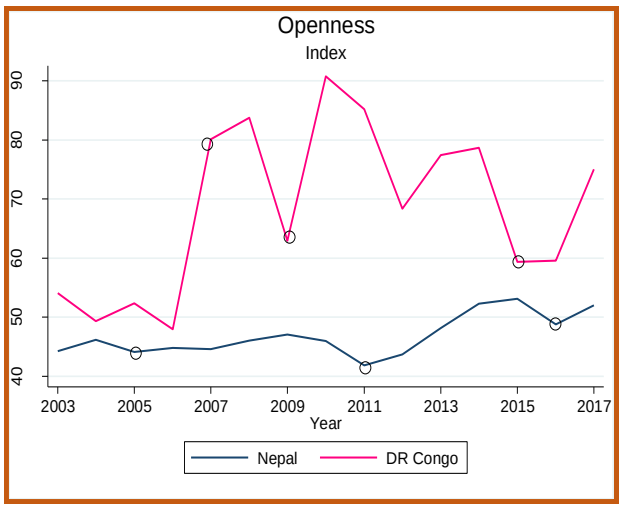


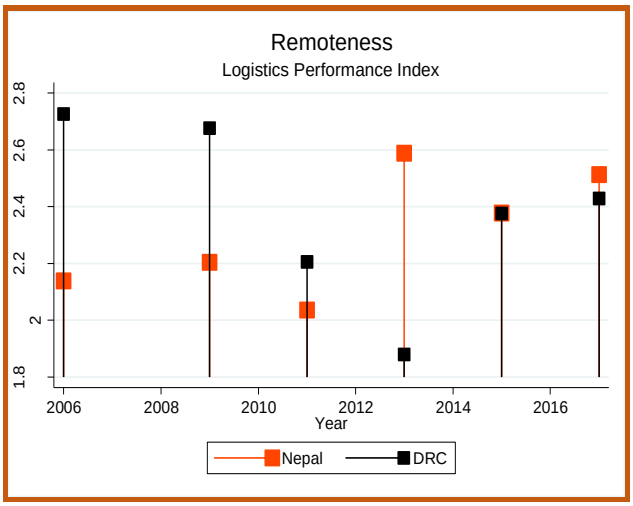


Source: Own calculations

For the export diversification, its interpretation is made in the opposite direction (see Annex 2), the higher the index is, and the more the exports (in terms of products and trading partners) are less diversified. Thus, Nepal's exports structure is more diversified than the exports of DR Congo. In addition, since 2008 the value added in terms of quality in the products exported by Nepal is higher compared to the value added in products exported by DR Congo.

Figures 4. Openness and Remoteness to the trade for Nepal and DR Congo





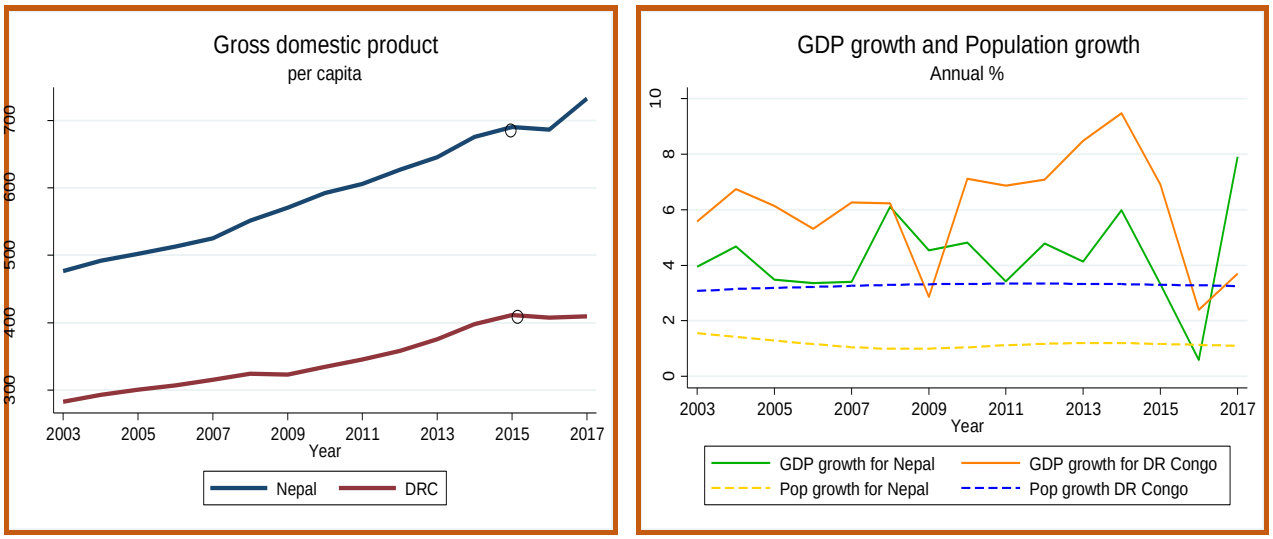
Source: Own calculations

Unlike the fact that there is a dramatic drop of the exports quality in DR Congo from 2008, the Congolese economy remains more open than the economy of Nepal. However, as evidenced by the remoteness index, even less open to the trade compared to the DR Congo, Nepal holds at least since 2013 more efficient commercial structures than those of the DR Congo in terms of the trade and transport-related infrastructure as well as the administrative procedures (Example: efficiency of customs clearance process) and commercial procedures (Example: ease of arranging competitively priced shipments, ability to track and trace consignments).

3.1.2. Socio-economic indicators

In this sub-section, we first present the GDP of Nepal and DR Congo as well as the net official development assistance and official aid received for the two countries studied. To better establish the comparison between states we opted for GDP per capita instead of nominal GDP or its growth. Also, a correlational link between GDP and ODA is likely to be important. Secondly, we retrace the evolution of foreign direct investment and gender development before ending with the evolution description of life expectancy at birth and the literacy rate for both countries.

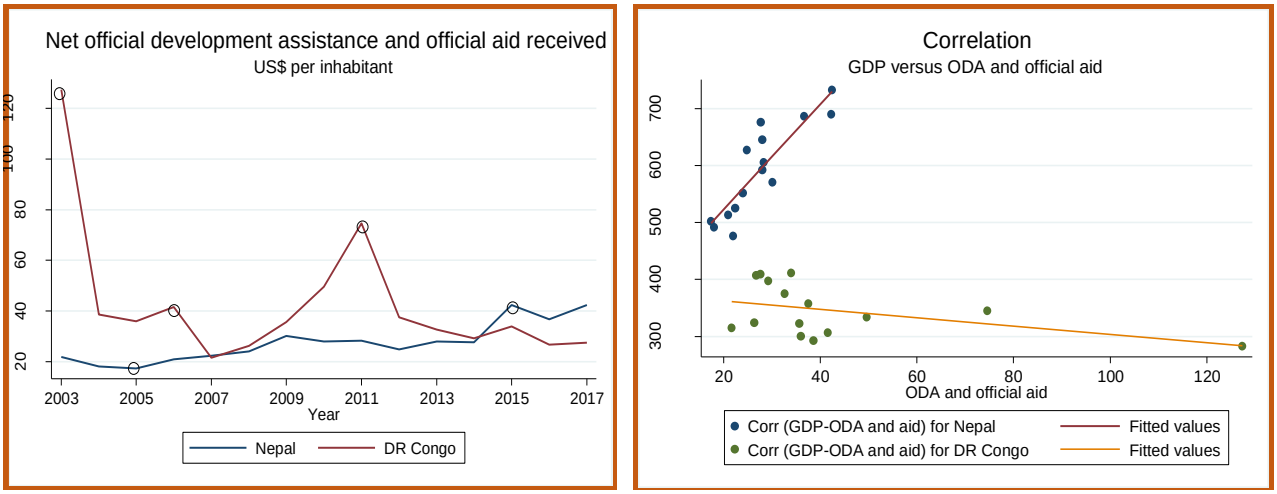
Figures 5. GDP per capita, GDP growth and Population growth for Nepal and DR Congo



Source: Own calculations

Compared with the DR Congo, the gross domestic product has evolved excessively in Nepal during these 15 years to reach the US $ 700 per capita representing almost the double GDP of the DR Congo whose growth is more important than that of Nepal. For both countries, GDP growth is more important than population growth. If this trend persists, it augurs a better future for Nepal and DR Congo with regard to GDP or income level. However, the GDP of these two countries decreased in 2015, which is certainly due to the earthquakes that hit Nepal and the political uncertainty that prevailed at the time in DR Congo. These two phenomena have too much impact on the economies of these two countries.

Figures 6. Net official development assistance and official aid for DR Congo and Nepal

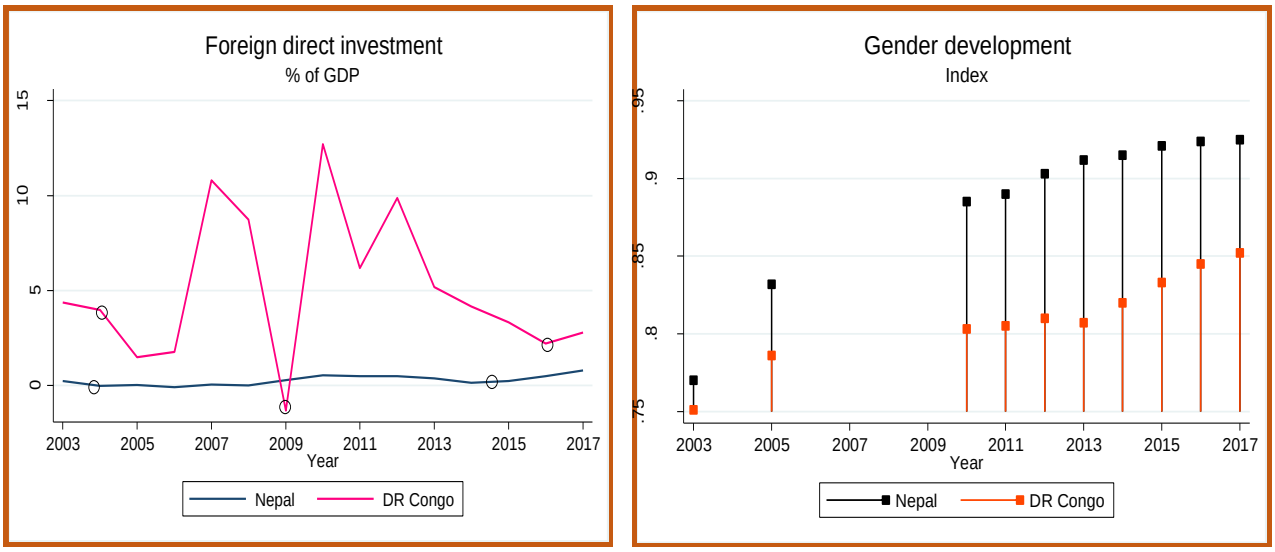


Source: Own calculations

Just after the pacification of the DR Congo (in 2003) ODA and aids decreased in this country before increasing further throughout the electoral processes of 2011 during which the country needed enough foreign aid to complete these processes . In Nepal after some political turbulence in 2005, they had to resort to aid and assistance in order to level a little bit the economy of this country. Also with the 2015 Earthquake, Nepal has seen development assistance and aid increase by one notch and it was extremely needed to raise its economy.

In addition, aids and assistance can be obtained but their management in order to enable these assistance to really contribute to the development in all its facets is also a big problem and especially for low-income countries. According to our observations, it is only in Nepal where these aids and assistance have had to evolve in the same direction as the GDP compared to the DR Congo. This suggests some mismanagement in the funds of aids and assistance in DR Congo.

Figures 7. Foreign direct investment and Gender development for Nepal and DR Congo

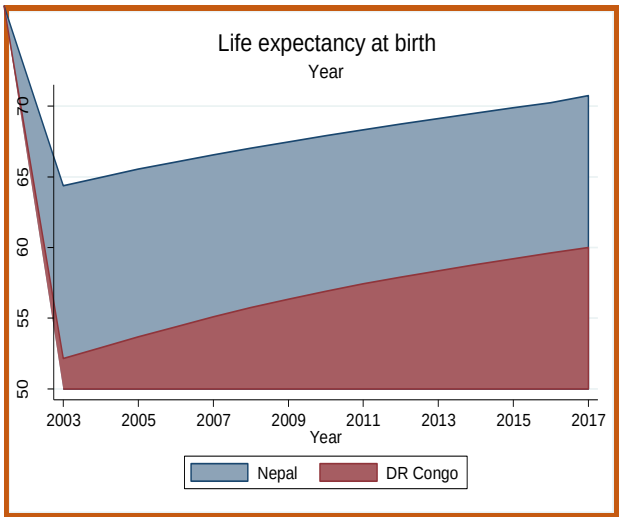


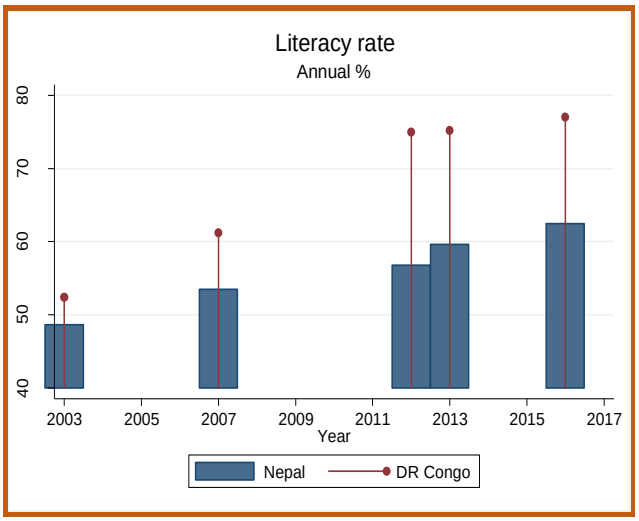
Source: Own calculations

We see in the charts above the essential role of foreign direct investment in the GDP essentially for the DR Congo. However, for the two countries, the share of these investments in the GDP are decreasing or stagnating each time that announces a major political event (pre-electoral period in 2004, 2009 and 2015 in DR Congo and period of political conflicts from 2004 in Nepal). This may be related to the fact that during these periods foreign investors are more reluctant to invest again while waiting for the post-electoral period not enameled by conflict. In Nepal, during the earthquake, the new investment opportunities had caused an important FDI contribution to GDP.

However, in terms of the gender development index, we observe sharp improvements for both countries with higher levels of this indicator in Nepal than in DR Congo over the period of our analyzes. With these observations, we can say that the consideration of gender is much more important in Nepal than in DR Congo.

