

# On the Dynamic of Country Development

Onialisoa Mirana Rakotoarivelo<sup>1</sup> & Hanitriniaina Sammy Grégoire Ravelonirina<sup>1</sup>

<sup>1</sup> Department of Mathematics and Computer Science, Faculty of Sciences, University of Antananarivo, Madagascar

Correspondence: Hanitriniaina Sammy Grégoire Ravelonirina, Department of Mathematics and Computer Science, Faculty of Sciences, University of Antananarivo, Madagascar. E-mail: rhsammy@yahoo.fr

Received: January 7, 2019 Accepted: February 11, 2019 Online Published: February 20, 2019

doi:10.5539/jmr.v11n2p1

URL: <https://doi.org/10.5539/jmr.v11n2p1>

## Abstract

In this work, we study the dynamics of the development of a country  $P$ . We find that this dynamic is governed by forces called development forces. There are three different types: natural force, exterior force, and interior force of development. They all have three components: human, economic and political. Depending on the intensity of these three forces, the resilience to natural and negative exterior forces, the level of development of  $P$  varies between two consecutive periods. This study allows us to conclude that development relies essentially on the interior force.

**Keywords:** development, development's forces, dynamical system, resilience

## 1. Introduction

Development is a very wide concept with many aspects. Todaro (1977) supported that development is concerned with the economic and political processes necessary for affecting rapid structural and institutional transformation of entire societies in a manner that will influence more economic progress to the broadest segments of their populations. The French economist (Perroux, 1961) argued that the aspects of development of a country are social, technical and infrastructures, economic and cultural. Sen (1999b) defines development as freedom, a suitably broad definition that incorporates not only economic indicators but also freedoms like human and political rights, social opportunities, transparency guarantees and protective security. These different definitions of a country's development show that development is a change of society towards better conditions and is based on economic, social and political aspects. Yet these conditions are subjected to different forces which can alter considerably in positive or negative ways the economy, social and political situation of one given country  $P$ . These forces are first the result of its geographical, geological and climatic situation and which leads to natural disasters. Second, they can come from other either countries or partners or international organizations, during this study we consider sanctions. And they can even be a force from the country itself viewed by its economic, social and political situation.

Natural disasters are the result of the interaction between natural hazards (floods, earthquakes, tsunamis, volcanic eruptions, ...) and social systems (cities, schools, hospitals, roads, ...). Impacts of natural disasters depend on the vulnerability and resilience of a society. Nowadays the losses caused by natural disasters keep increasing (Mileti & Joseph Henry, 1999). That can become a real drag on a country's development, according to Mark Malloch Brown, (Rapport mondial, 2004), natural disasters exert considerable pressure on development (Note 1). They significantly reduce the chances of achieving the Millennium Development Goals, and in particular halve extreme poverty by 2015. The global economic loss caused by natural disasters was more than US \$ 1.8 trillion between 1995 and 2015, and US \$ 262 billion in Europe alone (CRED & UNISDR, 2015). Stephane Hallegatte even advances the idea that natural disasters plunge 26 million people into poverty (Note 2). According to him, if there were no natural disasters for a year, the population living below the poverty line would be reduced by 26 million out of a total of 700 million people currently.

Similarly, sanctions hinder the growth and development of a country  $P$ . Employed first in 1919 by the U.S. President Woodrow Wilson during his speech in Indianapolis, sanctions are used since the early 1960s to project power or influencing another government's behavior without resorting to military conflict, to destabilize a hostile regime and hasten its demise instead of deploying force to target country to withdraw its troops from border skirmishes and desist from military adventures. Since then, several other foreign policy goals have been pursued, including efforts to protect human rights and promote democracy, stem nuclear proliferation, and fight international terrorism (Hufbauer, Schott, & Elliott, 1999a). According to the sanctions literature, the cost of sanctions against a target country is supposed to result in maximum economic damage in order to coerce the target state to alter its policies in favor of the sender states (Hufbauer, Schott, Elliott, & B. Oegg, 2007 and Dizaji & van Bergeijk, 2013). (Neuenkirch & Neumeier, 2015a) found that on average, the imposition of UN sanctions decreases the target state's annual real per capita GDP growth rate by more than 2 percentage points (pp) and about 13.4% declines in GDP (Note 3). Their effects do not stop with the economic recessions but also on

humanitarian crisis and a serious social impoverishment (Allen & Lektzian, 2013; Garfield & Santana, 1997 and Daponte & Garfield, 2000).

Finally, every country, whatever the type of the country's regime, either aristocratic or democratic or autocratic, has always its leaders. By their action, these leading people shape political, human and economic situation. Leaders can improve the situation like the case of some Asian countries as well as worsen it like the case of many African countries. On one hand, the impressive economic success achieved by the East Asian newly industrializing countries (NICs)-Taiwan, South Korea, Singapore and Hong-Kong since the 1960s is due to the role play by the state (Gore, 1996), macroeconomic performance, political and institutional stability (Jaffrelot, 2008), public investment in infrastructure and human capital, the strategy of external openness, growth driven by exports, the competitive market of factors of production, the flexibility of economic policies and the speed of adjustment to external shocks (World Bank, 2008), a high level of schooling, a relatively egalitarian income distribution and a demographic transition early. On the other hand, there are many African countries struggling to get out of poverty traps and misery. Africa faces many problem: human and social (the high youth unemployment rate, the prevalence of precarious (UN Commission ?conomique pour l'Afrique, UNEP et FAO, ONUDI, & UNDP, 2015); low quality education of public school, health system problem (IFC, 2016), food insecurity and undernourishment, (Banque Africaine de Développement, & UNDP CEA, 2017), economic (the weight of debt, mismanagement of the economy and unsustainable external debt, manufacturing decreasing, (Zamfir, 2016) and politic (military conflicts, institutional weaknesses, the effects of insecurity and political uncertainty, (UNISDR, 2008).

Despite of the complexity of development itself, all of these situation show that many forces can impact development's level. Then we have two questions: what are forces that influence the development's dynamics of one country? And how they impact development's level? We hypothesize that there are different types of forces which governs development and that they impacts it negatively or positively. To answer these questions, the paper is structured as follows: section two introduces the different types of development forces. Section three discusses the links between development and these different forces. Then Section four establishes one development equation. And finally the last section is about Discussion and Conclusion. We adopt different method during the elaboration of this theory: documentation, inductive method and the theory of dynamical system.

The first section introduces development forces and their characteristic.

## 2. Development Forces

Let's assume  $P$  a country.

**Definition 1** We denote by **development force** all action which can increase or decrease the development's level of  $P$ .

**Proposition 2** There are three types of development forces: **natural force**  $N$ , **negative exterior force**  $E$  and **interior force**  $I$ .

*Proof.* Let  $P$  be a country. Firstly  $P$  is located on the globe, it is exposed to all the natural hazards that results from its geographical, geological and climatic condition. Hence the existence of the natural force manifested by the hazards conditioned and the vulnerability of  $P$  which leads to natural disasters. Secondly, there are more than 180 countries in the world. These countries interact with each other through trade, partnerships, bilateral and/or multi-lateral relations, conventions, Charters and agreements. These different relationships produce power struggles and interdependencies between countries. Failure to respect these agreements leads to sanctions from signatory countries and/or International Organizations. Thus, if we consider two countries  $P$  and  $P'$ ,  $P'$  can start actions against  $P$  which can affect badly the economic, social and political status of  $P$ . Hence the existence of negative exterior force of  $P$  from foreign countries. And third, the economic, political and social situation of  $P$  are the results of the leading way of the established regime. Hence the existence of the interior force of  $P$ .

First, let's see the characteristics of the **natural force**.

### 2.1 Natural Force

**Definition 3** Hazards (geophysical, atmospheric, or hydrological event, rainfall, tropical storms, flooding, and earthquake) are events triggered by natural forces, but they only turn into disasters if people are exposed to the hazard and are not resilient to fully absorbing the impact without damage to life or property causing substantial damages, disruption, and perhaps casualties and leaving the affected communities unable to function normally. A disaster implies some combination of losses, in human, physical, and financial capital, and a reduction in economic activity such as income generation, investment, consumption, production, and employment in the real economy, (Behrman & Srinivasan, 1995). Natural disasters is also the product of the combined effects of the intensity of the hazards and the social vulnerability (O'Keefe, Westgate, & Wisner, 1976).

**Definition 4** Let  $P$  be a country. A **natural force** of  $P$  is a set of hazards conditioned by the geographical, geological,

biological and meteorological situation that alter the three components of development (human, economic and politic (Rakotoarivelo & Ravelonirina, 2017).

**Proposition 5** The natural force of P is mainly composed by hazards.

*Proof.* Immediate according to the Definition 4.

Globalisation makes all countries interconnected, interlinked and interdependent. These interactions usually come from different agreements like political, economic, military, trade, . . . This leads to the weakness and vulnerabilty of some countries on foreign country. Let’s see the **negative exterior force**.

