EMANES EURO-MEDITERRANEAN AND AFRICAN NETWORK FOR ECONOMIC STUDIES

# WORKING PAPER

## Analysis of country convergence dynamics: a multi-dimensional approach

**Moubarack LO[1] and Amaye SY [2]**

EMANES Working Paper N° 60 / October, 2022

**Abstract**

Empirical verification of economic convergence between countries, which is carried out mainly through GDP per capita or similar unidimensional indicators, has produced mixed results. This study sets out stages for developing countries on their development path and provides an analysis of the dynamics between them, using an alternative approach to an analysis of convergence based on a single criterion (GDP per capita). In addition, it identifies the factors that determine the belonging of countries to the upper stages of development. In this regard, the performances achieved by the newly industrialised countries in terms of balanced economic growth, structural transformation and diversified exportation, encourage the idea of an identification of a group or "club" of dynamic developing countries that can be called "emerging" countries. The concept of “economic emergence” relies to this idea and builds on the characteristics of these “emerging countries”.

[1] Director General of the Bureau de Prospective Economique du Sénégal (BPE)
[2] Director of the Strategic Studies and Analysis Unit of the Bureau de Prospective Economique du Sénégal (BPE)

Applying traditional convergence analysis methods to a *synthetic index of "economic emergence"* (*Indice synthétique d'émergence économique,* ISEME, in French), calculated on 93 developing countries between 1995 and 2019, revealed that a slow process of absolute β-convergence amongst the sample countries occurred during the period examined. It failed to detect a sigma-convergence dynamic. The results of the Markov chain analysis indicate that, although at a slow pace, a convergence process did occur amongst the sample countries for the period under consideration.

An ordered Probit model showed that certain factors have a positive impact on the probability of being positioned in the upper "emergence" classes, notably human capital through access to secondary education, the quality of infrastructure, the cost of access to finance, the research and development effort of firms, as well as transaction costs through the cost of enforcing a contract.

**JEL Classification:** C43, C35, O47.

**Keywords:** Absolute convergence, conditional convergence, β-convergence, σ-convergence, structural transformation, emergence, competitiveness, composite index, panel data models, Markov, ordered Probit.

## Introduction

To date, the only goal set for poor nations is to seek convergence with rich countries. However, contemporary economic history shows that convergence is a long-term process (spread over decades or even hundreds of years). In this context, it is useful to set intermediate stages for developing countries that will allow them to distribute their efforts towards the goal of convergence over time. The results achieved by the newly industrialised countries in terms of economic growth, structural transformation and export performance, encourage the idea of a more refined classification of the so-called Third World countries, with a clear distinction between the group or "club" of dynamic developing countries that can be called "emerging" countries, the group of less advanced countries where the poorest countries are found and, finally, those classically developing countries that do not belong to either of the two groups or extreme "clubs" mentioned above. In the Robert dictionary, to "*emerge*" is said of "a phenomenon that attracts attention by its value". Thus, a formerly poor country emerges when it attracts interest and stands out from the mass of underdeveloped economies that are on the margins of global trade in goods, services, capital and ideas.

Such an exercise of a better classification of countries meets the requirements of fairness and statistical rigour. It has another virtue: it positively sanctions the progress made by the best-performing countries and allows them to celebrate intermediate victories ("quick wins") that stimulate them to continue to mobilise their energies, pursue the path they have chosen, undertake other structural reforms and institutionalise good practices. This is a very important step in the transformation process, that is the development project. Once these intermediate stages are defined, the notion of convergence can be used to analyse the dynamics between them.

Since the earliest studies, such as those by Kuznets (1955) and Williamson (1965), there has been a great deal of analysis of economic convergence between countries. The "convergence" hypothesis simply states that a country's initial conditions do not affect its per capita income in the long run, because poor countries will tend to grow faster than rich countries and will eventually catch up, leading to a gradual erosion of disparities in income levels between countries. Thus, in the long run, countries will converge towards a common level of per capita income.

Empirical testing of this hypothesis became important in the mid-1980s and 1990s, with the emergence of modern growth theory, since it was seen as an important element in unlocking the mechanisms of economic growth. These seminal studies, including Solow (1956), Abramovitz (1986), Baumol (1986), Barro and Sala-i-Martin (1992), have reached very broad and interesting conclusions about growth

and income convergence across countries. Some argue that developed countries tend to converge in terms of per capita income, but not the world as a whole. Others conclude that countries with low to medium-high levels of development show signs of convergence, but countries with medium-high to very high levels of development show signs of divergence. Meanwhile, others establish that convergence in per capita income across countries cannot occur in absolute terms, but rather depends on several factors.

These convergence analyses with mixed results are in many cases aimed at capturing the processes of gradual alignment of GDP per capita levels. Despite its many advantages (universality, relative ease of interpretation, comparability over time and space), GDP does not comprehensively reflect the complex nature of development processes. Synthetic indicators, which are constructed to take into account the multi-dimensional nature of development, are most often used to identify differences in levels of development and to establish a ranking. They are rarely used to study the dynamics of development processes and, therefore, the processes of convergence or divergence.

Thus, the contribution of our analysis to the literature is multiple. First, it provides an analysis of the dynamics of convergence in a sample of countries at intermediate stages of development. Second, it uses an alternative approach to an analysis of convergence dynamics, based on a single criterion (Growth Domestic Product (GDP) per capita). Indeed, it provides a multi-dimensional analysis of convergence or divergence processes, on the basis of a synthetic measure of "economic emergence". Finally, in addition to analysing the dynamics of convergence during the process of "economic emergence", it studies the levers that can be used to promote access to the desired results.

From a methodological point of view, the study has two lines of analysis. The first approaches convergence through several methods. First, a "*synthetic index of economic emergence*" (*Indice synthétique d'émergence économique, ISEME, in French*), calculated on 93 developing countries between 1995 and 2019, is used to determine the dynamics of the process leading to the reduction of economic performances within the countries in the sample. To this end, beta convergence and sigma convergence analysis methods are applied to the *ISEME*. A Markov chain model of the *ISEME* is used to analyse the internal dynamics of convergence within the countries in the sample. The second approach identifies, through an ordered Probit model, the factors that determine the inclusion of countries in the different "economic emergence" classes defined on the basis of the *ISEME*.