Figures 8. Life expectancy at birth and literacy rate for Nepal and DR Congo





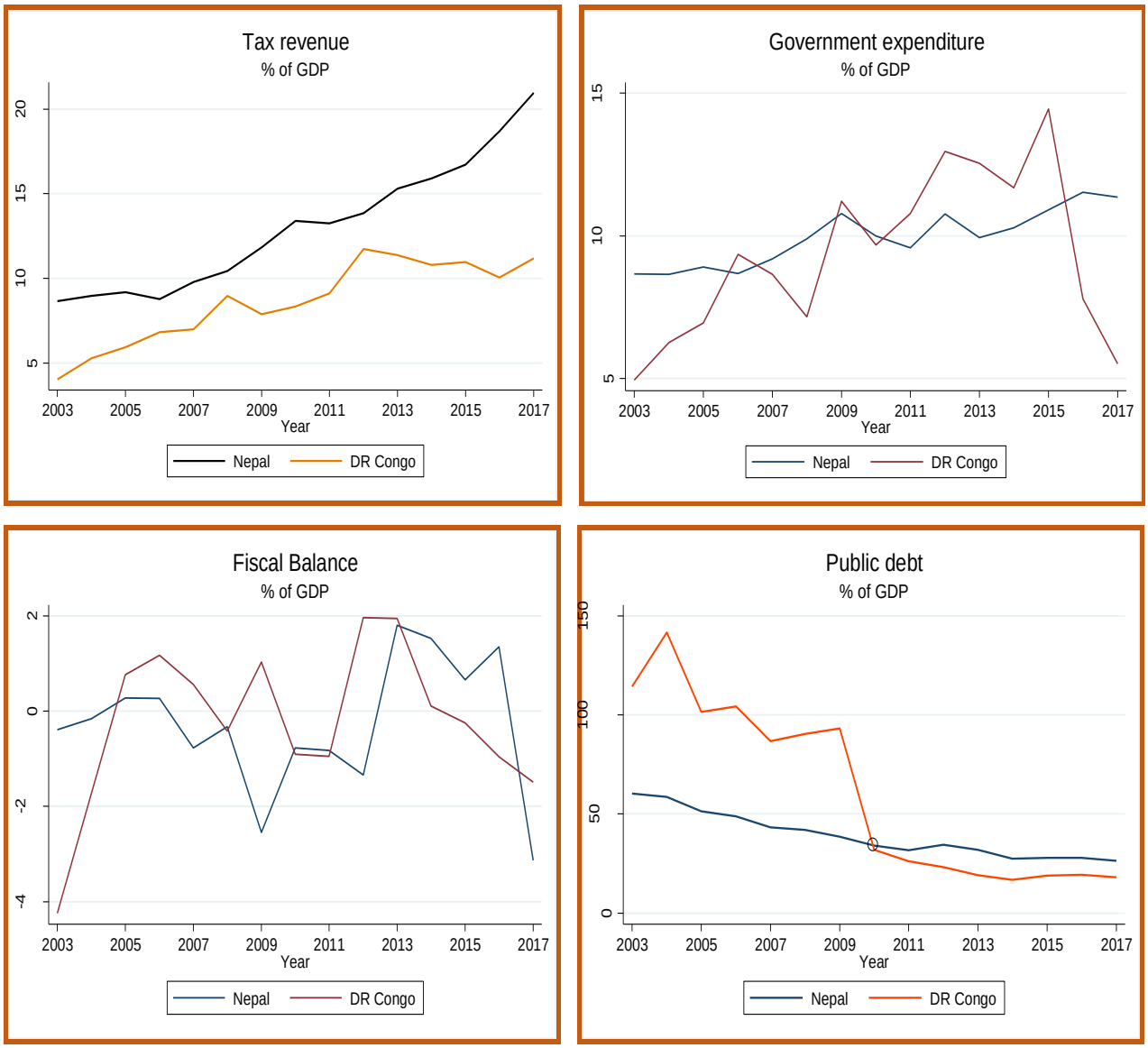
Source: Own calculations

The literacy rate is high in DR Congo compared to Nepal, unlike life expectancy at birth which is of a high level in Nepal for all periods under study. We should also note significant developments in the two countries concerning the two indicators. In all cases, the highest score for both indicators and for all countries appears in the last period and has increased since 2003; this shows that considerable efforts are being made each year in the fields of education and health.

3.1.3. Fiscal indicators

This sub-section describes the fiscal indicators chosen to assess economic resilience in low-income countries by applying them to illustrative cases. As for all dimensions, several indicators can allow us to capture the fiscal dimension but based on the criteria defined in the first chapter, we have chosen the tax revenue and the public debt for the DR Congo and Nepal over the under-study period. To better capture the fiscal dimension, we used also the variable government expenditure (which no longer have a reason to be considered in the foreground as it is already incorporated in the GDP) as well as fiscal balances (which also have not been considered in the foreground because it can be captured by the evolution of the public debt).

Figures 9. Fiscal indicators for Nepal and DR Congo



Source: Own calculations

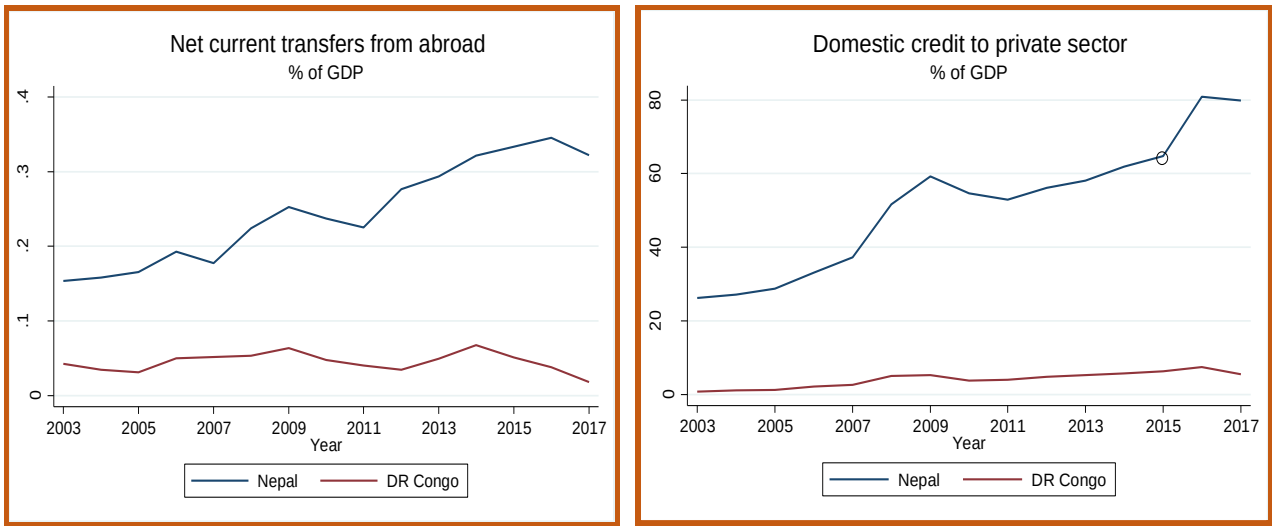
The shares of the tax revenue returned in the GDP are more important in Nepal. In DR Congo, since 2013, the trend in the evolution of these taxes has been decreased. These facts reflect the sovereignist fiscal independence of Nepal compared to the DR Congo. Government spending remained almost the same in Nepal over the study period but increased in DR Congo until the year 2015 when the country experienced a dramatic fall in this indicator. The DR Congo has an economy too turned towards the mining resources, this stagnation of the tax revenue since 2013 and the fall of the public expenditure would be explained of course by the fall of the prices of the raw materials at this time.

Moreover, following the budget deficits experienced by the DR Congo, the country had recorded high public debts (That reached even 141% of GDP in 2004) before it obtained in 2010 the benefits allowing it to reduce its debt by accessing to the initiatives in favor of poor countries heavily indebted (HIPC) and recording a debt lower than that of Nepal. Although not concerned by this initiative, Nepal is striving to properly administer its fiscal resources so that it is not too indebted. This confirms the independence of Nepal through the fiscal sector.

3.1.4. Financial indicators

In this sub-section, we describe the evolution of the financial indicators like the net current transfers from abroad, the domestic credit to private sector and the bank non performing loans for the DR Congo and Nepal from 2003 to 2017.

Figures 10. Net current transfers from abroad and Domestic credit to private sector



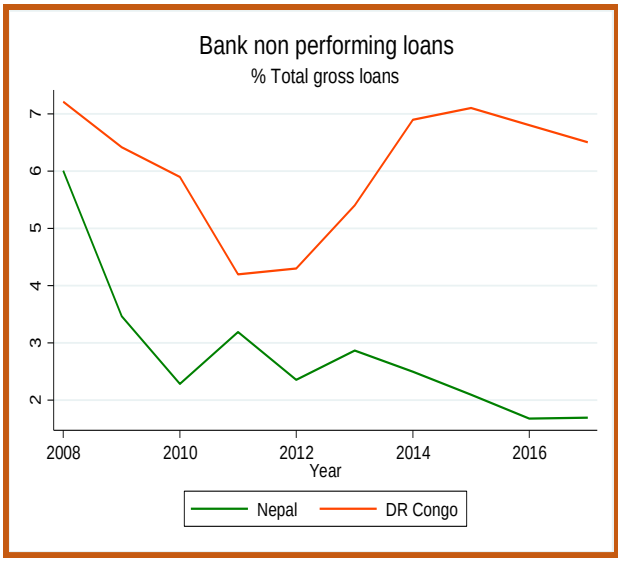
Source: Own calculations

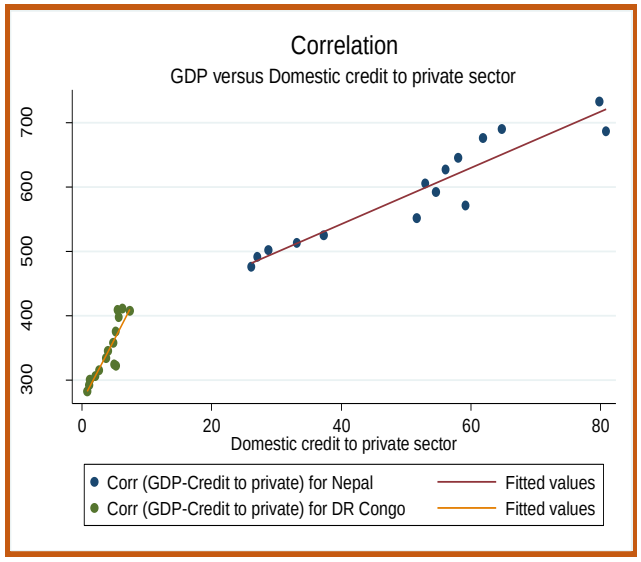
In the charts above, we can read that the difference in percentage of GDP between funds received and those sent out of the country is more important in Nepal than in DR Congo. This is good for the DR Congo (since over the whole period this balance is in surplus) and much more for Nepal, because it allows indigenous population to have surplus funds that can permit them either to finance their consumption or to finance certain investments beneficial to the economy.

In addition, the Nepalese private sector has more access to credit than for the DR Congo. This can offer to the Nepalese an opportunity not only to smooth their consumption and ensure a bright future, but also to finance the investment from the credit received. In both cases (for Nepal

and for DR Congo) the credits granted to the private sector are positively and strongly correlated with the GDP (see the following figures), this sufficiently demonstrates the importance of the credit granted to the private sector in the performance of the two countries.

Figures 11. Non-performing loans and the link between Credit to private sector and GDP





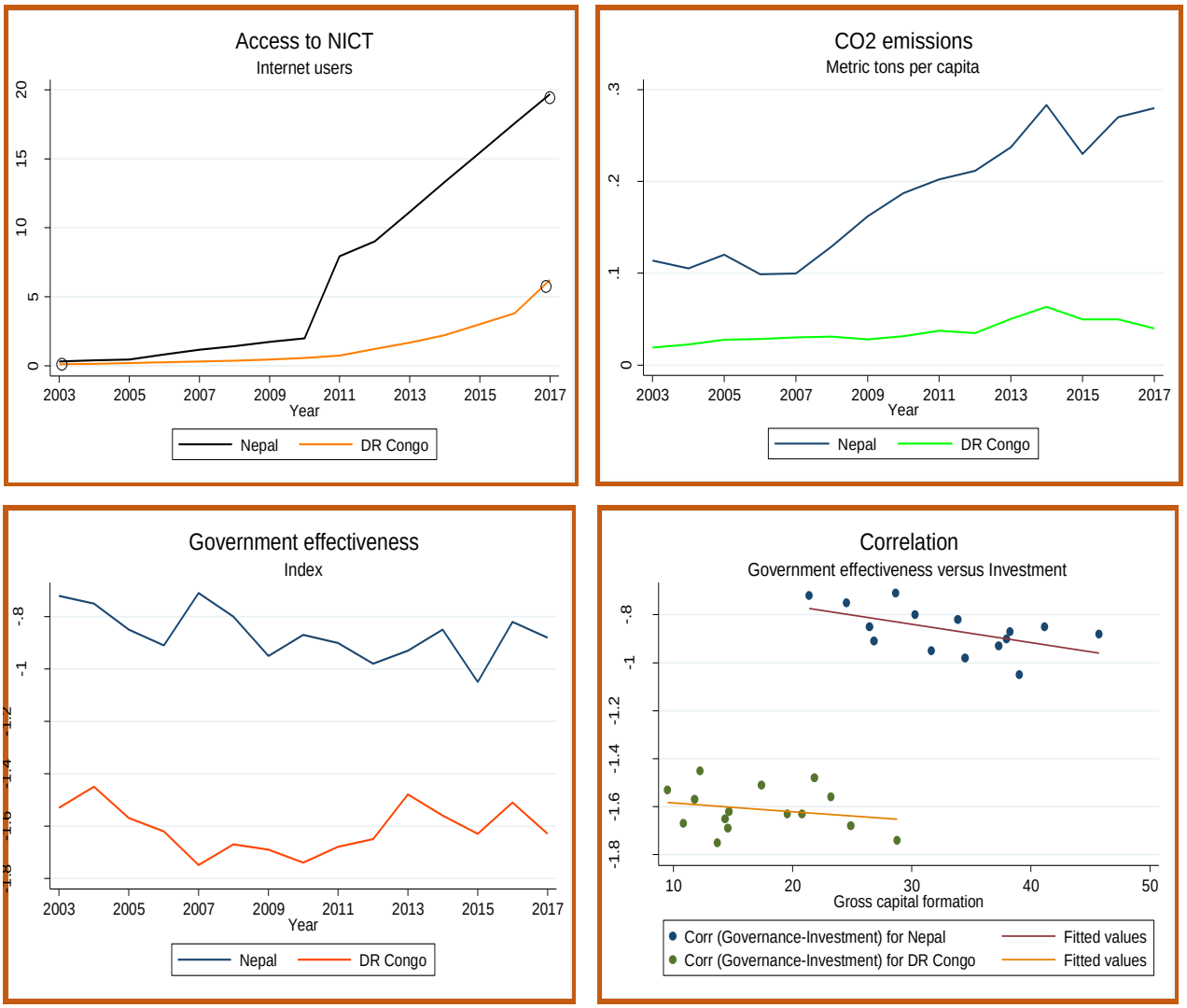
Source: Own calculations

With the low share to the GDP of private sector credit in DR Congo, the banking sector records a large percentage of non-performing loans differently from Nepal. Congolese banking institutions run a great deal of trouble if we compare them with those of Nepal, considering the fact that with the little credit given to the private sector it's difficult to recover the totality either. With this pace, the banking institutions in DR Congo are likely to go bankrupt, which will result in the reduction of credits accorded to the private sector and will follow the reduction of investments and consumption. The reduction of credit granted to the private sector is not good for an economy (see figure 11b: link between credit to private and GDP); it makes more vulnerable economic agents who will struggle to finance or to smooth their consumption and their investments.