2.2 Negative Exterior Force

In the literature, scholars distinguish two types of sanctions used in international relations: positive and negative sanctions. Positive sanctions take the form of actual or promised rewards (humanitarian aid, tariff’s reduction or tariff’s abolition and so on) whereas negative sanctions are the use or threatened use of punishments.

In this paper, we consider only the negative sanctions.

**Definition 6** US President Woodrow Wilson defines a country’s sanctions as a peaceful, silent and deadly remedy that no nation can resist. Sanctions involve several actions such as tariffs, export controls, import restrictions, travel bans, freezing assets, reduction or removal of foreign aid and severing of diplomatic relationships (Allen, 2008). To sanction one country P is to interrupt diplomatic and/or economic relations (Garfield, Devin, & Fausey, 1995).

**Remark 1** - The expressions "sender" and "target" denote respectively "the country that imposes sanctions and the country that receives the economic punishment", (Caruso, 2003).

- If the sanctions are enacted by one state, then we speak of **unilateral sanctions** and if they are taken by several states or by a regional or international organization, they are said to be defined by **multilateral sanctions**.

There are different types of sanctions according (Garfield et al., 1995): **economic sanctions**; **financial sanctions**: restrictions on the funding of the target country, direct payments investment restrictions, restrictions (or control) relating to banking transactions; **trade sanctions**: embargo, boycott, blocus; **smart sanctions**; **advertising sanctions**: sportive sanctions, cultural sanctions and **diplomatic sanctions**.

According to (Eyler, 2007), sanctions obey this following diagram (cf. Figure 1) :

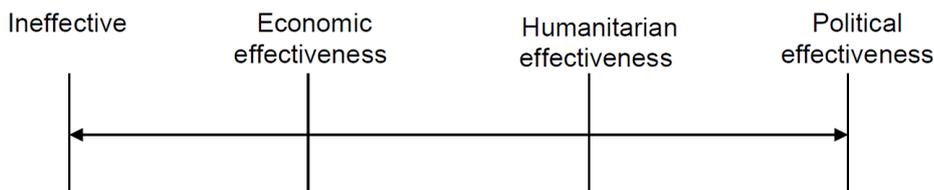


Figure 1. Sanction time-line and sanction effectiveness continuum

Note. This figure is from (Eyler, 2007). It shows that any sanction aims at touching and modifying the policy adopted by the sanctioned country. But to reach that point, it goes through economic and human repercussions.

**Definition 7** Given P a country and P' another country or an organization (Note 4). A **negative exterior force of P** is all actions made by P' toward P which have negative effects which produce negative effects on all three components of a P sanctioned country development.

**Proposition 8** The negative exterior force of P is the combination of sanctions from P'.

*Proof.* Immediate from the Definition 7.

The negative exterior force does not take into account if the sanctions are effective or not (Note 5). It measures all the impacts on the human, economic and political caused on the target country P.

Every country have its own force, let’s see the characteristic of **interior force**.

2.3 Interior Force

**Definition 9** (Rakotoarivelo & Ravelonirina, 2017) A **determining factor** is a sector and/or pillar area of the development as well as of the non development of a country.

**Definition 10** Given a country  $P$ . An **interior force** of  $P$ , all sectors and/or area on which the development of  $P$  relies on.

**Proposition 11** Interior force is composed by the ten determining factors and is subdivided into three groups: **human force, economic force and political force**, (Rakotoarivelo & Ravelonirina, 2017).

*Proof.* Obvious from the Definition 10.

Natural and negative exterior forces are not from  $P$ , then  $P$  can have the capacity to resist and to minimize their effects. We define this capacity as **”resilience”**.

#### 2.4 Resilience

Holling 1973, first described resilience as a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables. In operationalizing the concept of regional economic resilience, (Hill, Wial, & Wolman 2008), argue that resilience is the ability of a region . . . to recover successfully from shocks to its economy that either throw it off its growth path or have the potential to throw it off its growth path but do not actually do so. If applied to economic sanctions, this definition would only label a target state resilient if it were able to bounce back to the level of economic output and stability it experienced prior to the actual imposition of a given sanctioned regime.

The following section studies the link between these forces and the development.

### 3. Link Between Development and Development Forces

#### 3.1 Natural Force

Let  $N_t$  denotes the value of the natural force between two periods  $t$  and  $t + 1$ .

**Proposition 12** If the intensity of hazard is high (resp. low), then the value of the natural force is also high (resp. low).

*Proof.* Natural force is principally composed by hazards and so if the intensity of hazards varies then the value of natural force change as well.

**Proposition 13** Between two periods  $t$  and  $t + 1$ , the higher (rep. lower) the human, economic and politic damages caused by a natural force, the more (rep. less) the development of a country is affected.

*Proof.* This proof is divided in three parts, we assess the impacts in three components: human, economic and politic.

*Human components:* Disasters are antithesis of human development, (Baez, de la Fuente, & Santos, 2010). In fact, first, natural force kills around 60,000 people die worldwide from EM-DAT dataset (Note 6). Second, it affects education: destruction of infrastructure, loss of personal (De Janvry, Finan, Sadoulet, & Vakis, 2006 and Petal, 2008) and it has many consequences on both children and adults healths due especially from water which cause many disease or epidemic: malaria, diarrhea, dengue fever, cholera, typhoid, dysentery, diarrheal illnesses and yellow-fever (Shone, 2002; Alderman, Hoddnott, & Kinsey 2006; Cheng & Zhou, 2007; Campanella, 1999; Wade, 2002 and Vos, 1999). Last, it affects income and leads to household income constrains as it causes disruption of economic activities, (Baez, de la Fuente, & Santos, 2010).

*Economic components:* The principal impacts of natural force on economy is that it leads on average to negative effects on GDP. It is due to the destruction of capital stock and the disruption of economic activities and production, (Hochrainer, 2009a, 2009b; Benson & Clay, 2004, and Charvériat, 2000). Moreover, the reconstruction after an intense hazard affects public revenue, (Benson & Clay, 2004).

*Political components:* Natural force have indirect effects on politic. Indeed, depending on the way on how government manage (failure or successful) disaster have political effects on the government measured as political support during the next elections (Uslaner & Yamamura, 2016; Dodds, 2008, 2015; Brändström, 2016, and Bytzeck, 2008). And so, this can increase the risk of anti-government domestic political activities, anti-government demonstrations, riots, revolutions, intrastate conflict, (Choudhury, 2013).

**Theorem 14** Between  $t$  and  $t + 1$ , if the value of natural force increases  $N_t$ , therefore the development level  $D_t$  decreases

$$N_t = \frac{n_t}{D_t} \tag{1}$$

where  $n_t$ : intensity of hazards between  $t$  and  $t + 1$ ,  $n_t \in [0, 10]$ .

*Proof.* According to Proposition 13, the development level is inversely proportional to the value of  $N_t$ . So we choose one function which satisfied this condition.

**Example 1** Here are some illustrative examples about the impacts of natural force on development. First in Mozambique, World Bank has constructed 487 schools over 20 years, but more than 500 schools are destroyed by floods in 2000, (UNDP, 2008). Second, Malawi experienced fiscally chaos, in the period of the two droughts in the early 1990s, there was increase of 23 percent of the deficit, declined of GDP, increase of 30 percent of expenditure between 1992-1993 and 1994-1995), decrease of revenue (9 percent in 1992-1993 and again 11 percent in 1993-1994 ). Third (Benson, Twigg, & Rossetto, 2007), studied the impacts of natural disasters on poverty and found these results: in El Salvador, the two earthquakes in 2001 led to an estimated 2.6-3.6 per cent increase in poverty. In Honduras, the percentage of poor households increased from 63.1 per cent in March 1998 to 65.9 per cent in March 1999 as a consequence of Hurricane Mitch in October 1998. In Aceh, Indonesia, the 2004 tsunami is estimated to have increased the proportion of people living below the poverty line from 30 per cent to 50 per cent. During the 2011 earthquake and tsunami in Japan, scholars identified decreasing levels of trust in government following the disaster (Uslaner & Yamamura 2016).

Fourth, we see the case of Honduras in Figure 2

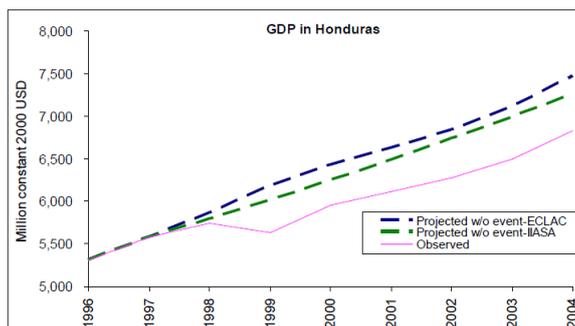


Figure 2. Observed GDP in Honduras with events vs. projected growth without events

Note. This graph is from (Zapata, 2008; World Bank, 2007). Zapata (2008) uses a model based projection, IIASA projects growth statistically based on pre-disaster observed GDP to make this prediction. And this show, how disaster can alter the GDP.