The application of traditional convergence analysis methods to *ISEME* revealed that a slow process of absolute β-convergence amongst the sample countries occurred during the period examined. It failed to detect a sigma-convergence dynamic.

The results of the Markov chain analysis indicate that, although at a slow pace, a convergence process occurred amongst the sample countries for the period under consideration.

An ordered Probit model showed that certain factors have a positive impact on the probability of being positioned in the higher "economic emergence" classes, notably human capital through access to secondary education, the quality of infrastructure, the cost of access to finance, the research and development effort of firms, and transaction costs through the cost of enforcing a contract. The effects on the *ISEME* score of a marginal improvement in these factors are greatest in the lowest performing class of countries.

The paper is divided into four parts. The first part reviews the theoretical and empirical literature on the concepts of convergence. The second presents the "*synthetic index of economic emergence"* (*ISEME*). The third part analyses the convergence or divergence dynamics of the countries in the sample, using several instruments. The last part estimates an ordered Probit model to identify the factors that most determine the probability of a country being in the upper "economic emergence" classes.

## I. Convergence concepts: a brief review of the literature

Over many decades, economic convergence between countries has been the subject of numerous analyses, such as those by Kuznets (1955) and Williamson (1965). These analyses aim to capture the processes of gradual alignment of GDP per capita levels (Mensah, 2020). In early studies, an index similar to the standard deviation was used as a measure of income dispersion, now known as σ-convergence. This then became the simplest concept of convergence and, according to Quah (1993), can be understood as the continuous dynamics of reducing per capita income differences between countries, leading to less dispersion and inequality between economies. The term σ-convergence was introduced by Barro (1991).

With the development of economic growth theories, a second concept, that of β-convergence, has emerged in studies such as Abramovitz (1986) and Baumol (1986)). These pioneering studies have served as a stimulus for much other work in this area, including Barro and Sala-i-Martin (1991). These studies derive from the neoclassical growth model of Solow (1956). According to the Solow (1956) model, capital accumulation is accompanied by a decrease in the marginal productivity of capital. This leads to the conclusion that the growth rate of gross domestic product (GDP) per capita in less developed countries should be higher than in more developed countries.

As Quah (1993) points out, β-convergence is a necessary, but not sufficient, condition for the existence of σ-convergence. For example, if poorer economies grow faster than richer ones to the point of overtaking them, there may be an increase in the dispersion of per capita income between regions, an outcome favourable to β-convergence, but not to σ-convergence.

It should also be noted that β-convergence is discussed in the literature under two main approaches, namely the absolute approach and the conditional approach. The absolute β-convergence considers that lagging economies tend to grow at higher economic growth rates than rich economies and, thus at some point, the per capita incomes of the two groups will equalise. The conditional form of convergence only occurs when countries have identical structural characteristics, because the growth rate of each economy will be higher the further it is from its own steady state. This concept of conditional convergence also predicts that countries may converge to different steady states and that economies will not necessarily reach the same level of per capita income in the long run.

Several empirical research papers have tested the validity of the convergence hypothesis.

Barro (1997) emphasised the positive role played by maintaining the rule of law, low public sector consumption, an initial high level of life expectancy and male school enrolment, a low fertility rate and improved terms of trade. From a given level of any of these variables, growth would be higher when the country started with low GDP per capita (the conditional convergence phenomenon). According to Barro (1997), the impact of democracy (political rights) on growth was not clear: where the level of democracy was low, the increase promoted growth but when it became higher, the new increase had a negative impact on growth, resulting from the crucial influence of pressure groups on public expenditure.

Sachs and Warner (1995) outlined the key roles of protection of property rights and trade openness to demonstrate that, during the period from 1970-1995, 'open' economies grew at the average rate of 4.5 per cent per annum whereas 'closed' economies only grew at 0.7 per cent. However, it was underlined that the "Chinese puzzle" to an extent contradicted these results. Cohen (2001) indicated that the Sachs-Warner variables were particularly significant when crossed with the education variable of a country. An 'open economy', according to Sachs-Warner, considerably increased the output of human capital.

Cohen and Soto (2002) went further, stating that poverty in countries should be interpreted as the multiplication of a set of handicaps relating to resources and total productivity. These handicaps combine to explain why some countries remained in the poverty trap. In order for countries to emerge from this trap, each of these handicaps should be addressed and corrected.

Comparing the industrial productivity of a sample of countries with varying levels of development, Cohen and Causa (2005) arrived at the same conclusion, by pointing at five constitutive handicap factors for less productive countries (including some European countries): namely physical capital, infrastructure, human capital, level of integration in international trade and net residual productivity of each economy.

Paprotny (2014) used GDP per capita and three demographic mortality indicators to show that Poland has virtually failed to converge with a group of 25 developed countries, except in the adoption of technology. Paprotny (2016) extended the analysis to Central and Eastern European countries and added employment in agriculture as an indicator of the modernity of the economy. The results overall showed a slight catch-up with developed countries.

The studies that analyse the concept of convergence through more comprehensive measures of development than per capita income (Konya) are rare. Mazumdar (2002) examined whether the Human Development Index (HDI), published since 1990 by the United Nations Development Programme in its annual Human Development Report (HDR), had converged across countries over the period 1960-1995 for the full sample of 91 countries, as well as for three groups of countries ranked by their level of human development. The results indicated divergence for all four cases, suggesting that the world's economies became more dissimilar over the period 1960-1995 with respect to the HDI. Noorbakhsh (2006) used a slightly updated HDI dataset from 1975 to 2002 at five-year intervals until 2000 and then 2002, finding evidence of weak β-convergence and σ-convergence for different subsets of countries and world regions. Sutcliffe (2004) addressed the issue of human development convergence by studying HDI trends for 99 countries in 1975, 1980, 1995 and 2001. The author concluded that the given countries were converging towards each other.