3.1.5. Spherical indicators

For these last indicators, in order to be able to evaluate the level of the economic resilience in DR Congo and Nepal, we describe the access to the new information and communication technologies, the index of the governance that relates to the political aspect and the CO_2 emission which is the environmental issue. In addition to this, we examine the correlation link between government effectiveness (governance) and investment.

Figures 12. Spherical indicators (Access to NICT, CO2 emissions and governance)



Source: Own calculations

For the other indicators chosen for the assessment of the economic resilience of low income countries, we observe the great progress made by Nepal in terms of access to NICTs compared to DR Congo. In 2003, for example, these two countries were at the same level in terms of the percentage of people using the internet, but in 2017 it is quite another story, because Nepal has made great progress in this area and its production may depend on it as well. The percentage of internet users in Nepal is even quadruple of internet users in DR Congo at the end of 2017.

However, even bad, the governance in Nepal is performing better than that of DR Congo. For both countries, governance is likely to have a negative impact on investment (see correlation between the government effectiveness and the investment). Governance in these countries is one

of the factors discouraging investors. Moreover, Nepal is a large polluter which emitting a large amount of CO_2 than the DR Congo. This suggests that compared to DR Congo, the emission of CO_2 for Nepal does not allow it to ensure good environmental prospects that can permit Nepal to emerge its economy on a very sustainable basis.

Section 2.ECONOMIC RESILIENCE INDEX for Nepal and DR Congo

In this section, we calculate the composite economic resilience index for the Nepal and the DR Congo by aggregating the standardized coefficients obtained from the various indicators chosen to assess and measure the economic resilience in low-income countries. First, aggregation results using simple arithmetic averages of the coefficients resulting from min-max normalization techniques for all variables allow us to obtain the sub-indices associated with each dimension. Secondly, the aggregation of the sub-indices using their geometric average allows us to obtain the composite index of economic resilience for both countries (Nepal and DR Congo) and for each year (from 2003 to 2017).

3.2.1. Min-max standardize of variables

From the outset, let's look at the characteristics of particular variables such as export diversification, public debt, Non-performing loans and CO_2 emissions. For these variables, the higher their values, the lower their contribution to the resilience of the economy. Hence, they will be treated differently with other variables (see the point 2.2.2). After calculating using the Excel spreadsheet software for which we find the min-max coefficients between 0 and 1 (see appendix 3), we present the various sub-indices (associated to each dimension) as well as the composite index of economic resilience since 2003 until 2017.

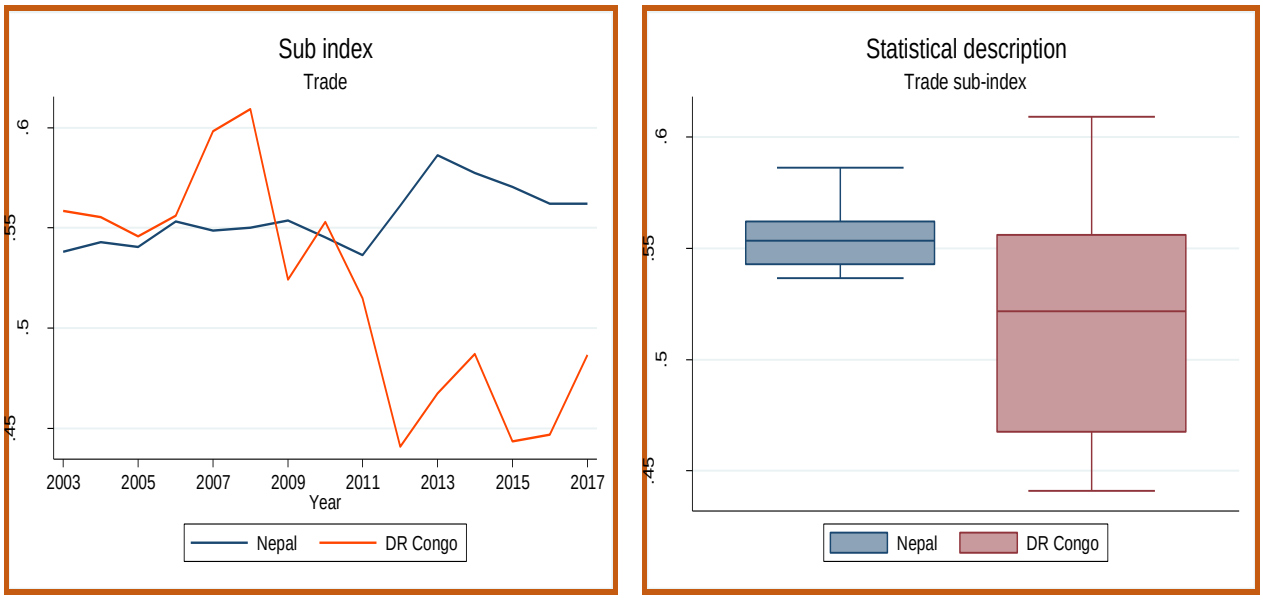
3.2.2. Measure of economic resilience sub-indices

At this point, we measured the sub-indices associated with each dimension of the economic resilience for both countries (The results are detailed in appendix 5). This subsection mentions the graphical evolution and the statistical description of these sub-indices over the study period (from 2003 to 2017). In the statistical descriptions we refer to the box plot in which we extract the information related to the minimum sub-index, the maximum sub-index and the statistical quartiles in order to capture the volatility of the sub-indices across the interquartile range (the difference between the third and the first quartile).

3.2.2.1. Trade dimension

We describe the evolution of the sub-index associated with the commercial dimension during the sub-study period (from 2003 to 2017). Also, we present some statistical characteristics associated with this sub-index.

Figures 13. Evolution and some statistics of the trade sub-index



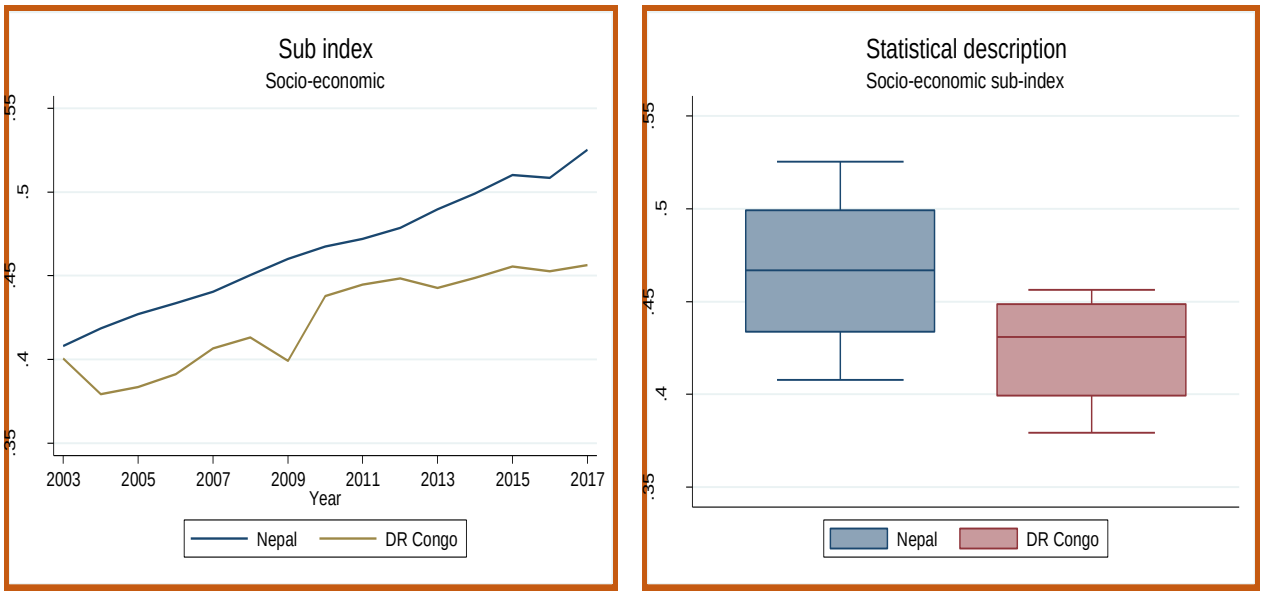
Source: Own calculations

For Nepal, the trade dimension sub-index remained almost constant for the pre-2011 period before showing more resilience until 2013; On average, Nepal scored 0.555 for this sub-index, with a lowest and highest scores respectively in 2011 (0.536) and 2013 (0.586). For DR Congo, this sub-index has fluctuated considerably with a broad score in 2008 (0.609) and a minimum score of 0.441 achieved in 2012; the score average for this sub-index is 0.519 lower than that of Nepal. The wide fluctuations of this sub-index in DR Congo compared to Nepal can also be observed from the box plot for which the interquartile range is wide. In addition, for all the years Nepal and DR Congo realized sub-indices of trade higher than the threshold required for a dimension to be judged of resilient (0.4 as defined in the point 2.2.2) (see annex 5).

3.2.2.2. Socioeconomic dimension

In this point we describe the evolution of the sub-index associated with the socioeconomic dimension during the sub-study period (from 2003 to 2017). Also, we present some statistical characteristics of this sub-index.

Figures 14. Evolution and some statistics of the socioeconomic sub-index



Source: Own calculations

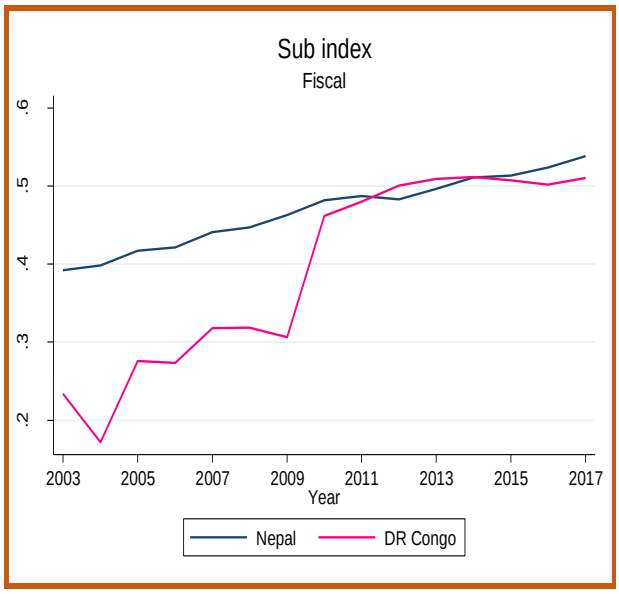
For both countries, the sub-index associated with the socio-economic dimension has evolved since 2003. However, Nepal has the highest score compared to DR Congo during the whole study period. On average, Nepal scored 0.466 (above the required threshold) for this sub-index, with lowest and highest scores respectively of 0.407 (in 2003) and 0.525 (in 2013). The wide fluctuations of this sub-index in Nepal compared to DR Congo can be observed from the box plot for which the interquartile range is wider in Nepal.

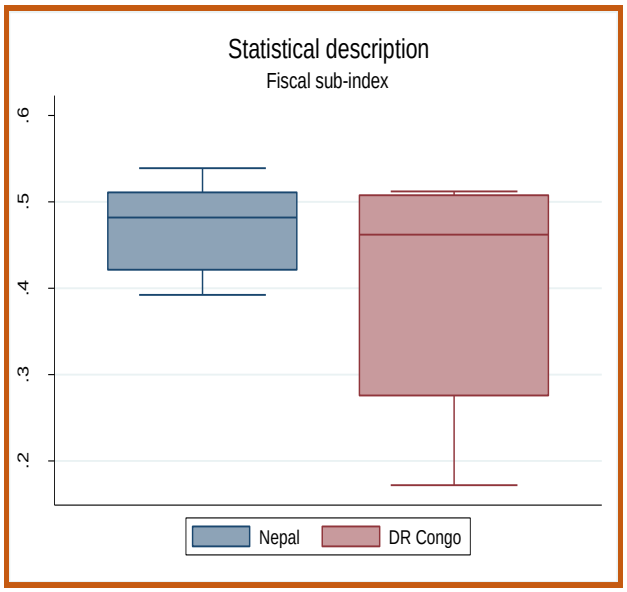
For the DR Congo, the score of this sub-index is on average 0.424 (slightly less than that of Nepal) with a minimum score of 37.9 (in 2004) and a maximum score of 45.6 (in 2017). Moreover, with the exception of the years 2004, 2005, 2006 and 2009, for the other years, the DR Congo saw this sub-index reach the threshold required to qualify a dimension as being resilient. For Nepal, over the entire sub-study period, this sub-index was resilient (see annex 5).

3.2.2.3. Fiscal dimension

In this point, the evolution of the sub-index associated with the fiscal dimension (aggregating the indicators related to the tax revenue and the public debt) during the sub-study period (from 2003 to 2017) is described as well as, some statistical characteristics associated with this sub-index and which can be visualized from the chart presenting the box plot (to the right of the graphs below) for each country.