### 3.2 Negative Exterior Force

Let  $E_t$  denotes the value of the negative exterior force between  $t$  and  $t + 1$ .

**Proposition 15** *If the intensity of the sanctions is high, then the value of the negative exterior force is also high.*

*Proof.* Immediate because negative exterior force is mainly composed by sanctions.

**Proposition 16** *If negative exterior force increases, thus the politic, economic and human components level decrease.*

*Proof.* This proof is divided in three parts, we assess the impacts in three components: human, economic and politic.

*Economics components:* Negative exterior force as sanctions aim to induce maximum economic damage in order to coerce the target state to modify its policies in favor of the sender states (Hufbauer et al., 2007 and Dizaji & van Bergeijk, 2013). And so, it inevitably causes adverse economic outcomes on national currency, poverty, GDP, trade, government consumption, employment and increase inflation (Peksen & Son, 2015; Neuenkirch & Neumeier, 2015a, 2015b; and Peksen & Drury, 2010).

*Human components:* Negative exterior force causes indirectly many humanitarian impacts especially embargo and blocus. In (Garfield, Devin, & Fausey, 1995; Garfield & Santana, 1997; and Gibbons & Garfield, 1999) we find that sanctions are correlated with more humanitarian problems. Others like (Ali Mohamed & Shah, 2000; Daponte & Garfield, 2000; Heine-Ellison, 2001; Neuenkirch & Neumeier, 2016) find that it induces infant mortality and reduces life expectancy. These effects are due to shortage in supplies and commodities necessary to subsistence and in health system due to the restriction in import, export and the withdrawal of foreign and aid ( Hufbauer et al., 2007 and Heine-Ellison, 2001). The imposition of sanctions increases state-sponsored repression and suggests that these sanctions contribute to worsening humanitarian conditions of the civilian population, (Wood, 2008).

*Political components:* Economic sanctions may cause more violence, oppression, restriction in the target country, deteriorating democratic freedom and civil rights, (Peksen & Drury, 2010) and worsen human rights conditions in the target country, (Drury & Li, 2006; and Peksen & Drury, 2009). Economic sanctions also lead to political instability in sanctioned

country by destabilizing the target leadership, (Marinov, 2005) and inciting more violence in the forms of protests and riots against the established regimes, (Allen, 2008; Peksen & Drury, 2010). (Thyne 2006), found that diplomatic statements criticizing the target alone can signal support for opposition groups within another country. (Allen 2008), showed that foreign economic pressure, especially against more democratic states, increases the level of violent and anti-violent protests against the government.

**Theorem 17** Between  $t$  and  $t + 1$ , if the negative exterior force value  $E_t$  increases, thus development level decreases  $D_t$ . So

$$E_t = \frac{e_t}{D_t} \tag{2}$$

where  $e_t$ : intensity of sanctions between  $t$  and  $t + 1$ ,  $e_t \in [0, 10]$ .

*Proof.* According to Proposition 16, between  $t$  and  $t + 1$ , the development level is inversely proportional to the value of  $E_t$ . So we take one function which completes this condition.

**Example 2** First for Iran, sanctions led to: 9% of decreasing in GDP in the two year sending March 2014, declination about 56% of Iranian Rial from January 2012 to January 2014, acceleration of inflation between 50% and 70% during 2011-2013, (Lew & Jacob, 2016). Secondly for Cuba sanctions induced: decrease in GDP from 35% to 50%, decline of exports and imports by 80% and 73% respectively within that same timeframe, fall from 70% in 1989 to less than 30% in 1993 in the use old installed capacity, (ECLAC, 2001).

And finally, Figure 3 shows impact of the duration of sanctions:

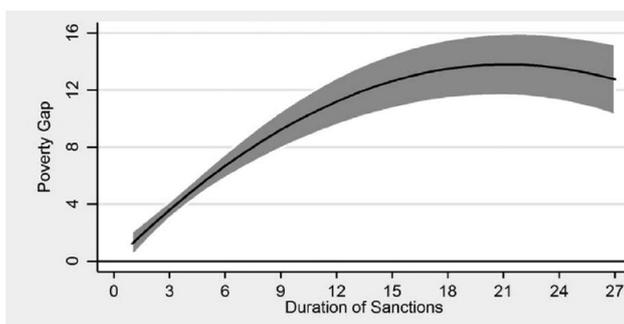


Figure 3. Impact of sanctions on poverty over time

Notes: This figure is from (Neuenkirch & Neumeier , 2016). It depicts the impact of US sanctions on the poverty gap over time. The shaded areas represent 95% confidence intervals.

### 3.3 Interior Force

Let  $I_t$  denote the value of the interior force between  $t$  and  $t + 1$ .

**Proposition 18** If interior force increases, thus the human, economic and politic components level increase.

*Proof.* According to Proposition 11, we see that interior force is composed by these three components.

**Proposition 19** At time  $t$ , if development interior force is high, then interior force's value  $i_t$  increases, and the development level increases.

*Proof.* As interior force is composed by three components, we then evaluate its intensity according them:

*Human components:* We evaluate human force on four levels: education, health, employment and culture. Firstly, (Bils & Klenow, 2000 and Hanushek & Kimko, 2000) find a positive correlation between a quality of education and economic growth; (Townsend, 2000) finds that it is the key issue to improve living standards and reduce social, income inequality and poverty. Secondly, health is essential to economic growth because it leads to improvements in income and have a positive impacts development, as can see from these different works (Workd Health Organisation, 1996 and Bils & Klenow, 2000). Thirdly, (Seyfried, 2005; Boltho & Glyn, 1995 and Swane & Vistrand, 2006) find that there is a relationship between employment, economic growth and it reduces poverty, (Islam, 2004 and Hull, 2009). Lastly, culture leads to development because it is a vehicle for economic development and social cohesion, (UNESCO, 20014).

*Economic components:* We assess the links between economic force and development by: economic growth, agriculture, infrastructure, industrialization and international trade. First, some scholars find that economic growth reduces poverty (DFID, 2007; Adams, 2002 and Ravallion & Chen, 1997) and drives to human development, in (Sen, 1996). Second, agriculture have many impacts on development it: leads to growth (Adelman, 2001) and GDP growth (Felbermayr & Gröschl, 2014 and World Bank, 2008), reduces poverty, (Timmer, 2002; Thirtle, Lin, & Piesse, 2003 and Christiaensen & Demery, 2007), stabilizes domestic food production and enhances food security, (Barro & Sala i Martin, 1995). Third, infrastructure reduce poverty in (Donaldson, 2009) and is strongly associated with improved human development (Bergasse, Paczynski, Dabrowski, & Dewulf, 2013; Straub & Terada-Hagiwara, 2010 and Seethepalli, Bramati, & Veredas., 2008) find a close relationship between infrastructure and economic growth. Fourth, international trade play an important role in development because it: reduces poverty (Mohsin, Kemal, & Qadir, 2001), improves growth rate, (Behrman & Srinivasan, 1995), and is strongly linked to economic performances (Greenway, Morgan, & Wright, 2002 and Waczaairg, 2001). Last, there is a significant association between the level of national income per head and the degree of industrialization, (Sutcliffe, 1971).

*Political components:* Scholars like (Rodrik, 1999; Acemoglu, Johnson, & Robinson, 2001; Acemoglu, Johnson, Robinson, & Thaicharoen, 2003 and Kaufman, 2005) by their work find that institutional factors are the fundamental factors for better countries' economic performance. The effects of politic in development is evaluated first on corruption. It affects the lives of people and their development, (World Bank, 2001) and leads to income inequality, (Gupta, Davoodi, & Terme, 1998). It also restrains economic growth (Mauro, 1995), increases poverty (Chetwynd, Frances & Spector, 2003), reduces investment levels and limit a country's ability to effectively respond to exterior shocks, (Rodrik, 1999), weakens political institutions and mass participation in good governance, (Johnston, 2000). Second, we measure it by political instability. It has negative effects on GDP growth, reduces private investment, and induces short term inflation (Roy & Hossain, 2013; Alesina, Özler, Roubini, & Swagel, 1996 and Polachek & Sevastianova, 2010).

**Theorem 20** So between  $t$  and  $t + 1$ , we have:

$$I_t = i_t D_t \quad (3)$$

where  $i_t$ : value of determining factors  $f_j$  between  $t$  and  $t + 1$ ,  $j \in \{1, \dots, 10\}$ ,  $i_t \in [-10, 10]$ .

*Proof.* From Proposition 19, we can deduce that development is proportional to the value of  $I_t$ . Hence the equation.

**Example 3** Interior force with positive value: China has lifted over 450 million people out of poverty since 1979, this is due to the rapid economic growth between 1985 and 2001, (Lin, 2003). Mozambique records also rapid reduction in poverty associated with growth over a shorter period. From 1996 to 2002, the economy grew by 62 per cent and the proportion of people living in poverty declined from 69 per cent to 54 per cent, (Arndt, James, & Simler, 2006). And for interior force with negative value: political instability is one of cause which can lead to negative value of this force. Political instability has direct impacts on economy, (Fosu, 1992) when studying Sub-Saharan Africa countries found that it causes more than 33 percent decrease of GDP growth over the 1960-1986 period. Also (Alesina et al., 1996) find a very robust relation between political instability and GDP per capita growth while studying 113 countries for the period 1950-1982.