As can be seen from the literature reviewed above, empirical verification of convergence is carried out mainly through GDP per capita or closely related unidimensional indicators. The results are mixed. Finally, the literature that analyses the concept of convergence through more comprehensive measures of development than per capita income is scarce. The Human Development Index (HDI) has made it possible to study convergence amongst countries, in terms of a more comprehensive measure of development than per capita income. This study is a further step in this direction.

## II. The Synthetic Index of Economic Emergence (ISEME)

The Synthetic Index of Economic Emergence (ISEME) has been developed following a theory conceptualised by Moubarack Lô (2017). According to this theory, the concept of "economic emergence" is both a process and an outcome. It is a process when it describes the dynamics set in motion by an underdeveloped country (which can be called an 'immersed' country, to put it simply) to extricate itself from the trap that keeps it in poverty and to evolve upwards, to get its head above water and give itself the means to develop in the future. In this case, we can speak of an "emerging" country, to underline the fact that it is an ongoing process. It is a vertical process that requires the mobilisation of a great driving force, to break down the handicaps that have so far prevented the country from developing. "Economic emergence" can also represent a country's achievement in its march towards full development. Having made many efforts in the recent past to meet global competitiveness standards, the formerly poor country manages to get out of the water, becoming an "emerged" country. It can then, within the framework of a horizontal process, move serenely towards the shores of development and converge with the most advanced countries.

Based on the definition above, "economic emergence" can be seen as comprising several aspects, each of which is measured by a set of economic variables. To emerge, a country must create wealth and ensure that it benefits the entire population (an inclusive wealth), sustainably accelerate its economic growth whilst maintaining a sound macroeconomic framework (dynamism and sound macroeconomic framework), diversify and continuously improve its production structure (structural transformation aspect) and become a dynamic player in international markets (insertion into the world economy aspect).

This index, ranging from 0 to 1, is constructed on the basis of an aggregation of sub-indices established on each of the selected dimensions. Each dimension contains several variables (see Table 1 and Annexe 1).

- **Inclusive wealth** is measured by GDP per capita in purchasing power parity (which quantifies the wealth of the country). To this variable, we can add life expectancy at birth, adjusted for income inequality, which is a good indicator of the inclusiveness of the wealth created.
- **Economic dynamism and sound macroeconomic framework** are measured by GDP per capita growth (this is the quantification of the real evolution of the wealth), the sustainability of GDP per capita growth[3] (this variable measures the stability of the evolution of income, with a country on the right trajectory of emergence evolving at a relatively constant rate),

[3] Average deviation of GDP per capita growth from China's over the last five years

gross fixed capital formation as a percentage of GDP, the budget balance (internal stability), the current account balance (external stability) and the level of inflation, which must be controlled in an economy that aspires to emergence.

- **The structural transformation** of the country is measured by grain yields (a proxy of the agricultural productivity which is not measured in many countries), as well as the sectoral composition of value added (industrial and manufacturing value added, labour productivity in industry).
- **Good integration into the world economy** is measured by indicators of foreign trade and foreign investment received by the country. Integration into international trade is measured by the share of the country's exports in GDP, the share of services exports in GDP, the export concentration index (it is important that the country's exports are sufficiently diversified and transformed, to allow the country to be competitive), the share of medium and high technology goods and services in exports (the country must incorporate technology in its exported products).The country's ability to attract foreign investment is captured by the weight of the country's foreign direct investment (FDI) in GDP and the share of FDI in the total received by the countries in the sample.

Table 1 below lists all the variables chosen for the construction of the ISEME.

Table 12 in the annexes shows the ISEME index scores of the 93 countries in the sample for the years 1995, 2007 and 2019. In 2019, Ireland is ranked first with a score of 0.96 followed by the Czech Republic (0.88), Hungary (0.87), Malaysia (0.91), China (0.85) and Slovakia (0.84). The average score for the countries in the sample is 0.56 in 2019 compared to 0.54 in 2007 and 0.45 in 1995. The median score is 0.54 in 2019 compared to 0.54 in 2007 and 0.45 in 1995. Between 1995 and 2007, 90 out of 93 countries improved their score, whilst between 2007 and 2019, only 57 countries show an increase in their score.

**Table 1 : ISEME components**

| DIMENSION | UNDER DIMENSION | INDICATORS | SOURCE |
|---|---|---|---|
| **INCLUSIVE WEALTH** | **RICHES** | GDP per capita, (constant PPP US$ 2011) | WDI |
| | | Inequality-adjusted life expectancy | HDR |
| **DYNAMISM AND SOUND MACROECONOMIC FRAMEWORK** | **ECONOMIC DYNAMISM** | GDP per capita growth (annual %) | WDI |
| | | Sustained GDP growth | WDI |
| | | Gross fixed capital formation (% of GDP) | WDI |
| | **MACROECONOMIC STABILITY** | Gross savings (% of GDP) | WDI |
| | | Budget balance (% of GDP) | WDI |
| | | Inflation (%) | WDI |
| | | Current account balance (% of GDP) | WDI |
| **STRUCTURAL CHANGE** | **PRODUCTIVITY** | Cereal yield (kg per hectare) | WDI |
| | | Industry (including construction), value added (as % of GDP) | WDI |
| | **INDUSTRY** | Manufacturing, value added (% of GDP) | WDI |
| | | Industry, value added (% of GDP) | WDI |
| | | Medium and high-tech industry (including construction) (% of manufacturing value added) | WDI |
| **INSERTION IN THE GLOBAL ECONOMY** | **EXTERNAL TRADE** | Country exports to country GDP (5-year average) | WDI |
| | | Medium and high technology exports (% of manufactured exports) | WDI |
| | | Concentration index | UNCTAD |
| | | Exports of manufactured goods (% of exports of goods.) | WDI |
| | | Services exports (% of GDP) | WDI |
| | **FOREIGN INVESTMENTS** | Total FDI per capita country over 5 years/Total FDI per capita sample over 5 years | WDI |
| | | Country FDI/GDP (5-year average) | WDI |

**Source:** Moubarack Lô and Amaye Sy (2021), "Manuel de l'émergence économique", Ed. Harmattan, January 2021

# III. Examining convergence through the synthetic index of emerging economies (ISEME)

This section examines beta and sigma convergence within the sample countries between 1995 and 2019.