Figures 15. Evolution and some statistics of the fiscal sub-index





Source: Own calculations

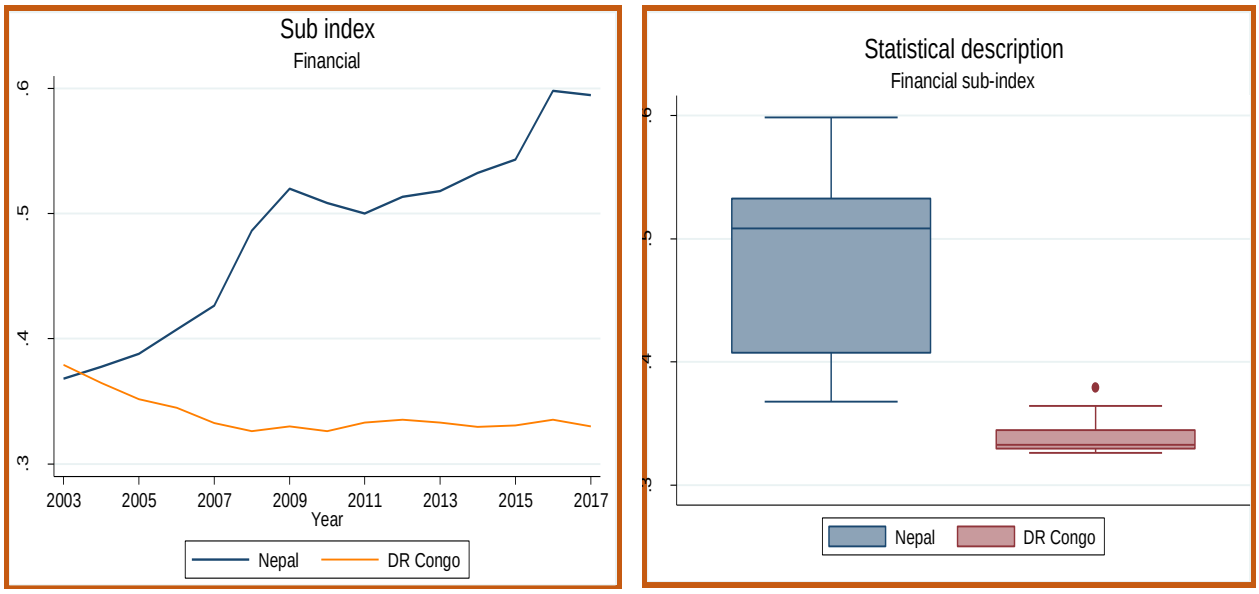
In general, the sub-index associated with the fiscal dimension increases for both countries. Before the crisis of 2008 the DR Congo fiscal sub-index has remained almost constant until 2009 and there is a strong increase in 2009-2010 which could be explained by the HIPC initiative and the cancelation of part of the debt. However, compared to the DR Congo, Nepal recorded the highest score (except from 2012 to 2014) with an average of 0.468 points over the entire study period, the minimum score for this country being 0.392 (in 2003) and the maximum score 0.539 (in 2017).

In comparison with Nepal, the DR Congo has experienced fairly significant fluctuations in this sub-index (see box plot with a large interquartile range) with an average score of 0.392 (lower than that of Nepal), the minimum score was realized in 2004 (0.172) and the maximum score in 2014 (0.512). Furthermore, since 2010 in DR Congo, the fiscal sub-index reaches the required threshold (0.40) in terms of resilience whereas for Nepal it is a little earlier (since 2005) that this sub-index exceeds the required threshold of resilient (see annex 5).

3.2.2.4. Financial dimension

In this point we describe the evolution of the sub-index associated with the financial dimension (aggregating the indicators related to the net current transfers from abroad, the domestic credit to private sector and the non performing loans) during the sub-study period. Also, we present some statistical characteristics of this sub-index (to the right of the graphs below).

Figures 16. Evolution and some statistics of the financial sub-index



Source: Own calculations

In general, with regard to the sub-index associated with the financial dimension, the two countries experienced different evolutions (increase for Nepal and decrease for DR Congo). Even if compared to DR Congo, this sub-index has fluctuated much more in Nepal(see the box plot) with a large interquartile range, the country still achieved the highest average (0.486) compared to the DR Congo for which the average score is 0.339.

The highest score in Nepal is 0.598 (in 2016), more than the maximum score for DR Congo (0.379 in 2003, the only year in which DR Congo had the big score compared to Nepal). The minimum score for Nepal was realized in 2003 (0.368) and is higher than the DR Congo minimum score (0.326 in 2008). In addition, DR Congo has never achieved a score higher than or equal to the required threshold for the under-study period, whereas for Nepal this sub-index has started to achieve resilience performance since 2006 the year in which Nepal scored above the required threshold (see annex 5).

3.2.2.5. Spherical dimension

In this point we describe the evolution of the sub-index associated with the spherical dimension (containing the other indicators not considered in the previous dimensions like the government effectiveness, the CO_2 emissions and the access to NICT) during the sub-study period. Also, we present some statistical characteristics related to this sub-index.

Figures 17. Evolution and some statistics of the spherical sub-index

Source: Own calculations

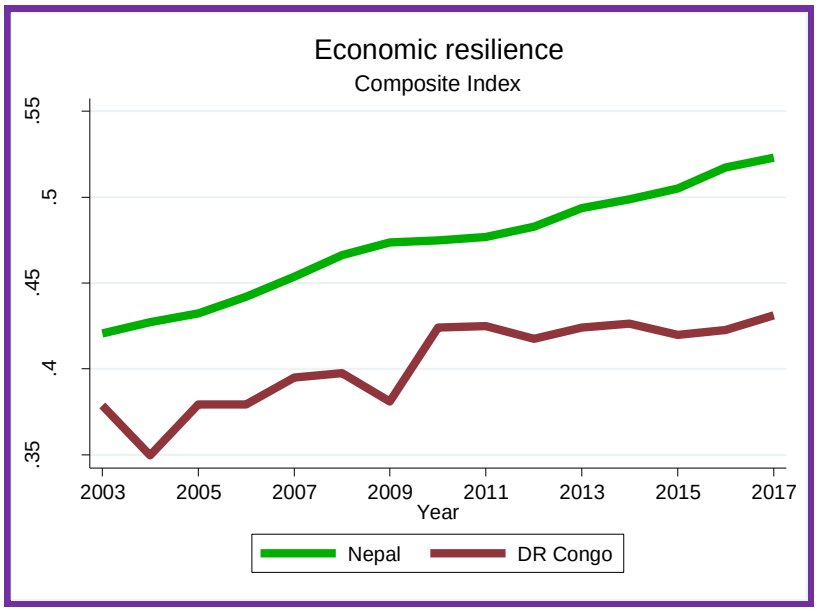
Throughout the study period (from 2003 to 2017), the sub-index related to the dimension that containing the other indicators is higher in Nepal than in DR Congo. The average of this sub-index is 0.404 for Nepal and 0.385 for the case of DR Congo. The biggest score for Nepal dates back to 2007 (0.423) while for DR Congo it is in 2017 that we observe the biggest score related to this sub-index (0.399).

The minimum score for these two countries was achieved in 2010 (0.386) for Nepal and in 2007 (0.374) for DR Congo. For this sub-index, Nepal experienced the largest fluctuations compared to the DR Congo (see the box plot) and Apart from the period (from 2009 to 2014), for the other years Nepal has at least achieved a score which shows that the spherical dimension is resilient (more than 0.4). Furthermore, for this dimension (sub-index), since 2003 until 2017, the DR Congo records scores which are below the threshold of resilience.

3.2.3. Measure of economic Resilience index

At this stage, we present the economic resilience indices for the two countries (Nepal and DR Congo) on the under-study periods. The aggregated result of the composite index of economic resilience was obtained by calculating the geometric average of all sub-index associated with each dimension (trade, socioeconomic, fiscal, financial and spherical). The aggregated index facilitates the interpretation of the results as well as the comparative aspect of the study about the resilient capacity of the two countries considered.

Figures 18. Economic resilience index for the Nepal and the DR Congo

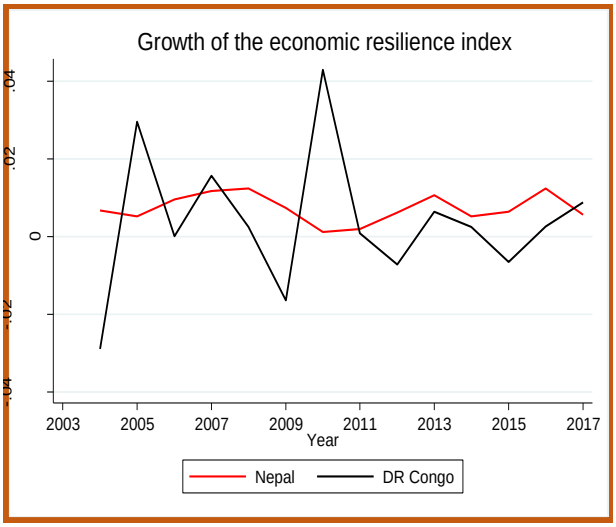


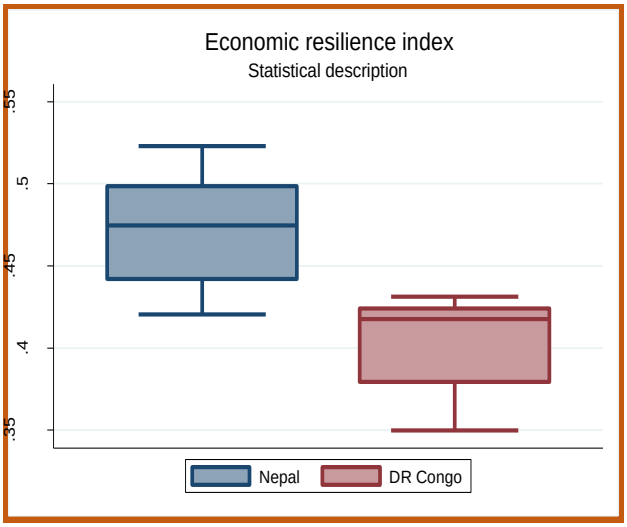
Economic resilience indices[12]		
	Nepal	DR Congo
2003	0.420	0.379
2004	0.427	0.350
2005	0.432	0.379
2006	0.442	0.379
2007	0.454	0.395
2008	0.466	0.397
2009	0.474	0.381
2010	0.475	0.424
2011	0.477	0.425
2012	0.483	0.418
2013	0.493	0.424
2014	0.499	0.426
2015	0.505	0.420
2016	0.517	0.422
2017	0.523	0.431
Average	0.472	0.403
Minimum	0.420	35.0
Maximum	0.523	0.431

Source: Own calculations

We have just calculated the composite indices of the economic resilience for Nepal and DR Congo since 2003 until 2017. According to the threshold set to determine the nature of the resilience index, over the entire study period, Nepal's economy proved to be resilient. For DR Congo, it is only since 2010 that its economy is resilient.

Figures 19. Growth of economic resilience index for Nepal and DR Congo





Source: Own calculations

[12] Cells in red indicate the year in which the index has declined compared to the previous year, cells in blue indicate the highest index achieved in the sub-study period, and cells in khaki refers to the lowest index achieved.

The general trend reflects an increase of the economic resilience index from 2003 to 2017 for both countries even though DR Congo has experienced four periods (in 2004, in 2009, in 2012 and 2015) during which the economic resilience index decline (see the graph above). These periods correspond to those of political turbulence in DR Congo (three years before the presidential elections of 2006, 2011 and 2017).

It is clear that the earthquake that hit Nepal in 2015 and the confused political situation in 2004 did not prevent this country to experiencing growth in terms of the economic resilience index. In addition, for Nepal, the highest index was recorded in 2017 and is higher than the highest index in DR Congo observed in the same year. By contrast, the lowest index in Nepal was observed in 2003 and this index is superior than the lowest index in DR Congo observed in 2004.

3.2.4. Contribution of each sub-index in the index of economic resilience

We present in this point the weight (or the contribution) of each dimension in the index of the economic resilience of each country and for each year (from 2003 to 2017). These weights quantify for each country the contribution (level of importance) of each sub-index (or dimension/sector) to the resilience of the economy. They were obtained from the operation aiming at making base 100 the sum of the sub-indices associated with the dimensions considered. The following table gives an image of these different weights:

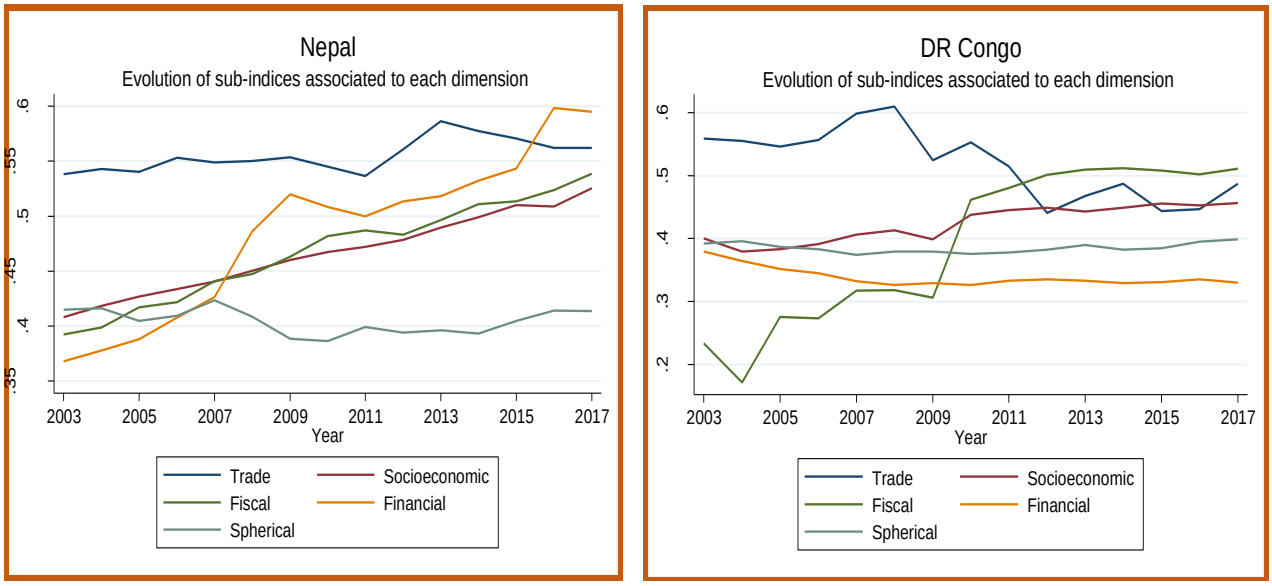
Table 4. Contribution of each dimension in the index of economic resilience