The last section is about the dynamic of development.

## 4. Equation of Development

### 4.1 Value of the Natural Force

The natural force is composed of several different hazards and each of them have their own scale of measurement, they must be normalized on the same scale so that we can evaluate and compare them by the value of the parameter  $n_t$ . For doing so, we categorize the hazards using 0 to 10 scale.

#### 4.1.1 Value of the Intensity

We use scale according to the type of hazards to measure their value:

- Earthquake: we use the Richter scale to measure it.
- Cyclone, Typhoon, Hurricane: we measure them according to the velocity of the wind and to the cyclonic basins of the ocean.
- Tsunami: we use the classification of the scientists Imamura (1949) and Iida (1970).
- Volcano: we use the VEI (Volcanic Explosivity Index) scale.
- Drought: the Standardized Precipitation Index (SPI) is used here to measure drought (Appendix, Table A1).

### 4.1.2 Value of the Resilience

To classify countries according to their resilience, we use the classification made by GOAL (Note 7) (Appendix Table A2). According to this classification, we adopt the value of the resilience to the natural force  $r_{n_t}$  as follow:

- If  $P$  is a country with minimal resilience then  $0 \leq r_{n_t} \leq 2$ .
- If  $P$  is a country with low resilience then  $2 < r_{n_t} \leq 4$ .
- If  $P$  is a country with medium resilience then  $4 < r_{n_t} \leq 6$ .
- If  $P$  is a resilient country  $6 < r_{n_t} \leq 8$ .
- If  $P$  is a country with high resilience then  $8 < r_{n_t} \leq 10$ .

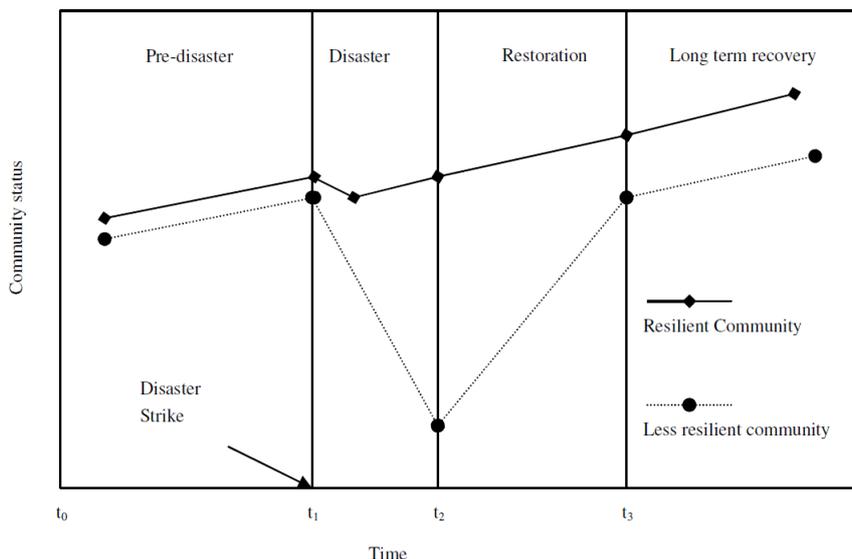


Figure 4. A hypothetical trajectory of resilient and less resilient community (Modified from Zhang, 2006)

Note. This figure is from (Mayunga, 2007). It represents two trajectories of communities over time through four phases, pre-disaster, disaster, restoration, and recovery. It shows that more resilient country experienced less disaster impacts and short term recovery. Whereas, less resilient country take more time for recovering. The other category of resilience is between these two levels.

### 4.2 Value of Negative Exterior Force

#### 4.2.1 Value of the Intensity Negative Exterior Force

We evaluate the value of the negative exterior force as follows (cf. Table 1):

Table 1. Value of negative exterior force

Sanction	Value of $e_t$
Advertising sanctions	2
Diplomatic sanctions	1
Financial sanctions	3
Smart sanctions	1
Trade sanctions	3

The value of  $n_t$  is the sum of the different sanctions used by senders to the target country.

#### 4.2.2 Value of the Resilience

To evaluate the resilience to negative exterior force noted  $r_{e_t}$ , which is the capacity of the targeted country to offset especially goods, products restricted and financial losses, and to continue the economy activity (export and imports), we adopt the following classification (cf. Table 2):

Table 2. Value of resilience to negative exterior force

Percentage of loss covered or substituted by $P$	Value of $r_{e_t}$
0% to 20%	$0 < r_{e_t} \leq 2$
20% to 40%	$2 < r_{e_t} \leq 4$
40% to 60%	$4 < r_{e_t} \leq 6$
60% to 80%	$6 < r_{e_t} \leq 8$
80% to 100%	$8 < r_{e_t} \leq 10$

**Example 4** In 2014, Iran’s Supreme Leader Ayatollah Khamenei proclaimed that the government would “turn every threat into an opportunity ...”. And so Iranian diverted trade products (exports non-oil products) and established new relationship in markets (Asia, Africa and Latin America). In 1994, Cuba began resilient to sanctions by growing and diversifying its imports and exports markets (ECLAC): exports rise from 10% in 1990 to 37% in 1997.

#### 4.3 Value of Interior Force Intensity

The interior force is mainly composed of the ten determining factors  $f_j, j \in \{1, \dots, 10\}$  and the Table A4 (Appendix), shows the components of each  $f_j$ .

**Remark 2** The component with the sign “+” indicates that this component increases the level of development whereas “-” diminishes it.

To calculate the value of the intensity of the interior force, each component of each determining factors is evaluated on percentage (%). After, we use the following formula:

$$\mathcal{V}_t(f_j) = \frac{\sum_{k=1}^{n_j} n_k^t}{n} \tag{4}$$

where  $f_j$ : determining factor,  $j \in \{1, \dots, 10\}$  and  $n_j = \text{card}(c_j^k)_t, c_j$  the  $k^{\text{th}}$  components of the  $j^{\text{th}}$  determining factor between  $t$  and  $t + 1$ , and  $n_k^t$ : the percentage of  $c_j^k$  between  $t$  and  $t + 1$ .

If the components  $c_j$  have a sign (-), then its value is multiplied by (-). And if the value of  $c_j$  preceded by sign (+) is negative, then  $c_j$  is also negative.

And we compute the value of the interior force, by using the formula:

$$n_t = \frac{\sum_{i=1}^{10} \mathcal{V}_t}{10} \tag{5}$$

These following components are exceptions, because they do not have data on percentage. And so, we have to convert them:

- Strong diplomacy: regional integration, international integration, number of ambassador discharged, deal win-win, deal satisfying international norms and condition. We take 100% the number of all regional and international organization, then the value of regional and international of  $P$  depends to the number(%) of regional and international integrated by  $P$ .
- Good governance: WGI Worldwide Governance Indicators by the World Bank in a scale of -2.5 to 2.5, we convert this index into percentage by adopting the following value, -2.5 corresponds to 0% and 2.5 to 100%.
- Liberty: we use the index Human Freedom Index by Cato Institute, on a scale of 0 to 10. We convert this scale by the following conversion, 0 corresponds to 0% and 1 to 100%.
- Rule of law: Rule of law index by WJP on a scale of 0 to 1 (1 strongest adherence to the rule of law). We convert this by the following conversion, 0 corresponds to 0% and 1 to 100% (Note 8).
- Culture: annual rate of daily newspaper variations (%), number of literary books (% of total), number of literary books (% of total), (Appendix Table A4), all of this indicators are from (UNESCO, 2014).
- Innovation: Global Index of Innovation by Cornell University, INSEAD and WIPO (Note 9).

It can be seen that variation in the intensity of the interior force influences the development of a country the most. Thus, the mastery of this force is essential for the development.

#### 4.4 Equation of Development With Negative Sanction

**Theorem 21** The development level of a country  $P$  at  $t + 1$  depends on the level reached at time  $t$  and the value of the three development forces between  $t$  and  $t + 1$ . So we have the following equation:

$$D_{t+1} = D_t + \text{Value(Interior Force)} - \text{Value(Natural Force)} - \text{Value(Negative Exterior Force)} + \xi(t) \tag{6}$$

Then, we have

$$D_{t+1} = D_t + I_t - N_t - E_t + \xi(t) \tag{7}$$

where  $\xi(t)$  is a "noise" term.

NB: Noise can come from another force or phenomena that are not predicted by the deterministic model, or it can from the irregularity, unpredictable development process or by observational process.