## III.1 Study of beta convergence

We first examine whether the countries in the sample show absolute convergence in levels of "economic emergence", i.e., β convergence.

The methodology used to test β-convergence generally consists of estimating an equation in the following form (Barro and Sala-i-Martín, 1992):

$$\frac{1}{T} * \frac{\log (ISEME)_{i,T}}{\log (ISEME)_{i,0}} = \alpha + \beta^{*} ISEME_{i,0} + \gamma * Z^{*}_{i,T} + \varepsilon_i \qquad (1)$$

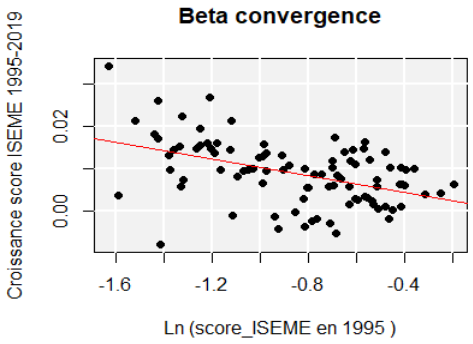
$\boldsymbol{ISEME_{i,t}}$ is the ISEME score that measures the "economic emergence" performance of country i at date t. Zi includes all other factors that can potentially determine economic emergence. α, β and γ are the parameters to be estimated. β captures the rate or speed of convergence.

A negative relationship between the growth rate of the ISEME and the initial level of the ISEME, i.e., a significant and negative β, indicates a convergence process. The estimated value of β also indicates the speed at which countries are approaching their steady state and, thus, the speed of convergence. Based on this value, the half-life can be calculated, i.e., the time it takes for the current disparities in "economic emergence" to be halved. If the value of γ is restricted to 0, absolute convergence is assumed, whereas if it is freely estimated, conditional convergence is assumed.

The estimation of the model between 1995 and 2019 yields a negative and statistically significant β coefficient. Thus, a process of absolute β-convergence between the countries in the sample has occurred over the period under examination. This means that the countries with the lowest levels of "economic emergence" in 1995 made stronger progress between 1995 and 2019.

To get an idea of the speed (in years) at which this convergence should take place, we calculated the half-life for closing the gap between the ISEME score of the relatively lagging and the relatively better performing countries. In this case, the convergence rate implies that half the gap should be closed in 70 years [4]

**Figure 3: Growth rate of ISEME score between 1995 and 2019 as a function of the level of ISEME score in 1995**




**Source**: authors

## III.2 Study of sigma convergence

As described above, another relevant type of convergence is σ-convergence. To test for σ-convergence, we analyse the behaviour of dispersion indicators. A quick overview of the three dispersion indicators in Figure 2 (standard deviation, coefficient of variation (CV), interquartile range) suggests that countries in 2019 had a lower dispersion of the ISEME score series than in 1995. However, the change in all three indicators is small over the period. The standard deviation has even increased slightly. Indeed, the standard deviation of ISEME scores increased over the period 1995-2008, i.e., until the onset of the economic crisis and between 2013 and 2019, whilst it decreased between 2009 and 2013. However, this upward trend in the standard deviation is misleading and does not tell us anything about the dispersion of economic emergence situations, because the average score within the sample has risen sharply over the period (see Figure 1). Indeed, the coefficient of variation of the scores, i.e., the ratio between the standard deviation and the mean, has continuously decreased between 1995 and 2019, except for the period 2013-2017 (see figure 2). However, this decrease in the coefficient of variation between 1995 and 2019 is not statistically significant (see Fisher test results, Table 3)

[4] Calculated as ln(1/2) divided by the respective beta coefficient.

**Figure 1:** Evolution of ISEME trend indicators over the entire sample

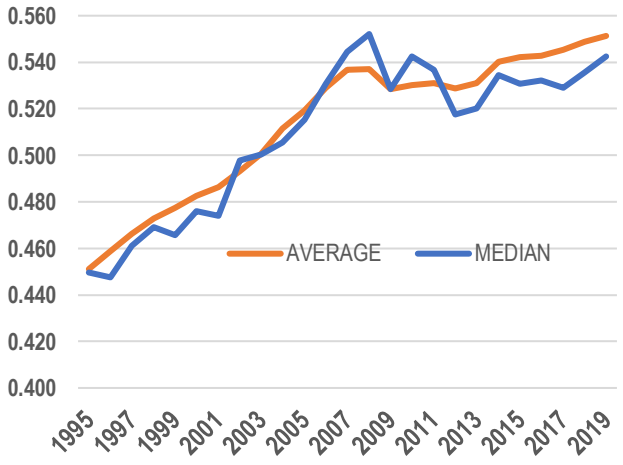



**Figure 2:** Evolution of the ISEME dispersion indicators over the whole sample

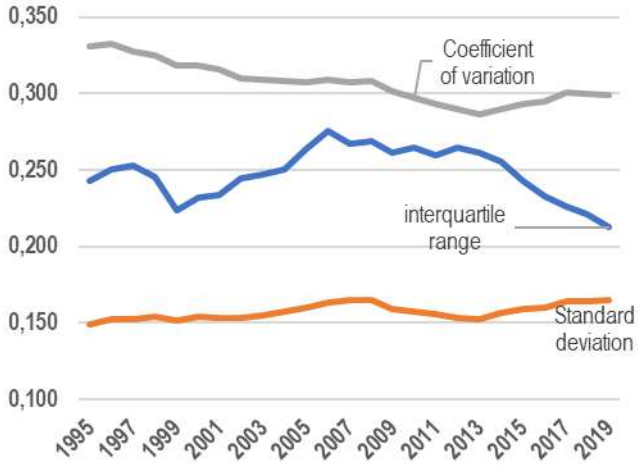



**Table 3: Results of the Fischer test for equality of CV coefficients of variation in 1995 and 2019**

| | Estimate | F value | Pr (>F) | Significance |
|---|---|---|---|---|
| CV 1995 | 0.3289477 | ND | ND | ND |
| CV 2019 | 0.2977789 | ND | ND | ND |
| Quotient | 1.1046710 | 0.8170433 | 0.3342378 | |

**Source**: authors

In the end, the analysis of dispersion indicators does not allow us to conclude that there is a process of σ-convergence over the period 1995-2019.