Year	DR Congo					Nepal				
	Trade	**Socioeco**	**Fiscal**	**Financ**	**Spher**	**Trade**	**Socioeco**	**fiscal**	**Financ**	**Spher**
2003	28.5%	20.4%	11.9%	19.2%	20.0%	25.4%	19.2%	18.5%	17.4%	19.5%
2004	29.7%	20.3%	9.2%	19.6%	21.2%	25.2%	19.4%	18.5%	17.5%	19.4%
2005	28.1%	19.7%	14.2%	18.1%	19.9%	24.8%	19.6%	19.2%	17.8%	18.6%
2006	28.5%	20.1%	14.0%	17.7%	19.7%	24.8%	19.5%	19.0%	18.3%	18.4%
2007	29.5%	20.0%	15.7%	16.4%	18.4%	24.2%	19.3%	19.3%	18.7%	18.5%
2008	29.8%	20.2%	15.5%	15.9%	18.6%	23.5%	19.2%	19.1%	20.8%	17.4%
2009	27.0%	20.6%	15.8%	17.0%	19.6%	23.2%	19.3%	19.4%	21.8%	16.3%
2010	25.7%	20.3%	21.4%	15.1%	17.5%	22.7%	19.6%	20.2%	21.3%	16.2%
2011	23.9%	20.7%	22.3%	15.5%	17.6%	22.4%	19.7%	20.3%	20.9%	16.7%
2012	20.9%	21.3%	23.8%	15.9%	18.1%	23.1%	19.7%	19.9%	21.1%	16.2%
2013	21.8%	20.7%	23.8%	15.5%	18.2%	23.6%	19.7%	20.0%	20.8%	15.9%
2014	22.5%	20.8%	23.7%	15.3%	17.7%	23.0%	19.9%	20.3%	21.2%	15.6%
2015	20.9%	21.4%	23.9%	15.6%	18.2%	22.5%	20.0%	20.2%	21.4%	15.9%
2016	21.1%	21.2%	23.5%	15.7%	18.5%	21.6%	19.5%	20.1%	22.9%	15.9%
2017	22.3%	20.9%	23.4%	15.1%	18.3%	21.3%	19.9%	20.5%	22.6%	15.7%

Source: Own calculations

The colored cells determine the dimension that has contributed more (or which weigh more) to the economic resilience. From 2003 to 2011 the trade has done much to make DR Congo's economy more resilient while the fiscal dimension has contributed more to this strengthening since 2012 until 2017. This performance of the fiscal dimension is certainly related to the various reliefs that the country received in 2010 with the reduction of its debts under the Heavily Indebted Poor Countries Initiative. However, for Nepal the trade dimension has managed to contribute more than all other dimensions until 2015 because, of course, its proximity and its commercial relations with China which is one of world economic powers. In 2016 and 2017 it is the financial dimension that has contributed the most to make Nepal's economy more resilient. We can view this information in the following graphs retracing the evolution of the sub-indices (basis for calculating contributions/weights) associated with each dimension:

Figures 20. Evolution of sub-index related to each dimension



Source: Own calculations

Section 3.PRINCIPAL COMPONENT ANALYSIS

Principal Component Analysis helps us reduce the dimensionality of our data. This is particularly important in the presence of highly correlated variables. For this reason, we examine the correlation between the variables. Clearly, for both countries (Nepal and DR Congo) the variables in the data are highly correlated (see annex 4), therefore coefficient value lies between ± 0.50 and ± 1. We would like to summarize the information contained in the data into fewer variables than those initially contained in the dataset. The Principal Component Analysis can help us do it.

3.3.1. Preliminary tests

These tests are very important because they tell us about the structure of our data and whether the principal component analysis is suitable. The table below indicates that the two determinants of correlation matrices for both cases (Nepal and DR Congo) are not singular. The significance of the Bartlett test also pushes us to reject the null hypothesis of the correlation matrix identity, which corroborates with a KMO coefficient that is far greater than 0.5. So, the principal component analysis in these two cases (Nepal and DR Congo) is justified.

Table 5. Preliminary tests of the principal component analysis

Nepal	DR Congo
• ***Determinant of the correlation matrix*** Determinant = 0.0002 • ***Bartlett test of sphericity*** Chi-square = 9590.090 Degrees of freedom = 153 p-value = 0.000 H0: variables are not intercorrelated • ***Kaiser-Meyer-Olkin Measure*** = 0.693	• ***Determinant of the correlation matrix*** Determinant = 0.0015 • ***Bartlett test of sphericity*** Chi-square = 4502.026 Degrees of freedom = 153 p-value = 0.000 H0: variables are not intercorrelated • ***Kaiser-Meyer-Olkin Measure*** = 0.670

Source: Own calculations

3.3.2. Principal components to retain

The two tables below show the eigenvalues (total variance accounted by each component). The sum of all eignevalues equals the total number of variables. Clearly, as the number of components increases the eigenvalue decreases. Kaiser criterion suggests to retain those components with eigenvalues equal or higher than 1.

Table 6. Distribution of eigenvalues for Nepal

```
Principal components/correlation     Number of observations =        60
                                     Number of components   =        14
                                     Trace                  =        18
Rotation: (unrotated = principal)    Rho                    =    1.0000
--------------------------------------------------------------------------
Component |   Eigenvalue   Difference         Proportion   Cumulative
----------+---------------------------------------------------------------
    Comp1 |      13.8116      11.8628             0.7673       0.7673
    Comp2 |      1.94881      1.16669             0.1083       0.8756
    Comp3 |      .782124      .156699             0.0435       0.9190
    Comp4 |      .625424      .215829             0.0347       0.9538
    Comp5 |      .409595      .247812             0.0228       0.9765
--------------------------------------------------------------------------
```

Source: Own calculations

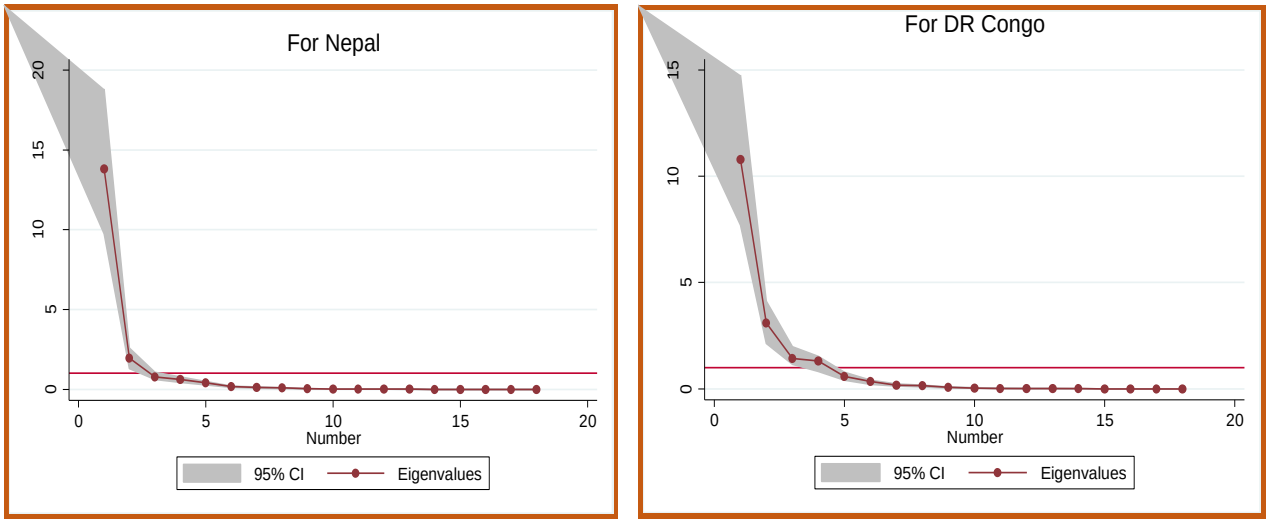
Table 7. Distribution of eigenvalues for DR Congo

```
Principal components/correlation     Number of observations =        60
                                     Number of components   =        14
                                     Trace                  =        18
Rotation: (unrotated = principal)    Rho                    =    1.0000
--------------------------------------------------------------------------
Component |   Eigenvalue   Difference         Proportion   Cumulative
----------+---------------------------------------------------------------
    Comp1 |      10.7865      7.68451             0.5992       0.5992
    Comp2 |      3.10198      1.67286             0.1723       0.7716
    Comp3 |      1.42912      .128899             0.0794       0.8510
    Comp4 |      1.30023      .710533             0.0722       0.9232
    Comp5 |      .589694      .251597             0.0328       0.9560
--------------------------------------------------------------------------
```

Source: Own calculations

For Nepal, the first two principal components have eigenvalues greater than 1, these two components explain 87.56% of the variation in the data, and then we use the first two principal components. For the DR Congo, these are the first four components (representing 92.32% of the variation in the data) that we retain for the rest of our analyses. These two tables can be summarized graphically in referring in to Cartel scree test.

Figures 21. Scree plot of eigenvalues after principal component analysis



Source: Own Calculations

3.3.3. Loading variables in the principal components

Principal component analysis allows us to see how variables are loaded into each component. However, the tables below provide the eigenvectors that allow us to see exactly how each

variable is loaded into each component. The coefficients of each variable are the linear combinations that make up each component. However, variables whose contribution is greater than the average contribution $1/p$ are retained for interpretation in order to give meaning to our principal components. We know that $p = \sqrt{18} \approx 4$; so, $\frac{1}{4} = 0.25$. Variable whose correlation with principal component is greater than 0.25 will be retained in order to give economic meaning to our principal components. After doing the rotation we get:

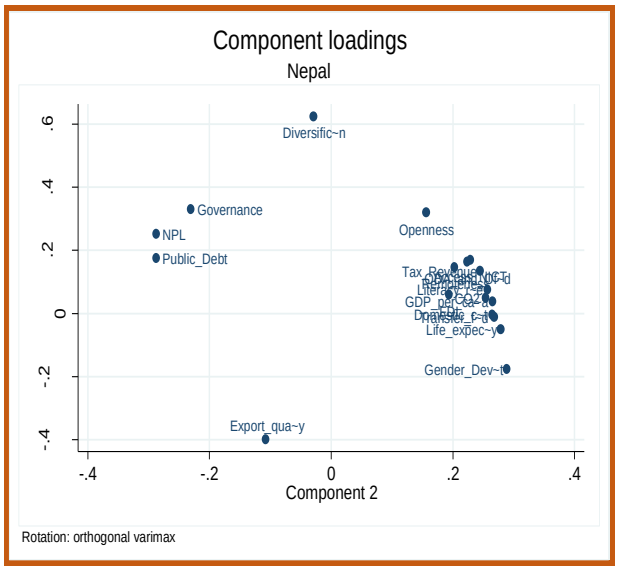
Table 8. Loading variables in each retained principal component for Nepal

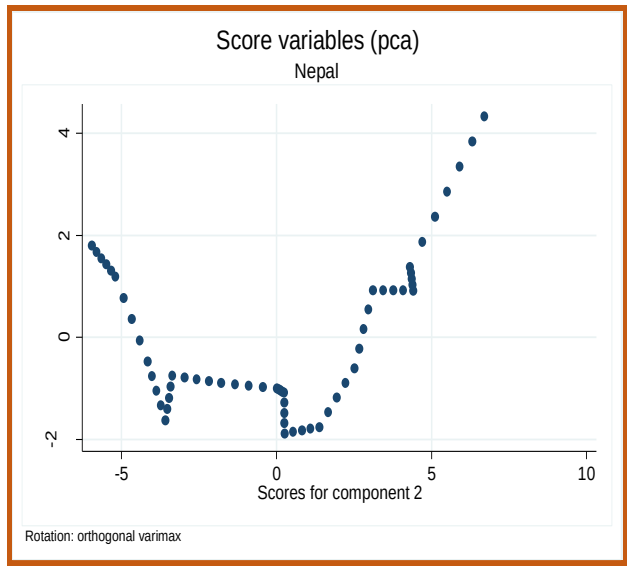
Variable	Comp1	Comp2	Unexplained
Openness	0.3203		.2269
Diversification	0.6254		.1562
Export quality	-0.3983		.2996
Remoteness			.2762
GDP per capita		0.2655	.006558
FDI			.4389
ODA and aid			.1125
Gender dev.		0.2888	.01668
Life expectancy		0.2786	.008127
Literacy rate		0.2568	.01882
Tax revenue			.0158
Public debt		-0.2876	.02506
Transfers abroad		0.2676	.04939
Domestic credit		0.2648	.06081
NPL	0.2529	-0.2876	.04033
Governance	0.3314		.3475
CO2		0.2541	.07446
Access NICT			.06573

Source: Own Calculations

For the first component, which largely defines the variability of our data (76.7%), it is positively correlated with the diversification, the openness, the non-performing loans and the governance, and is negatively correlated with the quality of exports. Based on these data, we can designate this component as **commercial governance** which is supposed to represent the trade dimension. The second component, with the indicators that are correlated with it, can take the sense of **socioeconomic and financial development** which relates to the socioeconomic and financial dimensions of our variables. This information can be represented in the following graphs which describe the components loadings (to see the loading of each indicator in the principal components retained) and score variables (to see the structure of the data):

Figures 22. Component loadings and score variables for Nepal





Source: Own Calculations

The score variables reflects the correlation between the observations and the principal components to check the quality of the data and to verify if there are or are not outliers that could be the basis of the bias. Observing the variable score for Nepal, we notice that there is no data that moves away from other observations. So, there are no outliers for the case of Nepal.