*Proof.* The development at time  $t + 1$  depends on its level at  $t$  and the value of development's forces. Thus, we have

$$D_{t+1} = D_t + \text{Value(development's forces)} \tag{8}$$

We add the noise term  $\xi(t)$  to measure all of unpredictable phenomena which affect development apart of theses forces. And according to Theorems 14, 17 and 20, we find that development is pushed downward by natural and negative exterior forces and pushed upward by interior force. So, the equation (8) becomes

$$D_{t+1} = D_t + \text{Value(Interior Force)} - \text{Value(Natural Force)} - \text{Value(Negative Exterior Force)} + \xi(t)$$

$$D_{t+1} = D_t + I_t - N_t - E_t + \xi(t)$$

**Theorem 22** *So the equation (6) becomes*

$$D_{t+1} = D_t + i_t D_t - \frac{n_t}{D_t} - \frac{e_t}{D_t} + \xi(t) \tag{9}$$

Considering the natural and exterior resilience capacity, we obtain the final equation:

$$D_{t+1} = D_t + i_t D_t - \frac{(n'_t - r_{n_t})}{D_t} - \frac{(e'_t - r_{e_t})}{D_t} + \xi(t) \tag{10}$$

where  $i_t$ : the value of determining factors between  $t$  and  $t + 1$ ,

$n'_t$ : the value of hazards between  $t$  and  $t + 1$ ,

$r_{n_t}$ : the value of resilience to hazards between  $t$  and  $t + 1$ ,

$e'_t$ : the value of sanctions between  $t$  and  $t + 1$ ,

$r_{e_t}$ : the value of resilience to sanctions between  $t$  and  $t + 1$ ,

$b_t = b'_t - r_{n_t}$  and  $e_t = e'_t - r_{e_t}$ ,

$\xi(t)$ : the noise.

*Proof.* The deterministic part of the equation (9) is obtained by using equations (1), (2) and (3). Also for the equation (10), is got by using the principle that the resilience reduces the impacts of natural and negative exterior forces. And then we add the noise term in both equations (9) and (10).

**Corollary 23** *The development level of P at t + 1 increases (resp. decreases, in equilibrium) if the interior force produced is greater (resp. lower, equal) than the sum of natural and negative exterior forces.*

*Proof.* Immediate according to the equation (6).

**Remark 3** If between the period  $t$  to  $t + 1$ , there is no natural force and/or the negative exterior force  $E_t$ , then  $n_t = r_{n_t} = e_t = r_{e_t} = 0$ . And if between this period there are more than one hazards or sanctions, then we add up their values.

In the following, we focus only on the deterministic part of the equation. And let denotes by  $f$  the function associated to the equation  $D_{t+1} - D_t = 0$ .

**Theorem 24** *If  $i_t > 0$ , so  $D_{t+1}$  increases between two consecutive periods  $t$  and  $t + 1$ . In other words, for a given country, the level of development depends essentially on the value of the interior force.*

*Proof.* Let denotes by  $f(x) = \frac{i_t x^2 + B_t}{x^2}$ , where  $B_t = (b'_t - r_{n_t}) + (e'_t - r_{e_t})$  the function associated with the equation  $D_{t+1} - D_t = 0$ . And the derivative of  $f$  shows that if  $i_t > 0$ , then  $f'(x) > 0$ . And so,  $D_{t+1} > D_t$ .

**Theorem 25** If  $i_t < 0$ , then  $D_{t+1}$  increases if the value of  $D_n$  is between the root of  $f$  and decreases otherwise.

*Proof.* The study of the function  $f$  associated with the equation  $D_{t+1} - D_t = 0$  shows that  $D_t \in \left[-\sqrt{-\frac{B_t}{i_t}}, 0\right] \cup \left[0, \sqrt{-\frac{B_t}{i_t}}\right]$  and  $D_{n+1}$  decreases if  $D_n \in \left]-\infty, -\sqrt{-\frac{B_t}{i_t}}\right[ \cup \left]\sqrt{-\frac{B_t}{i_t}}, +\infty\right[$ , where  $B_t = (b'_t - r_{n_t}) + (e'_t - r_{e_t}) > 0$  and  $i_t < 0$ .

**Theorem 26** Let be  $i_t < 0$ . For  $\pm \sqrt{-\frac{B_t}{i_t}}$  neighboring (resp. far) of 0, then the increasing time of  $D_{n+1}$  is fast (resp. slow).

*Proof.* The study of  $f$  shows that  $\pm \sqrt{-\frac{B_t}{i_t}}$  is the root of  $f'$ , and then if  $-A \gg B$  we have the result.

**Theorem 27** Development's fixed points are not stable.

*Proof.* Development has two equilibrium points.

$$x_1 = \frac{\sqrt{i_t B_t}}{a_t} \text{ and } x_2 = -\frac{\sqrt{i_t B_t}}{a_t}$$

where  $B_t = (n_t - r_{n_t}) + (e_t - r_{e_t})$ .

$x_1$  and  $x_2$  are stable if  $-1 < i_t < 0$ . However, with this value of  $a_t$ ,  $x_1$  and  $x_2$  are not defined because  $\beta_t > 0$  for all period  $t$ . So we can conclude the non-stability of the fixed points.

### 5. Discussion and Conclusion

From this work, we conclude that between  $t$  and  $t + 1$ , each country  $P$  is subjected to: hazards conditioned by its geographical and geological situation; different actions that comes from another country  $P'$  and its own force. These three different forces act on the human, economic and political components of  $P$  called development forces: natural force  $n_t$ , negative exterior force and interior force  $i_t$ . Depending of the intensity of  $n_t$ ,  $e_t$  and  $i_t$ , they influence the level of development  $D_{t+1}$  of  $P$ .

For the natural force, we find that the main impacts of this force on development are mostly the human and economic aspects and these impacts leads to political consequences. The socio-economic impacts depend intrinsically on the intensity of the hazards, the nature of the hazards, the vulnerability and the resilience of  $P$ . Every country experiences natural force, but they are different on the level of resilience. This capacity is very important because it allows to recover and minimize rapidly the economic and human impacts of natural disaster. Resilience  $r_{n_t}$  of  $P$  plays an important role in development. Based on the studies we have seen previously, if the relative resilience is high, it significantly decreases its impacts and thus allows for the continuity of all the activities. In addition, a strong resilience between  $t$  and  $t + 1$  ensures a sustained and increasing level of development regardless of the intensity of these forces.

For the negative exterior force of  $P$ , it arises from the different interactions between two countries or more countries and affects particularly the political and economic sovereignty of one of the two countries. The negative exterior force  $e_t$  worsens the situation of  $P$ . Constituted by sanctions, this force aims to make economic pressure to induce political change. This kind of force has many adverse economic impacts that which extends to human components. So, it deteriorates economic, human and politics situation of  $P$ . Even though,  $P$  can not delete directly sanctions, it can be resilient to this force. The resilience here, allows  $P$  to find solution that can reduce the economic impacts of sanction by finding new trade partner, substituting the goods and financial aid.

For the interior force  $i_t$  of  $P$ , it is the driving force of  $P$ . Evaluating by the economic, political performance and the social situation, it can have negative and positive intensity. Negative intensity corresponds to interior force that exacerbate the development of  $P$ , and positive improves it. Further result shows that development of  $P$  depend essentially on  $i_t$ . No matter, how high natural and negative exterior force are, if the interior force is high, then development is not too much affected. But if it is not, then the development of  $P$  considerably decreases.

This paper shows as well that  $D_{t+1}$  continuously increases if the interior force  $i_t$  unceasingly increases and a very high resilience of  $P$ . Another result is that  $D_{t+1}$  is greater (resp. lower, equal) than  $D_t$  between  $t$  and  $t + 1$  if intensity of  $i_t$  is greater (reps. lower, equal) to the sum of  $n_t$  and  $e_t$ . Therefore, to increase the level of development, the interior force  $i_t$  must be greater than the other two forces. Then, without the forces  $n_t$  and  $e_t$ , the development is linear and strictly increasing or decreasing depending of the value of  $i_t$ . Further result is about the dynamic of the development, we find that it has two fixed points that are not stable. And so, the development is not stable, that is, there is no particular level to reach and where  $P$  can stay indefinitely. In addition, the non-stability of fixed points implies that there is not a level where each country tends to reach. And even if the country reaches the level of the fixed-point value between two consecutive periods  $t$  and  $t + 1$ , it can decrease or increase immediately the period after.

Development requires the control of the three development forces. For the natural force, as it can not be avoided, it is necessary to introduce into politics the resilience of each country and minimize the damage from as much as possible. For the negative exterior force, the impacts of sanction can be reduced by a strong diplomacy and international politics, diversification of bilateral and multilateral relations and adjustment of politic. And for the interior force, development involves a high value of this force which depends on: sustained economic growth, stable political situation and better social environment. With this work, we have more perspectives: we can add vulnerability of  $P$  in the equation and see the dependency between vulnerability and resilience of  $P$  to better model the reality. As exterior force have many aspects, we can explore another sorts of exterior force like: aid, grants, globalisation. All of them have their own particularity and its effects on the development. And finally, we also expect for future research to focus on the non linear noise term of the equation (9), investigate the effects of whether additive or multiplicative or other type of noise on the dynamic of the system and then study how types of noise alter the behavior of the country development.