The concept of σ-convergence is useful for analysing the evolution of the dispersion of performances between countries, but it is not suitable for describing the movements of countries within the distribution of these performances (Monfort, 2008). However, such movements can make a considerable contribution to the analysis of inter-country disparities, by providing more details on the mechanisms at work in the convergence process (Magrini, 2007). Indeed, a constant standard deviation can go hand in hand with very different dynamics, ranging from inter-crossing and leapfrogging to persistent inequality and trapdoor phenomena (Quah, 1996). The distinction between these dynamics is, however, of key importance.

## III.3 Analysis of convergence by Markov chains

In order to detect individual country movements within the distribution of performances in terms of "economic emergence" and to describe their dynamics, one of the most appropriate approaches is based on Markov chains and transition matrices. Markov chains can be used for modelling stochastic processes where the next phase of the process depends only on the current phase. If time is the parameter, the process can be considered as a case where the past can affect the future only through the present.

Stochastic Markov processes have been widely used in economic modelling. Nelson and Winter (1982) used a Markov process to describe technological change. Markov processes have been used to model changes in productivity over time (Fernandes and Isgut, 2005; Michael and Hao, 2009), as well as changes in the growth regime. Jerzmanoswki (2006) estimates a Markov change growth model with four such regimes: miracle growth, stable growth, stagnation and crisis. This method has been used by several authors to study, amongst others, the dynamics of per capita income (Quah 1993, Kremer et al. 2001, Im and Rosenblatt 2013), as well as the evolution of the export sophistication index (Fortunato and Razo 2014).

We will provide a brief description of the methodology underlying the Markov chain analysis and apply it to the distribution of ISEME scores of the sample countries.

### III.3.1 Description of the Markov chain model

Based on the scores in ISEME, let us define a set of N non-overlapping emergence classes. The method for determining the classes will be presented later.

Suppose that the ISEME score of a country follows a first-order Markov chain with time-invariant transition probabilities, denoted by {*p*ij}, with i = 1,...,N and j = 1,...,N. N and j = 1, ..., N.

Each *p*ij describes the probability that the emergence state i is followed by state j. We denote the set of emergence states as $S = \{s1, s2, \dots, sN\}$.

The probability that $s_t$ is equal to a particular value j depends only on the most recent value $s_{t-1}$ and not on other past realisations of $s$ :

$$\Pr(s_t = \mathrm{j} | s_{t-1} = \mathrm{i}, s_{t-2} = k, \dots) = \Pr(s_t = \mathrm{j} | s_{t-1} = \mathrm{i}) = p_{\mathrm{ij}}$$

In other words, the ISEME score of a country in period t depends only on the ISEME score in the previous period (t-1) and not on other past achievements.

- **Transition matrix**

We can represent the transition probabilities in matrix form, as follows:

$$\mathrm{P} = \begin{pmatrix} P_{11} & P_{12} & \dots & P_{1N} \\ P_{21} & P_{22} & \dots & P_{2N} \\ \dots & \dots & \dots & \dots \\ P_{N1} & P_{N2} & \dots & P_{NN} \end{pmatrix}$$

P is an N x N matrix of transition probabilities or simply a transition matrix.

Note that $\sum_j p_{ij} = 1$. In matrix notation, P x $\mathbf{1} = \mathbf{1}$, where $\mathbf{1}$ is the N-dimensional vector with all elements equal to 1. The diagonal elements indicate the probability of countries remaining in the emergence class after a period. The off-diagonal elements indicate the probability of a given country moving to another emergence class after a period or a step. The transition matrix can be estimated using the maximum likelihood method.

- **Long-term equilibrium:**

The transition matrix can be used to describe the evolution of the ISEME score over time. For example, after n periods, the distribution of ISEME scores at time t + n will be given by $d_{t+n} = P^n\, d_t$ where $d_t$ is a vector of dimension N x 1 describing the distribution of ISEME scores at time t.

If there is an integer N such that $P^N$ has no zero elements, the Markov chain is called "regular" and the transition matrix is called "ergodic". In this case, any class can be reached from another after a certain number of passes or transitions. Furthermore, an ergodic transition matrix converges to a boundary matrix M* of rank 1 in which all rows are equal to each other and equal to the ergodic or stationary distribution of the Markov chain. The latter can be interpreted as the long-term equilibrium of the distribution of scores in the ISEME. The vector of ergodic probabilities can be seen as indicating the unconditional probabilities of each of the k different states, i.e., independently of the initial state. The ergodic character of the Markov chain and the existence of a stationary distribution are ensured when the modulus of the second eigenvalue of the transition matrix is strictly less than 1.

The stationary distribution makes it possible to identify the form that convergence between the countries studied will take in the long term. There are three possible cases. The case of a unimodal stationary distribution (reduced to a single class) can be interpreted as the existence of a convergence of countries in the long term, towards this single class. The case of a multimodal limit

distribution, which shows a concentration of countries in certain classes in the long term, can be interpreted as the existence of different convergence clubs in the long term. Finally, a stationary distribution dispersed between the different classes, without any particular concentration of countries in one of these classes, is interpreted as divergence.

- **Convergence speed indicators**

The transition matrix also provides information on the persistence of classes and the speed of convergence of the economic emergence process. Thus, the stability index S can be calculated for the transition matrix P of dimension n as follows:

$$S = Tr(P)/n$$

where Tr(P) is the trace of P, i.e., the sum of the elements of the main diagonal. A high value of S indicates a stable process, i.e., a process for which the chances of moving from one category to another are low.