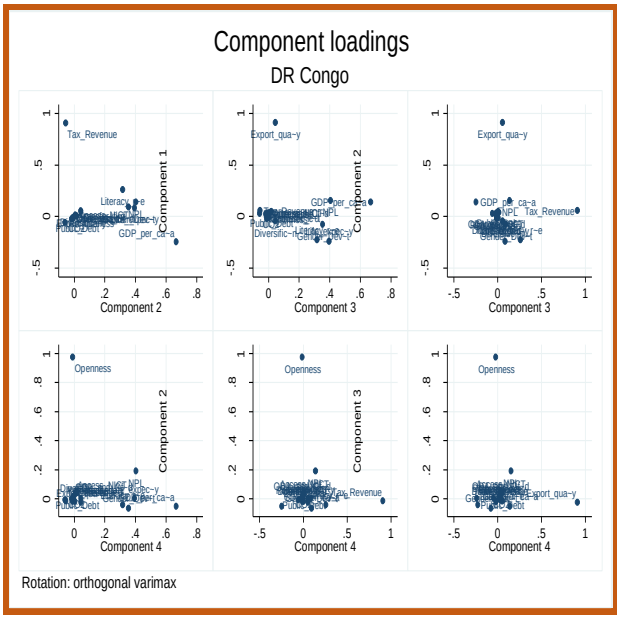
Table 9. Loading variables in each retained principal component for DR Congo

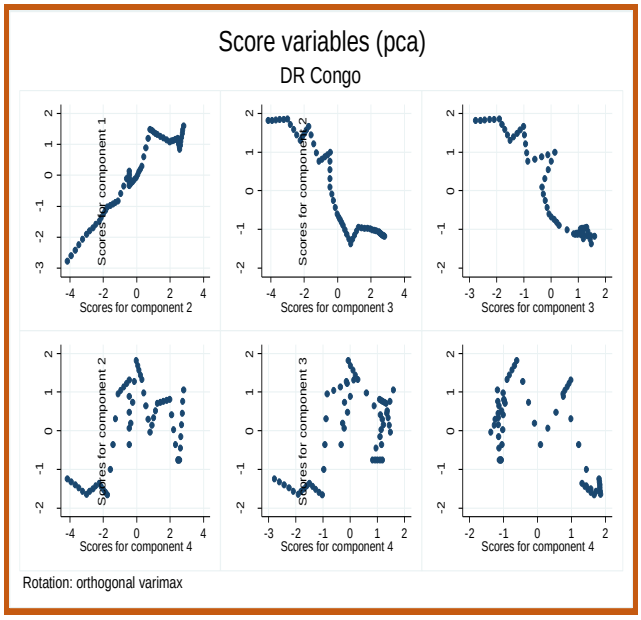
Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
Openness	-0.4709				.1331
Diversification	0.3442		-0.2836		.09293
Export quality	-0.3104				.0524
Remoteness		-0.3417	0.2872		.1299
GDP per capita		0.2845			.01672
FDI		-0.5225	-0.2992		.1801
ODA and aid					.224
Gender dev.		0.2746			.01217
Life expectancy		0.2746			.006019
Literacy rate		0.3071			.004929
Tax revenue		0.2870	0.2864		.05083
Public debt	-0.3247		-0.6107		.02953
Transfers abroad				0.7653	.08425
Domestic credit					.09407
NPL			0.3252		.01323
Governance		0.5129	-0.2611		.1393
CO2	0.3067			0.2757	.06315
Access NICT				-0.4277	.05549

Source: Own Calculations

We note that, with the elements that are in sufficient correlation with the first component, we can name the latter as **trade-related management**, which corroborates well with the trade dimension retained in our data, the second component can also be called **socio-economic governance** that also fits with the socio-economic dimension, the third component can be described as **fiscal governance** that fits well with the fiscal dimension and the fourth component can refers to **the financial and environmental technology** that can fits with the spherical dimension. For the DR Congo the outliers are not too marked. All this information is contained in the following graphs:

Figures 23. Component loadings and score variables for DR Congo





Source: Own Calculations

PARTIAL CONCLUSION

This chapter has been reserved for data analysis. After presenting the variables needed to measure economic resilience in low-income countries, using arithmetic averages, we determined the sub-index associated with each dimension as well as the economic resilience index. The results thus obtained show that over the study-period, Nepal has been more economically resilient compared to DR Congo. Globally Trade is a dimension that has contributed more to the economic resilience for these two countries although other dimensions in a certain period (2016 and 2017 in Nepal with the financial dimension; from 2012 to 2017 in DR Congo with fiscal dimension) have had to disregard the trade dimension as the one that contribute the most to make the two economies resilient. These last results are also confirmed by the principal components analysis.

Fourth Chapter. MAIN FINDINGS AND POLICY IMPLICATIONS

In this fourth chapter we present the main findings regarding the results of our analysis as well as the national and international economic policy implications that all these results may have for the two countries considered as illustrative cases. To finish this chapter, we will present some particular aspects of our research in terms of future perspectives, difficulties encountered, limitations and the proposition of new research approaches.

Section 1.MAIN FINDINGS

The main results can be summarized in two points, the first comment the variables retained to assess and measure the economic resilience in low-income countries as well as the methodological framework used to analyze them in order to quantify the economic resilience in low-income countries, and the second point is a framework in which we discuss our results in terms of sub-indices associated with each dimension.

4.1.1. Retained variables and methodological framework

Having defined the criteria for selecting the variables to be considered (as presented in Appendix 1), we selected eighteen variables to measure and evaluate the economic resilience of low-income countries. Taking into account the nature of each of them, these 18 variables (or indicators) were divided into five dimensions (trade, socioeconomic, fiscal, financial and spherical).

However, in this batch of indicators, there were also initially the “investment” and “government spending” variables. Given that by considering these two indicators and the gross domestic product at the same time would lead us to a double counting, since the GDP already includes the investment and the governmental expenses, we have judged good either to choose the GDP only or to choose the investment and/or government expenditures. We have finally opted for GDP since it is more complete than the other two.

The reasons that led us to use the two averages operations (geometric and arithmetic) differently is that, **at first** given that by applying the min-max normalization technique negative normalized coefficients can emerge (Generally, for observations with some values less than the minimum values), it was important for us to abstain at first from applying the geometric average because the eighteenth root of a negative number does not give a real number. So for the normalized coefficients, the arithmetic average was better adapted to determine sub-indices whose values are

between 0 and 1 (like for Bates et al. 2014; and Angeon & Bates 2015). Already having these sub-indices (greater than 0) it was then logical for us to look for how to mitigate the effects outliers by applying the geometric average in order to determine the economic resilience index.

Secondly, we observed that the initial databases were less affected by fluctuations of sampling that is why we determined the sub-indices associated with each dimension by applying the arithmetic average. To aggregate these sub-indices we relied on the work of Clark-Carter (2005) in which the author demonstrates that the geometric mean is an appropriate measure for data involving indices. Also, having an outlier (0.379) for the case of the DR Congo at financial sub-index (see box plot of figures 16) although not too significant, it was important for us to take into account the outliers problem in our final results. And so, to mitigate this effect of outliers in our results, it was important for us to use the geometric average.

We note almost a similarity of the results on the dimension that contributes the most to make the economy more resilient by applying the min-max technique as well as the principal component analysis. For this aspect of analysis, we suppose that applying one or the other technique give the same result. By drawing this lesson, we join Nardo et al. (2005) who found that both techniques can produce more or less similar results, at least in terms of the contribution (or weight) of each dimension in the level of economic resilience.

4.1.2. Dimensional level (sub-indices)

Yet landlocked, Nepal shows commercial performance in terms of resilience capacity since 2009 compared to DR Congo. In its isolation, Nepal shares the borders with one of the great economic powers (China) and one of the major demographic powers (India). These geographical situations are certainly favorable to Nepal in terms of trade given that India is its main customer (yarn of synthetic staple fibers, nutmeg, carpets in materials textiles, jute, sugar cane, tobacco, cereals, etc.) with just over 50% of Nepalese agricultural products exported to India. Nepal benefits from its economic structures in terms of infrastructure and trade procedures that allow this country to make its trade at the service of the economic resilience compared to the DR Congo.

Although having certain advantages that may allow the emergence of new production methods and techniques, the opening of an economy is also dangerous since it exposes the country to various external shocks. Compared to Nepal, the period before 2009 has shown an improvement

of the economic resilience of the DR Congo mainly due to a growing openness to trade. Alas this situation is deteriorating overnight which mainly reflects the fact that the DR Congo relies on an economy that is less and less diversified and depends mainly on mining products whose prices are very sensitive to the global economic situation.

Since the fall in raw material prices, the DR Congo has experienced a decline in the contribution of this dimension to economic resilience. The level of concentration in the only mining products (lack of diversification of the economy), the corruption that gangrenes the trade sector in DR Congo leaving no room for maneuver to the administration to make the trade at the service of the development; and the bad management of this sector are among the key contributing factors in preventing the commercial sector from truly serving economic resilience.

Conversely, although poor, the Nepal economy contributes the most to the economic resilience compared to DR Congo. Nepal's productive machinery relying on the production of agricultural products offers this country an opportunity to make its agricultural sector a lung of economic resilience. According to data from the World Bank (2017), Nepal is made up of 81% of the living populations in rural areas and many of them are poor but given the importance that the state gives to the agriculture (on average it represents 47.27 percent of the GDP) this sector further strengthens the resilient capacity of the country.

Nepal's agricultural products are not only used for subsistence farming, as in other developing countries, it is also used for business (the transformation in industry, sales to Aboriginals and especially to exports). Also, some effective projects (especially those of the international cooperation and development of the European Union) have made to increase the standard of living in the Nepal's rural households who had decided to abandon since a certain period the agriculture as subsistence farming and focus on the agri-business.

We know that Nepal's domestic credit to private sector is roughly estimated at 80% of GDP in 2017, this means that the Nepalese people have enough funds to finance their consumption and can also participate effectively in agricultural investment actions in order to increase the production of goods and promote food self-sufficiency. Also the country exports about 75% of diversified agricultural products. All these elements (agricultural business, funds to finance consumption of agricultural products and to invest in agriculture, exports to a great external

market such as Indian markets, and food self-sufficiency) prove sufficiently the contribution of agriculture making Nepal's economy more and more resilient.

Furthermore, managing the opportunities offered to a country gives a sense on the contribution of the economic dimension to building a truly resilient economy. As an illustration, the various aid and assistance received by the DR Congo (high than the assistance and aids received by Nepal) tend to evolve in the opposite direction with the gross domestic production (see chart 6b). This describes in all a society where immoral values (mismanagement, misappropriation, injustice, corruption, clientelism, etc.) have become a normal situation. In this situation, it is a bit difficult for a sector to be effective in helping to make the economy more resilient.

In addition, the various political turbulences, particularly related to the post-election periods in DR Congo (2004, 2009 and 2015) and the period after the death of King Birendra in Nepal, have had enormous impacts on the socio-economic sphere. These results nonetheless demonstrate the role of politics in the deterioration of the economic and social fabric of low-income countries. The calmer the political situation is, the better the economy becomes and the more resilient is the economy. However, the 2015 Nepal Earthquake has not led to a degradation of the socio-economic conditions (with GDP growth of 2.1% higher than the Nepalese average GDP growth which is 1.8%) as we could have expected. This situation demonstrates the resilient capacity of Nepal's economy and may be due to the size of the international and regional (South East Asia) mobilization which aimed at saving the Nepalese people from this natural disaster.

For the fiscal dimension, compared to DR Congo, Nepal has long shown good fiscal prospects in terms of the contribution of this dimension in economic resilience. Moreover, in 2010, after reaching the completion point of the highly indebted poor countries initiative that led to the reduction of its debts, the DR Congo saw significant improvements with regard to the contribution of this dimension to economic resilience. Not having access to this favor for the relief of its debts, Nepal since 2015 as for other periods, settle for of its effective management of the fiscal dimension. This efficiency makes this dimension a real pillar contributing to make the Nepal's economy more resilient compared to the DR Congo which, despite the relief, continues to run up more debt.

Apart from the year 2003, for the other years, Nepal has had financial sub-indices higher than those achieved by DR Congo. This is less surprising to us since we know that apart from the

country's agricultural production, Nepal is also a country that has many opportunities in terms of funds that different Nepalese households receive from abroad. In addition, access to credit for the private sector (especially the private sector involved in agriculture) as well as the performance linked to the amortization of bank loans by private borrowers make this dimension a pillar of the strengthening of Nepal's economic resilience.

For the DR Congo where the banking sector is suffering enormously with excessively high non performing loans and almost non-existent private loans, it is important for the national authorities and banks to adopt clear rules for ensuring the solidity of the banking sector in order to provide some reforms that can allow Congolese people to have a sufficient access to credit. It is also important for Congolese people to be informed on the role of financial institutions in the economic development; this can help to build confidence in the banking sector and avoid the bankruptcy of financial institutions. Credit is an important indicator that can lead a country to build its economy on solid resilient bases as we can see in Chart 11b on the correlation between private credit and GDP.

The spherical dimension (Considered as taking into account other indicators that are not part of the trade, socio-economic, fiscal or financial dimension), although having enormous environmental potentialities, the DR Congo experienced a sub-index associated with this dimension less than those realized by Nepal throughout the study period. The governance aspect and the access to the new information and communication technologies, although not too efficient for Nepal, are indicators that allow Nepal to have the spherical dimension contributing more to economic resilience compared to the DR. Congo. Quality of governance is a key factor for promotion of investment and for building resilience. But both DR Congo and Nepal know unsatisfactory situation due to hassles, corruption, clientelism and all other kinds of anti-values that live in the societies of low-income countries. Political turmoil is also likely to negatively impact economic resilience and especially for the DR Congo case.

Section 2.POLICY IMPLICATIONS

In this section we present the implications of the economic resilience in terms of economic policies at national and international level, with a particular focus on low income countries (which constitute the scope of this study) and especially in Nepal and DR Congo, considered as the illustrative cases.

4.2.1. Policy Implications at the National level

This point present the implications of economic resilience index in terms of policies at the national level in low-income countries and particularly Nepal and the DR Congo.

4.2.1.1. Embedding the resilience framework into national strategies

Low-income countries have specific characteristics which render these states particularly exposed to external economic shocks. This means that economic changes in these countries depend to a large extent on factors outside their control. Resilience building is therefore of particular relevance and of major importance for these states. The DR Congo and especially Nepal have made significant improvements in strengthening their resilience capacity compared to 2003.

In our thesis, the outcome of the resilience framework, produced interesting tendencies, namely that many low-income counties can succeed economically in spite of their economic vulnerability if they adopt good trade, good socio-economic policy, good financial policy, good fiscal policy. All these dimensions could enable these countries to reduce and even withstand the negative effects of shocks. With the dimensions mentioned above, good political, and environmental management are also conducing to resilience building. It thus follows that it pays to low-income countries to embed resilience building measures in their plans and strategies without taking certain risks (for example: opening, reduction of production in order to protect environment).

4.2.1.2. Profiling for identifying resilience strengths and weaknesses

Despite the exercise we have made to identify the source dimensions of economic resilience in illustrative cases (Nepal and DR Congo), profiling strengths and weaknesses in resilience would also require an exercise that could be done in consultation with stakeholders in the field, including politicians representing different ideologies, experts in different aspects of political, economic, social and environmental governance and representatives of different civil society groups. One method of performing such a profiling exercise in practice has been described in Briguglio et al. (2009).

Once the strengths and weakness in terms of resilience are identified, corresponding measures to maximize the strengths and address the weakness should be drawn up and mainstreamed in national strategic directions. For example, if it is found that macroeconomic stability is endangered due to lack of fiscal discipline leading to the accumulation of public debt measures

should be introduced to address these weaknesses. This argument also applies to gaps in the other resilience-building policies identified in this study, including trade, socio-economic, financial and spherical governance.

4.2.1.3. Implication for domestic and foreign direct investment

Investment (originating domestically or from foreign sources) is an important contributor to growth and development. One expects that, everything else remaining equal, in a country that is well-governed economically and enjoying political and social stability, domestic and foreign investments are more likely to be attracted. Other factors which serve to attract investment are good quality infrastructure and a favorable business culture. Low-income countries tend to be disadvantaged with regard to investment attraction.