### Acknowledgements

Thanks for reviewers of Journal of Mathematics Research for their constructive and fruitful suggestions and remarks.

### References

- Acemoglu, D., Johnson, S., Robinson, J., & Thaicharoen, Y. (2003). Institutional causes, macroeconomic symptoms: volatility, crises and growth. *Journal of Monetary Economics*. [https://doi.org/10.1016/S0304-3932\(02\)00208-8](https://doi.org/10.1016/S0304-3932(02)00208-8)
- Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *American Economic Review*. <https://doi.org/10.1257/aer.91.5.1369>
- Adams, R. (2002). Economic Growth, Inequality and Poverty: Findings from a New Data Set 2972, World Bank. *Policy Research Working Paper*.
- Adelman, I. (2001). *Fallacies in development theory and their implications for policy*. Meier, G. M., & Stiglitz, J. E. (Eds.) *Frontiers of development economics: The future in perspective* (pp. 103-135). New York: World Bank.
- Alderman, H., Hoddinott, J., & Kinsey, B. (2006). Long-term consequences of early childhood malnutrition. *Oxford Economic Papers*. <https://doi.org/10.1093/oeq/gpl008>
- Alesina, A., Özler, S., Roubini, N., & Swagel, P. (1996). Political instability and economic growth. *Journal of Economic Growth*. <https://doi.org/10.1007/BF00138862>
- Ali Mohamed, M., & Shah, I. (2000). *Sanctions and childhood mortality in Iraq*. *Lancet* 355.
- Allen, R. G. D. (1962). *Mathematical Analysis for Economist*.
- Allen, S. H. (2008). The domestic political costs of economic sanctions. *Journal of Conflict Resolution*. <https://doi.org/10.1177/0022002708325044>
- Allen, S. H., & Lektzian, D. J. (2013). Economic sanctions: A blunt instrument? *Journal of Peace Res*. <https://doi.org/10.1177/0022343312456224>
- Arndt, J., & Simler. (2006). *Has Economic Growth in Mozambique Been Pro-Poor?*. Food Consumption and Nutrition Division Discussion Paper 202
- Baez, J., de la Fuente, A., & Santos, I. (2010). Do natural disasters affect human capital? an assessment based on existing empirical evidence.
- Bair, J., Hinnion, R., & Justens, D. (1929). *Applications économiques au service de la Mathématique*.
- Banque Africaine de Développement et UNDP CEA. (2017). *Rapport sur le développement durable en Afrique - suivi des progrès accomplis dans la mise en oeuvre de l'agenda 2063 et des objectifs de développement durable*.
- Barro, R. J., & Sala, M. X. (1995). *Economic Growth*. McGraw Hill, New York.
- Behrman, J., & Srinivasan, T. N. (1995). *Handbook of development economics*. Elsevier Science: The Netherlands.
- Benson, C., & Clay, E. J. (2004). *Understanding the Economic and Financial Impacts of Natural Disasters*. The World Bank. <https://doi.org/10.1596/0-8213-5685-2>
- Benson, C., Twigg, J., & Rossetto, T. (2007). Outils d'integration de la reduction des risques de catastrophes - Note d'orientation ? l'intention des organisations de developpement. *Federation internationale des Societes de la Croix-Rouge et du Croissant-Rouge/consortium Provention*.
- Bergasse, E., Paczynski, W., Dabrowski, M., & Dewulf, L. (2013). *The relationship between energy and socio-economic*

- development in the Southern and Eastern Mediterranean*. Paper produced for the MEDPRO Project.
- Bhalotra. (2006). Childhood Mortality and Economic Growth. (*WIDER*) research paper No. 2006/79.
- Bils, M., & Klenow. (2000). Does schooling cause growth? *American Economic Review*.  
<https://doi.org/10.1257/aer.90.5.1160>
- Boltho, A., & Glyn, A. (1995). Can macroeconomic policies raise employment? *International Labour Review*.
- Brändström, A. (2016). *Crisis, Accountability and Blame Management : Strategies and Survival of Political Office-Holders*. Stockholm; Utrecht: CRISMART, Swedish Defence University; Utrecht University.
- Bureau pour la prévention des crises et du relèvement. (2004). *La réduction des risques de catastrophes: Un défi pour le développement, Un rapport mondial*.
- Bytzek, E. (2008). Flood response and political survival: Gerhard Schröder and the 2002 elbe flood in Germany. *Boin, A., McConnell, A., & 'tHart, P., eds. Governing after Crisis. The Politics of Investigation, Accountability, and Learning. Cambridge: Cambridge University Press.* <https://doi.org/10.1017/CBO9780511756122.004>
- Campanella, N. (1999). Infectious diseases and natural disasters: the effects of Hurricane Mitch over Villanueva municipal area, Nicaragua. *Public Health Reviews*.
- Caruso, R. (2003). *The impact of international economic sanctions on trade: An empirical analysis*. Peace Economics, Peace Science and Public Policy.
- Charvériat, C. (2000). Natural disasters in Latin America and the Caribbean: An overview of risk. *Research Department Working Paper 434. Inter-American Development Bank, Washington, DC*.
- Cheng, Y., & Zhou, L. (2007). The long-term health and economic consequences of the 1959-1961 famine in China. *Journal of Health Economics*.
- Chetwynd, E., Chetwynd, F., & Spector, B. (2003). *Corruption and Poverty: A review of recent literature*. Washington, Water street SW.
- Choudhury, Z. A. (2013). *Politics of natural disaster: How governments maintain legitimacy in the wake of major disasters, 1990-2010*.
- Christiaensen, L., & Demery, L. (2007). Down to Earth: Agriculture and Poverty Reduction in Africa, Directions in Development. *Washington, D.C.: The World Bank.* <https://doi.org/10.1596/978-0-8213-6854-1>
- CRED and UNISDR. (2015). The human cost of weather related disasters (1995-2015).
- Daponte, B., & Garfield, R. (2000). The effect of economic sanctions on the mortality of Iraqi children prior to the 1991 Persian Gulf War. *Am. Journal of Public Health* 90.
- De Janvry, Finan, A. F., Sadoulet, E., & Vakis, R. (2006). Can conditional cash transfer programs serve as safety nets in keeping children at school and from working when exposed to shocks? *Journal of Development Economics*.
- DFID. (2007). Growth - Building jobs and prosperity in Developing country.
- Dizaji, S. F., & Van Bergeijk, P. A. G. (2013). Potential early phase success and ultimate failure of economic sanctions: A VAR approach with an application to Iran. *Journal of Peace Research*.
- Dodds, G. G. (2008). Governing after crisis: the politics of investigation, accountability and learning. *Cambridge University Press.* <https://doi.org/10.1002/rhc3.12074>
- Dodds, G. G. (2015). "This Was No Act of God": *Disaster, Causality, and Politics. Risk, Hazards and Crisis*. Public Policy.
- Donaldson, D. (2009). *Railroads of the Raj: Estimating the impact of transportation infrastructure*. London School of Economics. Mimeo.
- Drury, A. C., & Li, Y. (2006). *US economic sanction threats against China: Failing to leverage better human rights*. Foreign Policy Analysis 2.
- ECLAC. (2001). *The Cuban economy. structural reforms and economic performance in the 1990s*. Retrieved from <http://www.cepal.org/publicaciones/xml/8/9458/r746-rev1-parte5.pdf>.
- Eyler, R. (2007). *Economic Sanction - International policy and economy at work*.
- Felbermayr, G., & Gröschl, J. (2014). The growth effects of natural disasters. *Journal of Development Economics*.