The concept of convergence half-life refers to the number of periods required to halve the difference between the current class distribution and the stationary distribution. The higher the convergence half-life, the slower the convergence to the stationary state and, therefore, the slower the transitions from one class to another.

$$\text{Convergence half-life} = -\log(2)/\log(|\lambda 2|)$$

$\lambda 2$ is the second largest eigenvalue of the transition matrix P

## III.3.2 Implementation of Markov chain modelling

For the purpose of modelling the "economic emergence" process of the countries studied using Markov chains, it is first necessary to associate classes with the ISEME scores. For this purpose, the ISEME index needs to be broken down and the boundaries identified.

- **ISEME discretisation**

This division was carried out in two stages: first, the sample was segmented on the basis of the 21 ISEME variables. The method used is hierarchical ascending classification (HAC). This initial segmentation, based on the ISEME variables, yielded 6 fairly ordered classes according to ISEME level. However, it does not allow a given country to be assigned to a group solely on the basis of its ISEME

score (the classes obtained at the end of this first stage overlap). As a result, a second classification that identifies ISEME thresholds is performed, on the basis of the results of the first classification. Intuitively, the second segmentation corresponds to discretising the ISEME, so that the resulting qualitative variable is as "close" as possible to the categorical variable derived from the first segmentation (or CAH segmentation). The second discretisation is, thus, "supervised" by the first. This can be solved by an algorithm that sets a distance measure between two categorical variables and initial thresholds and iteratively updates the previous thresholds, so as to reduce the distance between the segmentation associated with the thresholds and the CAH segmentation (Cheng-Jung Tsai et al 2007).

**Table 4: Thresholds obtained with the supervised discretisation method**

| Class | Immersed or underdeveloped | Aspiring to emerge | Potentially emerging | Pre-emerging | Emerging | Emerged |
|---|---|---|---|---|---|---|
| Interval | [0 ; 0.35] | ]0.35 ; 0.45] | ]0.45 ; 0.5] | ]0.5 ; 0.6] | ]0.6 ; 0.75] | ]0.75 ; 1] |

**Source**: Authors' calculations

Table 4 shows the results obtained by implementing the two-stage ISEME cut-off method. Thus, countries with an ISEME score greater than 0.75 are called "emerged" (EMGE) countries. An "emerging" (EMGEANT) country has an ISEME score strictly above 0.6 and below 0.75. whilst countries with an ISEME between 0.5 and 0.6 are called "pre-emerging" (PRE EMG). Potentially emerging countries (POT EMG) are those with an ISEME in the range [0.45; 0.5]. Countries with an ISEME between 0.35 and 0.45 are called "aspiring emerging countries" (AECs). Countries with an ISEME score less than or equal to 0.35 are considered "immersed" (IMG) or "underdeveloped" (UNDERDEVELOPED) countries,

Given the small number of countries in the "underdeveloped" and potentially emerging class, each of the two groups is merged with the next higher adjacent class. Thus, in the framework of Markov chain modelling, countries are classified into four different classes: Emerged, Emerging, Pre-emerging and Immersed (see Table 5).

**Table 5: Initial distribution (in 1995) of emergence classes considered for Markov chain modelling**

| Emergence class | EMERGED (EMGE) | EMERGING (EMGEANT) | PRE EMERGING (PRE EMG) | IMMERSED (IMG) |
|---|---|---|---|---|
| Number of countries | 2 | 13 | 31 | 47 |
| Distribution | 2% | 14% | 33% | 51% |

**Source**: Authors' calculations

- **Markov chain modelling results**

Applying the concepts of Markov chain models to the class data associated with ISEME, over the period 1995-2019, gives the following results:

**Table 6: Transition matrix over the period 1995-2019**

| | | 1995 | | | |
|---|---|---|---|---|---|
| | | EMGE | EMGEANT | PRE EMG | IMG |
| 2019 | EMGE | 100% | 69% | 16% | 0% |
| | EMGEANT | 0% | 23% | 48% | 0% |
| | PRE EMG | 0% | 8% | 26% | 38% |
| | IMG | 0% | 0% | 10% | 62% |

Source: Authors' calculations

**Table 7: Convergence indicators associated with the transition matrix for the period 1995-2019**

| Stationary or long-term distribution | EMGE | EMGEANT | PRE EMG | IMG |
|---|---|---|---|---|
| | 100% | 2 | 0 | 0 |
| Half-life of convergence | 2.1 periods or 50.4 years | | | |
| Stability index | 0.53 | | | |

Source: Authors' calculations

The transition matrix (see Table 6) does not indicate a relative persistence in the distribution of economic emergence classes. This is illustrated by the stability index S which takes a relatively low value of 0.53 (see Table 7). The values on the diagonal associated with the intermediate classes are relatively low. Indeed, for each of the emergent and pre-emergent states, the probability of being in the class and remaining in it, is lower than the probability of being in the class and moving to the next higher class after a quarter of a century. In other words, these countries are more likely to improve their emergence status than to maintain it over a 25-year period. In particular, 65% and 69% respectively of the 'Pre-Emerging' and 'Emerging' countries in 1995 moved up to a higher category in 2019. In contrast, the probability of being an immersed country and remaining so over a ten-year period is relatively high (p44 =62%). This may suggest that immersed countries are subject to a poverty trap.

Table 6 also indicates that downgrades without being absent are rare. On the one hand, once a country joins the group of "Emerging" countries, it is likely to remain in this group (p11=100%). On the other hand, only 10% and 8% of the "Pre-Emerging" and "Emerging" countries respectively experienced a downgrade between 1995 and 2019.

These results indicate a process of convergence where the least successful countries in economic emergence are catching up with the most successful ones, with the distribution evolving towards one with lower frequencies at the extremes, as clearly indicated by the stationary distribution (see Table 7). The distribution is, therefore, likely to have fewer disparities over the long term, with a concentration of countries in the higher categories.