However, good economic governance could to an extent make up for these inherent deficiencies. Blomström & Kokko (2001) and Gangi &Andulrazak (2012) discuss the attraction of FDI. The present study has obvious implications for investment attraction because of the connection between economic resilience building and factors that are conducive to investment attraction in low-income countries, including good economic, social, fiscal, financial, political and environmental governance.

4.2.2. Policy Implication at the International Level

In this point we present what can be the implications of an economic resilience (measured by an index) in terms of policies at the international level about the low-income countries and particularly, our illustrative cases (Nepal and DR Congo).

4.2.2.1. Resilience and Official development assistance and official aids

The resilience framework proposed in this study can have important implications for donor countries and international organizations and that can change the situation. However, an important implication of the present study, with regard to conditionality relating to aid and other forms of support, is that resilience building should feature as a major objective of such support for low-income countries given that the economic resilience capacity can be a proof that the country has the ability to manage efficiently the received funds in order to be able to strengthen further itself in terms of resilience and economic performance. Once this requirement is respected, both parties (donors and recipient) can be reassured about the performance of the aid.

Briguglio (2009) argues that aid aimed at promoting and supporting economic stability, market efficiency, social development and environmental management is likely to have a lasting effect on recipient countries, not only because this aids and assistance build economic resilience but also because it is likely to foster the belief in the recipient country itself that it can climb the development ladder through improved economic governance.

4.2.2.2. The World Bank and low income countries

The portfolio of development-facilitating instruments available to all World Bank members is also available to low-income countries. The Bank proposes to these countries to also participate in the programs of the International Development Association (IDA). IDA is an attractive tool for developing countries because it offers loans with little or no interest that can be repaid over a period of 25 to 40 years with a grace period of 5 to 10 years. This mechanism was designed to help the poorest countries with concessional financing. The exception for low-income economies may include two important measures, namely the removal of the maximum cap per capita and the doubling of the basic allocation. With these changes, the country allocation for low-income economies has been recently increased.

The low-income countries offer the possibility of concessional support, but in general, the World Bank is not one of the most attractive sources of financial support for low-income countries, mainly because of the conditional heaviness associated with this support. The World Bank tried to reduce these disadvantages and one of the tools that can eventually assist in the process is the Program for Result Financing (P4R). In addition, if the economic resilience criterion could be factored into World Bank support programs in order to help countries with weak resilient capacity to strengthen their economies; perhaps many low-income countries might be better able to take advantage of World Bank funds. However, when such support is triggered on the basis of a vulnerability criterion, it should be primarily aimed at enhancing the economic resilience of low-income beneficiary countries.

4.2.2.3. The IMF and support eligibility

The voice of low-income countries is generally considered not to be strong enough within this International Monetary Fund (Broome 2011). At least the some reform in the Fund brought two flexible short term lending mechanisms of specific interest for low-income countries, namely the standby credit facility and the rapid credit facility. Griffith-Jones and Tyson (2010), however,

argue that the focus of the IMF's compensatory financing, including the automatic provision of very rapid and significant liquidity for countries facing purely external shocks, has been aimed for low-income countries.

Again, if a resilience criterion is factored into IMF support programs in order to help countries with weak resilient capacity to strengthen their economies, many low-income countries may be better served by the IMF. As explained with respect to World Bank systems, when such support is triggered on the basis of a vulnerability criterion, it should focus on strengthening the economic resilience of low-income beneficiary countries.

Section 3.SOME IMPORTANT ASPECTS OF THE THESIS

Since the subject covers a relatively high field (low-income countries), in this section it is quite simply a question of presenting the future prospects, the difficulties encountered as well as the limits and the propositions with regard other research approaches related to the economic resilience in low-income countries.

4.3.1. Future perspective

Despite some efforts made by many low-income countries, particularly Nepal and DR Congo, these countries still have a lot of work to do in order to build their economies on more resilient pillars, and that means improvements in all the indicators that we have identified as influencing the future economic resilience (trade indicators, socio-economic indicators, fiscal indicators, financial indicators and spherical indicators). However, further efforts must be made in order to make the low-income economies less vulnerable and more resilient, so with that the sustainability of these economies is assured for the benefit of people in low-income countries and the world.

4.3.2. Encountered difficulties

In this study, we encountered some difficulties. Time was running out for us to be able to conduct this study on all low-income countries and do some fieldwork in order to be able to investigate the situation of low-income countries in terms of the resilient capacity of their economies, some scientific papers and documents on the economic performance of low-income countries have allowed us to overcome this difficulty. Also, the difficult access to some documents related to the economic resilience in the low-income countries, we have managed ourselves with the few documents fruits of our research to constitute the bulk of the literature.

4.3.3. Limits and research approach

Like any research work, ours also suffers from a number of limitations.

- ✓ Since resilience and vulnerability are two peer-to-peer terms it was important to refer to the second term as well in order to build a theoretical reference in terms of the policies to be suggested;
- ✓ Such a theme should also be analyzed on the basis of field exercises and interviews given to experts and/or authorities (political or otherwise) in some of the low-income countries in order to inquire effectively about the situation in the group of countries concerned by this study;
- ✓ The thresholds used to designate the nature of the economic resilience index could be well defined (using the median index value for all countries) if we would have available data from all low-income countries.

We think that the limits thus underlined do not in any way diminish the relevance of the conclusions which we have reached and which confirm certain statements developed in our review of the literature.

PARTIAL CONCLUSION

In this fourth and last chapter, we presented the main findings (construction of the methodological framework and the results associated with each dimension), the implications (at national and international level) of our results in terms of economic policies as well as certain particular aspects of our study. Nepal has had a remarkable performance over the last 15 years in terms of economic resilience compared to DR Congo. The fact of being resilient while the country was experiencing the earthquake in 2015 testifies to the resilience capacity of Nepal's economy. Several factors can explain this counter-performance in DR Congo, notably the corruption, the clientelism, the misappropriation, the mismanagement and other anti-values that could negatively affect the smooth running of the society. For low-income countries, there is a need to abandon all these practices in order to build strong and resilient economies. All these efforts require the involvement of the authorities of these countries, the implication of the population of these countries and the implication of international institutions.

GENERAL CONCLUSION AND RECOMMENDATIONS

Considering two illustrative cases subject of a comparative study (DR Congo and Nepal), the objective of this thesis was to identify and examine the different variables to be taken into account in order to assess and measure economic resilience in low-income countries. This goal led us to first present all the different theoretical and empirical approaches related to the topic and thus, we determined the different criteria for choosing the variables to be taken into account.

On this basis, we then explored the choices of the variables. After a qualitative analysis, four indicators of the commercial dimension (openness, export diversification, export quality and remoteness), six indicators of the socioeconomic dimension (GDP, FDI, ODA and official aid received, gender development, life expectancy at birth, and literacy rate), two fiscal indicators (tax revenue and public debt), three financial indicators (Net current account from abroad, domestic credit to private sector and non performing loans) as well as the others indicators that we have grouped in spherical dimension were selected to measure the economic resilience capacity of low-income countries. However, three indicators relating to the Government effectiveness, the emission of CO_2 and the access to NICT were added in order to be able to constitute the designated dimension of spherical.

Finally, on the basis of the indicators defined in each dimension (trade, socio-economic, fiscal, financial, and spherical) and their minimum and maximum thresholds relating to the reality of low-income countries, we used the min-max technique to derive the coefficients whose values are between 0 and 1 and which come from the standardization process. A series of operations of aggregating these coefficients through the simple arithmetic average allowed us to identify the sub-indices associated with each dimension. After these operations we proceed to the aggregation of all sub-indices into a single composite index across the geometric average and the result of this last aggregation allowed us to release the composite index that is considered as the economic resilience index.

However, based on the variables chosen and grouped into different dimensions, we performed a multivariate analysis, especially the principal component analysis in order to reduce the dimensionality of the variables (initially we had 18) to a small number of components with the purpose of having an idea about the dimension that would largely explain the variability of the data. This kind of analysis gave the same results as those of min-max normalization technique.

After analyzing the data, we arrived at the results according to which the efforts to make more resilient economies are being made after each year for both countries. However, for all the years of analysis (from 2003 to 2017) Nepal presents an index of economic resilience higher than that of the DR Congo. The size of a country does not make it resilient, it depends on many factors other than the size of its surface, and these other factors (or indicators) allow us to measure the economic resilient capacity of the low-income countries. Furthermore, for all study-period (from 2003 to 2017), Nepal is economically resilient in the true sense of the word (with indices above the threshold of 0.4). For DR Congo it is since 2010 that the country realizes the indices of economic resilience higher than the required threshold.

Moreover, for the dimension that contributes more to making the economy of these two countries resilient, the trade dimension (from 2003 to 2015 for Nepal and from 2003 to 2011 for DR Congo), the financial dimension (in 2016 and 2017 for Nepal), as well as the fiscal dimension (from 2012 to 2017 for DR Congo) are those dimensions whose contribution to bring the economy of these two countries to a resilient level is not negligible. In general, the trade dimension seems to be the most to contribute to this index thanks in particular to the weaknesses that other dimensions present. The important production of Nepal in agricultural product and its proximity with some world powers can make this country very powerful in this field, also the DR Congo with its mining productions although having not really visible impact on the economic life of Congolese citizens can be the basis of the efficiency of the trade sector, all other sectors being hit by corruptions, embezzlements and other anti-values. However, the relief to reduce DR Congo's debts in 2010 allowed this country to regain a big fiscal wind and from this period the fiscal dimension has become the lung of economic resilience in this country.

Each indicator having been considered with the same weight, the index produced in this study should be considered as still at the first stage of the development of the resilience index in low-income countries. Considering all the lessons learned in this work, we suggest that governments in low-income countries provide enough effort to improve the score of all the dimensions that contribute to making their economies more resilient:

- ✓ By promoting and supporting public or private entrepreneurial initiatives;
- ✓ By establishing genuine law-abiding states and fighting corruption; and
- ✓ By improving the socio-economic governance as well as the environment protection.

People in low-income countries to accompany their states:

- ✓ By adopting responsible and patriotic behavior vis-à-vis the public or private productive apparatus;
- ✓ By taking diversified initiatives in terms of investment in order to increase the production of their countries; and
- ✓ By promoting ethical values (abstain from immoral acts and anti-values, protect the environment and so on).

International institutions to help the low-income countries:

- ✓ By providing some training in the framework of good governance for public authorities in low-income countries.
- ✓ By accompanying them in the monitoring of projects (financed by international institutions or not); and

We do not pretend to have touched on all the aspects relating to this theme; nevertheless the few pithy aspects give an important base. Other researchers will be able to approach in the same direction and try to expand the space field by taking into account all low-income countries and by performing fieldwork to investigate all aspects of economic resilience in low-income countries.

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ANNEXES

Annex 1. Selection of variables

Variables	Simplicity	Transparency	Reproducibility	Comparability	Affordability	Wide	Usefulness
Openness	Opening to other market.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Open to the market in order to sell its products.
Export diversification	Range of products and trading partners.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Foreign markets to have several choices on their products.
Export quality	The quality of the exports.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	The ability to make a place for itself in foreign markets.
Remoteness	Infrastructure and procedure of accessibility to other markets.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Easy access to external markets.
GDP per capita	Per capita production.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Idea on productive capacity.
FDI	Foreign investment in the domestic country.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Improvement of the productive apparatus.
ODA and aid	Assistance to improve socio-economic conditions.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Improvement of social and economic conditions.
GDI	Take into account gender in socio-economic life.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Participation of all gender in the economic development.

Life expectancy	Health conditions.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Constancy in the production level.
Literacy rate	Knowledge for innovation.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Introduce new methods in the production process.
Tax revenue	Ability to self-manage.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Ensures the autonomy of tax structures.
Public debt	Condemned to sacrifice future generations.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Compromise of sustainable development.
Net transfers from abroad	Influence the income of population.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Improves aboriginal capacity in terms of income.
Credit to private	Contribute to improving investment.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Finance private production structures.
Non-performing loan	Crucial to the development of the banking sector.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less two hours to get the data (reports).	Data available for low -income countries.	Judge the room for maneuver in the banking sector.
Government effectiveness	Attraction and motivation to invest.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Motivating factor for investments.
CO2 emissions	Environmental constraints.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Long-term development depends on it.
Access to NICT	Technology serving production.	Methodology explained and data available.	The seriousness of the institution estimating it makes no doubt.	The unit of measurement makes it comparative.	More or less an hour to get the data.	Data available for low -income countries.	Improve its production capacities.