<https://doi.org/10.1016/j.jdeveco.2014.07.004>

- Fosu, A. K. (1992). Political Instability and Economic Growth: Evidence from Sub-Saharan Africa. *Economic Development and Cultural Change*.
- Galor, O. (2006). Discrete dynamical systems.
- Garfield, R. (2000). *Effets des sanctions économiques sur la santé et le bien-être des populations*.
- Garfield, R., Devin, J., & Fausey, J. (1995). The health impact of economic sanctions. *T. Bull N. Y. Acad Med*.
- Garfield, R., & Santana, S. (1997). The impact of the economic crisis and the US embargo on health in Cuba. *Am J Public Health*. <https://doi.org/10.2105/AJPH.87.1.15>
- Gibbons, E., & Garfield, R. (1999). The impact of economic sanctions on health and human rights in Haiti. *Am J Public Health*. <https://doi.org/10.2105/AJPH.89.10.1499>
- Gillman, M. (2008). *An Introduction to Mathematical Models in Ecology and Evolution*.
- GOAL. (2015). *Outil pour mesurer la résilience des communautés aux désastres - Manuel d'opération*.
- Gore, C. (1996). Methodological nationalism and the misunderstanding of East Asian industrialisation. *European Journal of Development Research*. <https://doi.org/10.1080/09578819608426654>
- Greenway, D. M., Morgan, W., & Wright, P. (2002). Trade liberalisation and economic growth in developing countries. *Journal of Development Economics*. [https://doi.org/10.1016/S0304-3878\(01\)00185-7](https://doi.org/10.1016/S0304-3878(01)00185-7)
- Gupta, S., Davoodi, H., & Terme, R. (1998). Does corruption affect income equality and poverty? *IMF Working Paper 98/76*. <https://doi.org/10.5089/9781451849844.001>
- Hallegate, S., Vogt-Schilb, A., Bangalore, M., & Rozenberg, J. (2017). Résumé - *Indestructible - Renforcer la résilience des plus pauvres face aux catastrophes naturelles*.
- Hanushek, E. A., & Kimko, D. D. (2000). Schooling, labour force quality, and the growth of nations. *American Economic Review*. <https://doi.org/10.1257/aer.90.5.1184>
- Heine-Ellison, S. (2001). The impact and effectiveness of multilateral economic sanctions: a comparative study. *International Journal of Human Rights*. <https://doi.org/10.1080/714003707>
- Hill, E., Wial, H., & Wolman, H. (2008). Exploring Regional Economic Resilience. *Macarthur Foundation Research Network on Building Resilient Regions, University of California, Berkeley*.
- Hochrainer, S. (2009). Assessing the Macroeconomic Impacts of Natural Disasters - Are there Any? *Policy Research Working Paper*.
- Hochrainer, S. (2009). Natural disaster death and socio-economic factors in selected Asian countries : A panel analysis. *International Institute for Applied Systems Analysis (IIASA)*.
- Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology & Systematics*. <https://doi.org/10.1146/annurev.es.04.110173.000245>
- Hufbauer, G. C., Schott, J. J., & Elliott, K. A. (1990a). *Economic sanctions reconsidered: History and current policy*. Institute for International Economics.
- Hufbauer, G. C., Schott, J. J., Elliott, K. A., & Oegg, B. (2007). *Economic sanctions reconsidered, Third edition*. Institute for International Economics.
- IFC. (2006). Transformer le développement de l'Afrique.
- Islam, R. (2004). *The nexus of economic growth, employment and poverty reduction: An empirical analysis*. International Labour Office.
- Jaffrelot, C. (2008). Le phénomènes des pays émergents.
- Johnston, M. (2000). *Good governance: rule of law, transparency and accountability*.
- Kaempfer, W. H., & Lowenberg, A. D. (2007). The political economic sanctions. *Handbook of Defense Economics, 2*. [https://doi.org/10.1016/S1574-0013\(06\)02027-8](https://doi.org/10.1016/S1574-0013(06)02027-8)
- Kaufman, D., Kraay, A., & Mastruzzi, M. (2005, mai). *Governance Matters IV? Governance indicators for 1996-2004, mimeo*. Washington (DC).

- Keefe, P. O., Westgate, K., & Wisner, B. (1976). *Taking the naturalness out of natural disasters*. Nature.
- Lew, & Jacob, J. (2016). Iran sanctions. *Congressional Research Service [database online]*. Retrieved from <http://www.fas.org/sfp/crs/mideast/RS20871.pdf>
- Lin. (2003). *Economic Growth, Income Inequality, and Poverty Reduction in People's Republic of China*. Asian Development Review.
- Longtin, A. (2003). Effects of noise on nonlinear dynamics., Nonlinear dynamics in physiology and medicine, *Interdisciplinary Applied Mathematics*.
- Luenberg, D. G. (1979). *Introduction to dynamic systems - Theory, Model and Application*.
- Marinov, N. (2005). Do economic sanctions destabilize country leaders? *American Journal of Political Science*.
- Marotto, F. R. (2006). *Introduction to Mathematical Modeling Using Discrete Dynamical Systems*.
- Mauro, P. (1995). Corruption and growth. *Quarterly Journal of Economics*. <https://doi.org/10.2307/2946696>
- Mayunga, J. S. (2007). Understanding and Applying the Concept of Community Disaster Resilience: A capital-based approach; *Draft working paper prepared for the summer academy for social vulnerability and resilience building, 22-28 July 2007, Munich, Germany*.
- Mileti, D., & Joseph, H. A. (1999). *Disasters by design: A reassessment of natural hazards in the United States*.
- Mohsin, M. H., Kemal, A. M., & Qadir, U. (2001). Impact of trade reforms on poverty. *Pakistan Institute of Development Economics, Sixteenth Annual General Meeting: Islamabad*.
- Neuenkirch, M., & Neumeier, F. (2015a). The impact of UN and US economic sanctions on GDP growth. *European Journal of Political Economy*.
- Neuenkirch, M., & Neumeier, F. (2015b). Always affecting the wrong people? The impact of US sanctions on poverty. *University of Trier Research Papers in Economics No. 03-2015*.
- Neuenkirch, M., & Neumeier, F. (2016). The impact of US sanctions on poverty. *Journal Development Economic*. <https://doi.org/10.1016/j.jdeveco.2016.03.005>
- Peksen, D., & Drury, A. C. (2009). Economic sanctions and political repression: Assessing the impact of coercive diplomacy on political freedoms. *Human Right Revue*.
- Peksen, D., & Drury, A. C. (2010). Coercive or corrosive: The negative impact of economic sanctions on democracy. *International Interactions*.
- Peksen, D., & Son, B. (2015). Economic coercion and currency crises in target countries. *Journal of Peace Research*. <https://doi.org/10.1177/0022343314563636>
- Perroux, F. (1961). Qu'est-ce que le développement?. *Etudes*.
- Petal, M. (2008). Disaster prevention for schools guidance for education sector decision-makers.
- Polachek, S. W., & Sevastianova, D. (2010). Does conflict disrupt growth? *IZA Discussion Paper No. 4762*.
- Rakotoarivelo, O. M., & Ravelonirina, H. S. G. (2017). Determining factors of country development and nondevelopment. *Pure and Applied Mathematics Journal*.
- Ravallion, & Chen, S. (1997). What can new survey data tell us about recent changes in distribution and poverty? *World Bank Economic Review*.
- Rodrik, R. (1999). Where did all the growth go? External shocks, social conflict and growth collapses. *Journal of Economic Growth*.
- Roy, M., & Hossain, B. F. (2013). Hartal: A violent challenge to the socio-economic development of Bangladesh. *International Journal of Scientific and Technology Research Volume 2*.
- Seethepalli, K., Bramati, M. C., & Veredas, D. (2008). How relevant is infrastructure to growth in East Asia? *Policy Research Working Paper No. 4597*, World Bank, Washington, DC.
- Sen, A. (1996). Development as Freedom. *Oxford Economic Papers*.
- Seyfried, W. (2005). Examining the relationship between employment and economic growth in the ten largest states. *Southwestern Economic Review*.

- Shone, R. (2002). *Economic Dynamics Phase Diagrams and Their Economic Application - Second Edition*.
- Sutcliffe, R. B. (1971). *Industry and underdevelopment*. London: Addison-Wesley.
- Swane, A., & Vistrand, H. (2006). *Jobless growth in Sweden? A descriptive study*.
- Thirtle, C., Lin, L., & Piesse, J. (2003). *The Impact of Research-Led Agriculture Productivity Growth on Poverty Reduction in Africa, Asia, and Latin America*. World Development.
- Thyne, C. L. (2006). ABC's, 123's and the golden rule: The pacifying effect of education on civil conflict, 1980-1999. *International Studies Quarterly* 50. <https://doi.org/10.1111/j.1468-2478.2006.00423.x>
- Timmer, C. P. (2002). *Agriculture and Economic Development*. B. Gardner and G. Rausser, eds., *Handbook of Agricultural Economics*.
- Townsend, P. (2000). *The International Analysis of Poverty*. London: Harvester Wheatsheaf.
- UN Commission économique pour l'Afrique, UNEP et FAO, ONUDI, and UNDP. (2015). *Réaliser le développement durable en Afrique par le biais d'une croissance verte et inclusive agriculture, Écosystèmes, Énergie, industrie et commerce*.
- UNESCO. (2014). The power of culture for development.
- UNISDR. (2008). *Disaster prevention for schools guidance for education sector decision-makers*.
- Uslaner, E. M., & Yamamura, E. (2016). Disaster and political trust. *The Japan Tsunami and Earthquake of 2011*.
- Vos, R. (1999). Economic and social effects of el Niño in Ecuador, 1997-98. *Inter-American Development Bank Technical Paper Series POV-107, Washington, DC*.
- Wacziarg, R. (2001). Measuring the dynamic gains from trade. *World Bank Policy Research Working Papers*. <https://doi.org/10.1093/wber/15.3.393>
- Wade, T. (2002). Does severe flooding increase the incidence of gastrointestinal illness? An analysis of the three data collection methods during a severe flood of the Mississippi river in 2001. *PhD dissertation, University of California, Berkeley, CA*.
- Wood, R. M. (2008). A hand upon the throat of the nation?: Economic sanctions and state repression. *Int. Stud. Q.* 52.
- World Health Organisation. (1996). *Health in Development*.
- World Bank. (1993). *The East Asian Miracle Economic Growth and Public Policy*. Oxford University Press.
- World Bank. (2001). *World development 200/2001: Attacking poverty*. UK. Oxford University Press.
- World Bank. (2008). *Agriculture for Development*.
- Yamano, T., Alderman, H., & Christiaensen, L. (2005). Child growth, shocks, and food aid in rural Ethiopia. *American Journal of Agricultural Economics*. <https://doi.org/10.1111/j.1467-8276.2005.00721.x>
- Zamfir, I. (2016). *La croissance économique de l'Afrique - Décollage ou ralentissement?*
- Zhang, W. B. (2006). *Discrete dynamical systems, Bifurcations and Chaos in economics*.