However, the convergence to the stationary distribution is rather slow. The asymptotic half-life is estimated at 2.1 periods. Since the period is 24 years, this implies that it will take about 50.4 years to halve the distance between the current distribution and the stationary or long-term distribution.

These results are consistent with the beta convergence process in economic emergence detected above, between the countries in the sample over the period 1995-2019. On the other hand, whilst the analysis of dispersion indicators did not lead to the conclusion of a sigma convergence process, the examination of the distribution by the Markov chain method reveals important movements that these measures failed to detect.

The dynamics of the transition are not necessarily constant over time and different time periods may be characterised by more or less rapid movements within the distribution. One way to examine this issue is to decompose the period into different sub-periods and check whether the dynamics change from one sub-period to another. Thus, we complete the analysis by considering the two sub-periods 1995-2007 and 2007-2019.

Tables 8 to 11 show the transition matrices for the two sub-periods and the summary statistics for the respective transition probability matrices.

Although the stationary distributions are identical between the two sub-periods, the speed of the convergence process is by far higher for the first sub-period, with a half-life of 1.8 for the 1995-2007 sub-period against a half-life of 39.4 for the 2007-2019 sub-period. Indeed, the convergence process has slowed down considerably in the second period compared to the previous one. The transition matrix associated with the second period shows strong persistence of the classes, with the diagonal elements showing the highest values for all classes (see Table 10). Persistence is also evidenced by the relatively high value of the associated stability indicator, which stands at 0.77 compared to 0.60 for the first sub-period.

**Table 8: Transition matrix over the period 1995-2007**

| | | 1995 | | | |
|---|---|---|---|---|---|
| | | EMGE | EMGEANT | PRE EMG | IMG |
| 2007 | EMGE | 100% | 54% | 0% | 0% |
| | EMGEANT | 0% | 46% | 71% | 2% |
| | PRE EMG | 0% | 0% | 26% | 32% |
| | IMG | 0% | 0% | 3% | 66% |

**Source**: Authors' calculations

**Table 9: Convergence indicators associated with the transition matrix 1995-2007**

| Stationary or long-term distribution | EMGE | EMGEANT | PRE EMG | IMG |
|---|---|---|---|---|
| | 100% | 0 | 0 | 0 |
| Half-life of convergence | 1.8 periods or 13 years | | | |
| Stability index | 0.60 | | | |

**Source**: Authors' calculations

**Table 10: Transition matrix over the period 2007-2019**

| | | 2007 | | | |
|---|---|---|---|---|---|
| | | EMGE | EMGEANT | PRE EMG | IMG |
| 2019 | EMGE | 100% | 24% | 0% | 0% |
| | EMGEANT | 0% | 55% | 9% | 0% |
| | PRE EMG | 0% | 21% | 70% | 16% |
| | IMG | 0% | 0% | 22% | 84% |

**Source**: Authors' calculations

**Table 11: Convergence indicators associated with the transition matrix 2007-2019**

| Stationary or long-term distribution | EMGE | EMGEANT | PRE EMG | IMG |
|---|---|---|---|---|
| | 100% | 0 | 0 | 0 |
| Half-life of convergence | 39.4 periods or 13-years | | | |
| Stability index | 0.77 | | | |

**Source**: Authors' calculations

## IV.Determinants of « economic emergence » classes

The results of the previous section highlight the slow pace of the convergence process. In this section, we identify the factors that determine the positioning of a country in one of the four “economic emergence” classes. To this end, we develop a model, in order to calculate the probability that a given country belongs to an “economic emergence” class, conditional on its performance on a set of factors. To this end, we estimate an ordered Probit model (see Box 4) with the “economic emergence” class associated with the ISEME score, as the dependent variable. The ordered Probit model has the advantage of taking into account the existence of an order between the “economic emergence” classes. The explanatory variables of the model are selected according to the procedure described below.

- **Presentation of the ordered Probit model**

The ordered Probit model is estimated based on a latent variable regression y* such that

$$y_i^* = \boldsymbol{X_i'}\beta + U_i$$

The vector X' contains the explanatory variables for the probability of belonging to each of the "emergence classes" $y_i$

The relationship between the observed variable y and the unobserved variable y* follows the following rule:

$$y_i = j \; si \; \alpha_{j-1} < y_i^* \leq \alpha_j$$

The thresholds $\alpha_j$ are estimated simultaneously with the β coefficients of the model.

The probabilities of belonging to the "economic emergence" classes are estimated as follows

$$p_{ij} = p(y_i = j) = p(\alpha_{j-1} < y_i^* \leq \alpha_j) = F\left(\alpha_j - \boldsymbol{X_i'}\beta\right) - F(\alpha_{j-1} - \boldsymbol{X_i'}\beta)$$

where F is the standard normal cdf.

The ordered probit model with j alternatives will have j sets of marginal effects. Marginal effects reflect the effects of an additional unit of each explanatory variable on the probabilities of belonging to each "economic emergence" class. Each additional unit in the independent variable increases/decreases the probability of selecting alternative j by the marginal effect expressed as a percentage.

$$\frac{\partial p_{ij}}{\partial X_{ri}} = \left\{F'(\alpha_{j-1} - X_i^*\beta) - F'(\alpha_j - X_i^*\beta)\right\}\beta_r$$

The sum of the marginal effects of each variable on the different alternatives is equal to zero.

- **Choice of explanatory variables**

The choice of variables is made in two steps. First, the 48 indicators that make up the Composite "Index of Levers of Economic Emergence" (ICLE), constructed by SY et LO (2021), are chosen. The ICLE aims to monitor the level of achievement of the prerequisites for "economic emergence". Indeed, the "economic emergence" of a nation is contingent on the implementation of proactive policy reforms, to achieve a level of structural competitiveness comparable to that of currently emerged countries (SY et LO, 2021), following the conditional convergence theory requirements.