Annex 2. Extrema values for the indicators

Variables	Particularity on the values	Values		
		Resilient If High	Min	Max
Openness	Generally its value is in percentage	Yes	***0.00***	***100.00***
Export diversification	The highest export diversification index (Theil index) in history does not exceed 6.44. Considering a margin of 0.56 to locate the upper bound and assuming that at least each country exports a product.	No	***0.00***	***7.00***
Export quality	Consider that the value 1 (even with high productive capacity, difficult to reach) proves a perfect quality of exports by low-income countries.	Yes	***0.00***	***1.00***
Remoteness	It is an indexed value.	Yes	***1.00***	***5.00***
GDP per capita	2019 fiscal year, low-income economies are defined as those with a GDP per capita of $995 or less in 2017.	Yes	***0.00***	***955.00***
FDI	Value reported to the GDP.	Yes	***0.00***	***100.00***
ODA and aid	Suppose that every ODA assistance and official aid received does not exceed 50% of the income for every inhabitant of low-income countries.	Yes	***0.00***	***477.50***
GDI	It is an indexed value.	Yes	***0.00***	***1.00***
Life expectancy	Today, centenarians have become rare.	Yes	***0.00***	***100.00***
Literacy rate	Value in percentage.	Yes	***0.00***	***100.00***
Tax revenue	Value reported to the GDP.	Yes	***0.00***	***100.00***
Public debt	With the sustainable development goals, it would be unacceptable today to have debts of up to 100% of GDP. In the past, it could be double the GDP and we were worried the least.	No	***0.00***	***200.00***
Net transfers from abroad	Value reported to the GDP.	Yes	***0.00***	***100.00***
Credit to private	Value reported to the GDP.	Yes	***0.00***	***100.00***
NPL	Value in percentage.	No	***0.00***	***100.00***
Gov. effectiveness	It is an indexed value.	Yes	***-2.50***	***2.50***
CO2 emissions	We consider 1 ton per year per capita (representing a little less than 20% of the world average which is estimated at $\left(\frac{36\,153}{7\,715}\right) = 4.68$ tons per year per capita in 2017).	No	***0.00***	***1.00***
Access to NICT	Value in percentage	Yes	***0.00***	***100.00***

Annex 3. Standardization (min-max coefficient)

a) For Nepal

	Open	*Diver*	*Qual*	*Rem*	*GDP*	*FDI*	*ODA*	*Gend*	*Life*	*Liter*	*Tax*	*Debt*	*Trans*	*Cred*	*NPL*	*Gov*	*CO_2*	*NICT*
2003	0.442	0.629	0.808	0.274	0.499	0.002	0.046	0.770	0.644	0.486	0.087	0.698	0.002	0.261	0.841	0.356	0.886	0.003
2004	0.461	0.636	0.796	0.278	0.515	0.000	0.038	0.807	0.650	0.501	0.090	0.707	0.002	0.271	0.861	0.350	0.895	0.004
2005	0.441	0.656	0.783	0.281	0.526	0.000	0.036	0.832	0.655	0.512	0.092	0.743	0.002	0.287	0.875	0.330	0.880	0.004
2006	0.448	0.664	0.817	0.284	0.537	-0.001	0.044	0.838	0.661	0.523	0.088	0.756	0.002	0.332	0.889	0.318	0.901	0.008
2007	0.446	0.669	0.793	0.288	0.550	0.001	0.047	0.845	0.666	0.535	0.098	0.784	0.002	0.373	0.905	0.358	0.900	0.011
2008	0.460	0.669	0.776	0.295	0.578	0.000	0.050	0.861	0.670	0.543	0.104	0.790	0.002	0.517	0.940	0.340	0.871	0.014
2009	0.471	0.660	0.784	0.301	0.598	0.003	0.063	0.872	0.675	0.550	0.118	0.807	0.003	0.592	0.965	0.310	0.838	0.017
2010	0.460	0.662	0.784	0.275	0.620	0.005	0.059	0.885	0.679	0.556	0.134	0.830	0.002	0.546	0.977	0.326	0.813	0.020
2011	0.418	0.662	0.807	0.259	0.634	0.005	0.059	0.890	0.683	0.561	0.133	0.842	0.002	0.530	0.968	0.320	0.798	0.079
2012	0.437	0.657	0.816	0.334	0.657	0.005	0.052	0.903	0.687	0.568	0.139	0.828	0.003	0.561	0.976	0.304	0.788	0.090
2013	0.481	0.657	0.810	0.397	0.676	0.004	0.059	0.912	0.691	0.596	0.153	0.840	0.003	0.580	0.971	0.314	0.763	0.111
2014	0.523	0.647	0.779	0.361	0.708	0.002	0.058	0.915	0.695	0.617	0.159	0.863	0.003	0.619	0.975	0.330	0.716	0.133
2015	0.531	0.643	0.764	0.344	0.723	0.002	0.089	0.921	0.699	0.627	0.167	0.860	0.003	0.647	0.979	0.290	0.770	0.154
2016	0.488	0.644	0.768	0.349	0.719	0.005	0.077	0.924	0.703	0.625	0.187	0.861	0.003	0.808	0.983	0.336	0.730	0.176
2017	0.520	0.630	0.721	0.378	0.767	0.008	0.089	0.925	0.707	0.656	0.210	0.868	0.003	0.798	0.983	0.324	0.720	0.197

b) For DR Congo

	Open	*Diver*	*Qual*	*Rem*	*GDP*	*FDI*	*ODA*	*Gend*	*Life*	*Liter*	*Tax*	*Debt*	*Trans*	*Cred*	*NPL*	*Gov*	*CO_2*	*NICT*
2003	0.540	0.327	0.917	0.450	0.296	0.044	0.267	0.751	0.521	0.524	0.040	0.428	0.000	0.008	1.130	0.194	0.981	0.001
2004	0.493	0.358	0.927	0.443	0.306	0.040	0.081	0.770	0.529	0.550	0.053	0.291	0.000	0.011	1.082	0.210	0.977	0.001
2005	0.523	0.383	0.841	0.436	0.315	0.015	0.075	0.786	0.537	0.572	0.059	0.493	0.000	0.012	1.042	0.186	0.973	0.002
2006	0.480	0.407	0.906	0.431	0.321	0.018	0.087	0.789	0.544	0.588	0.068	0.479	0.000	0.021	1.013	0.176	0.972	0.002
2007	0.801	0.414	0.752	0.425	0.330	0.108	0.045	0.793	0.551	0.612	0.070	0.566	0.001	0.026	0.971	0.150	0.970	0.003
2008	0.838	0.393	0.795	0.411	0.340	0.087	0.055	0.798	0.557	0.641	0.090	0.548	0.001	0.050	0.928	0.166	0.969	0.004
2009	0.629	0.401	0.648	0.419	0.338	-0.013	0.075	0.797	0.564	0.635	0.079	0.534	0.001	0.053	0.936	0.162	0.972	0.004
2010	0.907	0.395	0.550	0.359	0.350	0.127	0.104	0.803	0.569	0.673	0.084	0.840	0.000	0.037	0.941	0.152	0.969	0.006
2011	0.852	0.387	0.519	0.301	0.362	0.062	0.156	0.805	0.574	0.710	0.091	0.869	0.000	0.040	0.958	0.164	0.963	0.007
2012	0.684	0.360	0.453	0.268	0.375	0.099	0.079	0.810	0.579	0.750	0.117	0.884	0.000	0.048	0.957	0.170	0.965	0.012
2013	0.775	0.355	0.521	0.220	0.393	0.052	0.068	0.807	0.583	0.752	0.114	0.904	0.000	0.052	0.946	0.204	0.950	0.017
2014	0.787	0.338	0.514	0.310	0.416	0.042	0.061	0.820	0.588	0.765	0.108	0.916	0.001	0.057	0.931	0.188	0.937	0.022
2015	0.593	0.327	0.510	0.344	0.431	0.033	0.071	0.833	0.592	0.773	0.110	0.906	0.001	0.063	0.929	0.174	0.950	0.030
2016	0.596	0.330	0.511	0.351	0.427	0.022	0.056	0.845	0.596	0.770	0.100	0.903	0.000	0.074	0.932	0.198	0.950	0.038
2017	0.750	0.328	0.510	0.357	0.428	0.028	0.058	0.852	0.600	0.771	0.112	0.909	0.000	0.055	0.935	0.174	0.960	0.062

Annex 4. Correlation between the indicators

a) *For Nepal*

	Open	*Diver*	*Qual*	*Rem*	*GDP*	*FDI*	*ODA*	*Gend*	*Life*	*Liter*	*Tax*	*Debt*	*Trans*	*Cred*	*NPL*	*Gov*	*CO_2*	*NICT*
Open	1.000																	
Diver	0.518	1.000																
Qual	-0.750	-0.499	1.000															
Rem	0.797	0.380	-0.497	1.000														
GDP	0.765	0.302	-0.628	0.839	1.000													
FDI	0.334	0.362	-0.503	0.489	0.746	1.000												
ODA	0.782	0.416	-0.768	0.684	0.908	0.742	1.000											
Gend	0.628	-0.010	-0.472	0.755	0.945	0.649	0.797	1.000										
Life	0.706	0.166	-0.577	0.806	0.989	0.725	0.885	0.978	1.000									
Liter	0.817	0.302	-0.688	0.856	0.990	0.685	0.915	0.931	0.979	1.000								
Tax	0.768	0.421	-0.704	0.824	0.982	0.804	0.929	0.887	0.958	0.976	1.000							
Debt	-0.611	0.019	0.481	-0.704	-0.941	-0.686	-0.821	-0.985	-0.975	-0.924	-0.884	1.000						
Trans	0.783	0.234	-0.537	0.846	0.966	0.627	0.873	0.940	0.967	0.958	0.930	-0.926	1.000					
Cred	0.699	0.196	-0.657	0.744	0.952	0.759	0.920	0.926	0.964	0.945	0.946	-0.934	0.946	1.000				
NPL	-0.515	0.109	0.405	-0.626	-0.882	-0.699	-0.767	-0.959	-0.928	-0.847	-0.819	0.973	-0.885	-0.918	1.000			
Gov	-0.346	0.125	0.104	-0.462	-0.621	-0.417	-0.517	-0.723	-0.649	-0.573	-0.526	0.680	-0.654	-0.566	0.716	1.000		
CO_2	0.724	0.364	-0.528	0.830	0.970	0.755	0.835	0.901	0.946	0.940	0.957	-0.899	0.947	0.906	-0.846	-0.588	1.000	
NICT	0.777	0.482	-0.630	0.860	0.959	0.693	0.882	0.846	0.925	0.958	0.968	-0.828	0.920	0.877	-0.729	-0.505	0.942	1.000

a) *For DR Congo*

	Open	*Diver*	*Qual*	*Rem*	*GDP*	*FDI*	*ODA*	*Gend*	*Life*	*Liter*	*Tax*	*Debt*	*Trans*	*Cred*	*NPL*	*Gov*	*CO_2*	*NICT*
Open	1.000																	
Diver	-0.210	1.000																
Qual	-0.603	-0.367	1.000															
Rem	-0.521	-0.334	0.866	1.000														
GDP	0.342	0.614	-0.863	-0.692	1.000													
FDI	0.673	-0.370	-0.182	-0.269	-0.128	1.000												
ODA	-0.199	0.171	0.315	0.203	-0.452	0.060	1.000											
Gend	0.375	0.421	-0.811	-0.550	0.942	-0.124	-0.591	1.000										
Life	0.512	0.434	-0.939	-0.750	0.965	0.003	-0.489	0.951	1.000									
Liter	0.496	0.475	-0.955	-0.833	0.962	0.050	-0.447	0.907	0.986	1.000								
Tax	0.547	0.362	-0.926	-0.853	0.903	0.116	-0.520	0.863	0.954	0.974	1.000							
Debt	-0.568	-0.440	0.971	0.867	-0.903	-0.167	0.283	-0.835	-0.944	-0.967	-0.924	1.000						
Trans	0.195	-0.347	0.007	-0.045	-0.097	0.143	-0.087	-0.216	-0.061	-0.041	-0.010	0.047	1.000					
Cred	0.467	0.357	-0.856	-0.648	0.887	-0.031	-0.507	0.862	0.927	0.907	0.884	-0.828	0.184	1.000				
NPL	0.686	-0.038	-0.805	-0.593	0.736	0.192	-0.664	0.804	0.857	0.817	0.849	-0.761	0.255	0.891	1.000			
Gov	-0.614	0.630	0.188	-0.067	0.057	-0.505	0.165	-0.142	-0.137	-0.061	-0.123	0.124	-0.190	-0.140	-0.480	1.000		
CO_2	0.316	0.507	-0.769	-0.744	0.888	-0.089	-0.446	0.744	0.832	0.872	0.821	-0.828	0.241	0.805	0.673	0.189	1.000	
NICT	0.168	0.674	-0.607	-0.367	0.849	-0.300	-0.341	0.876	0.786	0.735	0.669	-0.664	-0.490	0.636	0.474	0.094	0.569	1.000

Annex 5. Sub-indices associated with each dimension for all years

Year	DR Congo					Nepal				
	Trade	**Socioeco**	**Fiscal**	**Financ**	**Spher**	**Trade**	**Socioeco**	**fiscal**	**Financ**	**Spher**
2003	55.9%	40.0%	23.4%	37.9%	39.2%	53.8%	40.8%	39.2%	36.8%	41.5%
2004	55.5%	37.9%	17.2%	36.5%	39.6%	54.3%	41.8%	39.9%	37.8%	41.6%
2005	54.6%	38.3%	27.6%	35.2%	38.7%	54.0%	42.7%	41.7%	38.8%	40.5%
2006	55.6%	39.1%	27.3%	34.5%	38.3%	55.3%	43.4%	42.2%	40.8%	40.9%
2007	59.8%	40.7%	31.8%	33.3%	37.4%	54.9%	44.1%	44.1%	42.7%	42.3%
2008	60.9%	41.3%	31.9%	32.6%	38.0%	55.0%	45.0%	44.7%	48.6%	40.8%
2009	52.4%	39.9%	30.6%	33.0%	37.9%	55.4%	46.0%	46.3%	52.0%	38.8%
2010	55.3%	43.8%	46.2%	32.6%	37.5%	54.5%	46.7%	48.2%	50.8%	38.6%
2011	51.5%	44.5%	48.0%	33.3%	37.8%	53.7%	47.2%	48.7%	50.0%	39.9%
2012	44.1%	44.9%	50.1%	33.5%	38.2%	56.1%	47.9%	48.3%	51.3%	39.4%
2013	46.8%	44.3%	50.9%	33.3%	39.0%	58.6%	49.0%	49.7%	51.8%	39.6%
2014	48.7%	44.9%	51.2%	33.0%	38.2%	57.7%	49.9%	51.1%	53.2%	39.3%
2015	44.3%	45.5%	50.8%	33.1%	38.5%	57.1%	51.0%	51.4%	54.3%	40.5%
2016	44.7%	45.3%	50.2%	33.5%	39.5%	56.2%	50.9%	52.4%	59.8%	41.4%
2017	48.7%	45.6%	51.1%	33.0%	39.9%	56.2%	52.5%	53.9%	59.5%	41.4%
Average	**51.9%**	**42.4%**	**39.2%**	**33.9%**	**38.5%**	**55.5%**	**46.6%**	**46.8%**	**48.6%**	**40.4%**
Minimum	**44.1%**	**37.9%**	**17.2%**	**32.6%**	**37.4%**	**53.7%**	**40.8%**	**39.2%**	**36.8%**	**38.6%**
Maximum	**60.9%**	**45.6%**	**51.2%**	**37.9%**	**39.9%**	**58.6%**	**52.5%**	**53.9%**	**59.8%**	**42.3%**

Annex 6. STATA Commands[13]

a) Graph	. line [name of variable] Year
b) Scatter and correlations	. scatter [name of variable 1] [name of variable 2] || lfit [name of variable 1] [name of variable 2]
c) Interpolation	. ipolate [name of variable], generate (New name) epolate
d) Convert to quarterly data	. isid year . expand 4 . by year, sort: gen month = 3*_n . gen quarterly_date = qofd(mdy(month, 1, year)) . format quarterly_date %tq . replace [name of variable]= . if inlist(month, 3, 9, 12) . ipolate [name of variable] quarterly_date, epolate generate (New name)
e) Preliminary tests PCA	. factortest [names of variables]
f) Principal components analysis	. corr [names of variables] . pca [names of variables] . screeplot, yline(1) ci(het) . pca [names of variables], component [(pc retained)] . rotate

[13] the brackets are excluded if we want to apply the commands