## Notes

Note 1. Mark Malloch Brown: Administrator, United Nations Development Program.

Note 2. Stephane Hallegatte: Economist at the World Bank and one of the authors of the "Indestructible" report the resilience of the poor to natural disasters .

Note 3. GDP: Gross Domestic Product.

Note 4.  $P'$  can be an organisation (UN (Organization United Nations), WB (World Bank), IMF (International Monetary Fund), EU (European Union), OUA (Organization of African Unity), CPS (Peace and Security Council of the African Union), ECOWAS (Economic Community of West African), NATO (North Atlantic Treaty Organization), OAS (Organization of American States), ASEAN (Association of South-East Asian Nations), . . . .

Note 5. Sanctions are effective if they have reached the initial goal set by the sanctioning country on the country sanctioned.

Note 6. EM-DAT: Centre or Research on the Epidemiology of Disasters, Public Health School, Catholic University of Louvain, Belgium, MunichRe and SwissRe.

Note 7. GOAL is an international humanitarian organization founded in Ireland in 1977, dedicated to alleviating the suffering of the poorest and most vulnerable communities across the world developing world.

Note 8. WJP: World Justice Project.

Note 9. INSEAD: European Institute of Business Administration and WIPO: World Intellectual Property Organization.

**Appendix**

Table A1. Drought classification using SPI index

Index SPI	Category	Value of $n_t$
from 0 to -0,99	Soft drought	$0 \leq n_t \leq 2$
from -1,00 to -1,49	Moderate drought	$2 < n_t \leq 5$
from -1,5 to -1,99	Great drought	$5 < n_t \leq 7$
< -2,0	Extreme drought	$7 < n_t \leq 10$

Note. This Table is from <https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi>. (12, December 2018) which categorize drought in four classes according to the SPI index.

Table A2. Classification of the resilience level of a country according to the GOAL measure

%	Level	Resilience Category
0-20	1	Minimal
20-40	2	Low
40-60	3	Medium
60-80	4	Resilient
80-100	5	High

Note. The Table is from (GOAL, 2015). It deals with the ranking of country resilience according to their measure.

Table A3. Value of the parameter  $n_t$

Hazards	Scale	Category	Value of $n_t$
Earthquake	$3 \leq I_s \leq 5,4$	Soft	$0 \leq n_t \leq 1$
	$5,4 \leq I_s \leq 6,9$	Medium	$1 < n_t \leq 5$
	$7 \leq I_s \leq 8$	Intense	$5 < n_t \leq 10$
Hurricane (NANP)	$29km/h \leq Wind \leq 117km/h$	Soft	$0 \leq n_t \leq 1$
	$118km/h \leq Wind \leq 209km/h$	Medium	$1 < n_t \leq 5$
	$Wind > 210km/h$	Intense	$5 < n_t \leq 10$
Typhoon (NOP)	$29km/h \leq Wind \leq 117km/h$	Soft	$0 \leq n_t \leq 1$
	$118km/h \leq Wind \leq 213km/h$	Medium	$1 < n_t \leq 5$
	$Wind \leq 214km/h$	Intense	$5 < n_t \leq 10$
Cyclone (SOIO)	$29km/h \leq Wind \leq 88km/h$	Soft	$0 \leq n_t \leq 1$
	$89km/h \leq Wind \leq 170km/h$	Medium	$1 < n_t \leq 5$
	$Wind > 170km/h$	Intense	$5 < n_t \leq 10$
Hurricane (BBAS)	$29km/h \leq Wind \leq 88km/h$	Soft	$0 \leq n_t \leq 1$
	$89km/h \leq Wind \leq 117km/h$	Medium	$1 < n_t \leq 5$
	$Wind \geq 118km/h$	Intense	$5 < n_t \leq 10$
Hurricane (SPSI)	$29km/h \leq Wind \leq 88km/h$	Soft	$0 \leq n_t \leq 1$
	$89km/h \leq Wind \leq 117km/h$	Medium	$1 < n_t \leq 5$
	$Wind \geq 118km/h$	Intense	$5 < n_t \leq 10$
Tsunami	$0,5m \leq H_m \leq 1m$	Soft	$0 \leq n_t \leq 1$
	$1m < H_m \leq 6m$	Medium	$1 < n_t \leq 5$
	$6m < H_m \leq 30m$	Intense	$5 < n_t \leq 10$
Volcano	VEI category: 0, 1, 2	Soft	$0 \leq n_t \leq 1$
	VEI category: 3, 4	Medium	$1 < n_t \leq 5$
	VEI category: 5, 6, 7	Intense	$5 < n_t \leq 10$

Note. The line 2-6 of the Table are from Data from CIA World Factbook. They are about the classification of hurricane, typhoon, cyclone according to the velocity of wind. It also shows the classification of: tsunami using the Imamura and Iida classification, volcano using the VEI scale and earthquake using the Richter scale. The last column corresponds to the value of the parameter  $n_t$  related to intensity of hazard.

NANP : North Atlantic - Northeast Pacific

NOP : Northwest Pacific

SOIO : Southwest Indian Ocean

BBAS : Bay of Bengal, Arabian Sea

SPSI : South Pacific, Southeast Indian Ocean

Table A4. Components of interior force

Interior force	Principal Components (%)
<b>Human components</b>	
Culture	<ul style="list-style-type: none"> <li>- Annual rate of daily newspaper variations (+),</li> <li>- Number of literary books (+),</li> <li>Number of literary books (+),</li> <li>- Annual rate of consumption of cultural papers (+),</li> <li>- Radio and television cultural program (+),</li> <li>- Imported feature films (-)</li> <li>- Distribution of national popular music compared to foreign music in % (+)</li> <li>- Percentage of use of mother tongue in everyday life (+),</li> <li>- Percentage of respect for the main national, popular and traditional festivals (+)</li> <li>- Protection and maintenance of cultural and natural sites (+)</li> <li>- Cultural exports in % of all cultural exchanges</li> </ul>
Education	<ul style="list-style-type: none"> <li>- Children out of school, primary (-)</li> <li>- School enrolment, secondary (+)</li> <li>- School enrolment, tertiary (+)</li> <li>- Educational public expense (+)</li> <li>- Adult formation (+)</li> <li>- Professional formation (+)</li> <li>- Mastery of technologies</li> </ul>
Health	<ul style="list-style-type: none"> <li>- Birth rate (+)</li> <li>- Death rate (-)</li> <li>- Maternal mortality (-)</li> <li>- Undernourishment (+)</li> <li>- Life expectancy (+)</li> </ul>
Employment	<ul style="list-style-type: none"> <li>- Children in employment (-)</li> <li>- Unemployment (+)</li> <li>- Vulnerable employment</li> <li>- Recruitment rate (+)</li> <li>- Job creation rate (+)</li> <li>- Employment to population(+)</li> </ul>
<b>Economic components</b>	
Economy	<ul style="list-style-type: none"> <li>- Central government debt (-)</li> <li>- Balance account (+)</li> <li>- External debt stocks (-)</li> <li>- Foreign direct investment (+)</li> <li>- GDP growth (+)</li> <li>- Inflation, consumer prices (-)</li> <li>- Total reserves (includes gold, current US\$) (+)</li> <li>- Broad money (+)</li> </ul>
Industry	<ul style="list-style-type: none"> <li>- Value added from industry (+)</li> </ul>
Trade	<ul style="list-style-type: none"> <li>- Exports of goods and services (+)</li> <li>- Imports of goods and services (-)</li> </ul>
Agriculture	<ul style="list-style-type: none"> <li>- Agricultural irrigated land (% of total agricultural land) (+)</li> <li>- Agricultural machinery (+)</li> </ul>
Infrastructure	<ul style="list-style-type: none"> <li>- Rail lines (+)</li> <li>- Access to electricity (+)</li> <li>- New technology (Innovation) (+)</li> <li>- Alternative and nuclear energy (+)</li> <li>- Fossil fuel energy consumption (+)</li> </ul>
<b>Politic components</b>	
	<ul style="list-style-type: none"> <li>- Good governance (+)</li> <li>- Liberty (+)</li> <li>- Strong diplomacy (+)</li> </ul>

Note. The above Table is about determining factors and their principal components. The sign (+) indicates that the components help to the increase of development, whereas (-) denote components which worsen it.

### **Copyrights**

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).