A country's structural competitiveness refers to its ability to produce a quality product that is likely to be successful on domestic and foreign markets. It goes beyond the mere ability to offer competitive prices. It requires, amongst other things, a world-class business environment, good governance, productive human capital, standard infrastructure, a deep financial system and the development of technological innovations. These 48 indicators, grouped into six dimensions (see Table 13 in the annexes), are, as far as possible, factors in which public reforms act directly. They are mostly raw data and come from three different and reliable sources: the World Bank's WDI database, the World Economic Forum and the Bertelsmann Stiftung's database.

In a second step, given the relatively large number of potential explanatory variables, we perform multi-collinearity analyses to retain only those variables with sufficiently low multi-collinearity. We rely on the so-called variance inflation factors (VIFs) to detect multi-collinearity. In order to select a set of variables with sufficiently low multi-collinearity, we implement a step-by-step selection, starting with the variable with the largest VIF. This is done by calculating the VIF values for the complete set of explanatory variables, after which the variable with the highest VIF is removed. Then the VIF values are recalculated for the reduced set of variables. This is repeated, until the largest VIF is below a threshold VIF value (set at 5). After this operation, we retained 26 explanatory variables from the initial list of 48 indicators.

- **Implementation of the ordered Probit model**

The ordered Probit model was estimated in cross-section, on a sample of 84 countries and over four years (336 observations). The dependent variable indicates whether each country belongs to one of the four "economic emergence" categories. The explanatory variables are lagged by five years in the model specification. Indeed, it is reasonable to consider that for a given country, the effects on its level of economic emergence on changes in competitiveness factors take time to materialise. The data on the explanatory variables are available for the years 2005, 2010, 2012 and 2015. The data on the "emergence class" variable used to estimate the model are, therefore, for the years 2010, 2015, 2017 and 2019. The explanatory variables were previously standardised (division by the respective standard deviations).

In order to have a parsimonious model, the specification was estimated using the stepwise regression method. Stepwise regression (or backward elimination) is a method of variable selection that starts with a model containing all the variables under consideration (called the full model) and then starts to remove the least significant variables one after the other, until a pre-specified stopping rule is reached, or until no variables remain in the model.

The stopping rule is satisfied when all remaining variables in the model have a p-value below a predefined threshold.

When this state is reached, backwards elimination ends and returns the model from the stage. The predefined threshold can be a fixed value, determined by AIC (Akaike Information Criterion) or BIC (Bayesian Information Criterion).

Table 14 in the annexes summarises the results of the estimates from the ordered Probit model, estimated using the backward step method with a threshold determined by the BIC criterion. The factors that stand out are the rate of access to secondary education, the quality of infrastructure, logistical performance, the cost of access to finance through the level of bank deposit rates, the research and development effort of companies, transaction costs through the cost of enforcing a contract and the quality of the anti-monopoly policy.

For all these variables, the marginal effects are larger in the class of "immersed" countries (see table 14 in the annexes). For example, an improvement of one additional unit (of one standard deviation, given that the explanatory variables have been standardised beforehand) in the gross secondary school enrolment rate, logistical performance and the cost of credit (decline) respectively reduces the probability of belonging to the "immersed" class by 18%, 14% and 9% respectively. In comparison, for the "emerging" countries, improvements of the same magnitude on the same variables, lead to a decrease in the probability of belonging to this class by 16%, 11% and 8% respectively (see table 14 in the annexes).

## Conclusions and policy implications

This study proposed an alternative approach to an analysis of the dynamics of convergence of economic performance based on a single criterion (GDP per capita). Indeed, it provided a multi-dimensional analysis of convergence or divergence processes based on a synthetic measure of "economic emergence".

A synthetic index of economic emergence, calculated on 93 developing countries between 1995 and 2019, was used to determine the dynamics of the process leading to the reduction of gaps in "economic emergence" performances within the sample countries. The results of the Markov chain analysis indicate that, albeit at a slow pace, a process of convergence has occurred between the countries in the sample, over the period considered.

These results are consistent with the process of beta convergence in "economic emergence" detected between the countries in the sample over the period 1995-2019. On the other hand, whilst the analysis of the dispersion indicators did not lead to the conclusion of a sigma convergence process, the examination of the distribution by the Markov chain method reveals important movements that these measures failed to detect.

An ordered Probit model has shown that certain factors have a positive impact on the probability of being positioned in the upper "economic emergence" classes, notably human capital through access to secondary education, the quality of infrastructure, the cost of access to finance, the research and development effort of companies, and transaction costs through the cost of enforcing a contract.

These results underline the crucial importance of policies and institutions favourable to "economic emergence". Developing countries must make it a priority to raise the level of education of their population. Education affects a country's productivity in three ways (Grant et al. 2017). First, it increases the collective ability of the workforce to carry out existing tasks more quickly. Second, secondary and tertiary education especially facilitate the transfer of knowledge about new information, products and technologies created by others (Barro and Lee 2010). Finally, by increasing creativity, it boosts a country's own capacity to create new knowledge, products and technologies.

Universal primary education, which was the priority of many developing countries because of the emphasis placed on it by the Millennium Development Goals, is important but insufficient. Investment in secondary education provides a far greater boost to economic development than that achieved by universal primary education alone (Grant et al 2017). It should be complemented by the goal of ensuring that large segments of the population have completed at least lower secondary education (IIASA 2008). In this sense, the focus of the Sustainable Development Goals (SDGs) on secondary education shows a greater awareness of its importance.

This analysis also finds a key role for policies that can promote access to finance. Financial under-development has long been identified as a crucial impediment to economic development, both because it reduces the level of aggregate investment and employment (Fonseca et al. 2021, Fonseca et al. 2022) and because it distorts the allocation of capital across firms and talented entrepreneurs (Fonseca et al. 2022, Buera et al. 2011, Bau et al. 2020). Levine (2008) and Fonseca et al. (2021) describe four main mechanisms through which finance can promote economic development: (i) the pooling of savings through risk diversification and risk management; (ii) the facilitation of exchange through the reduction of transaction costs; (iii) the improvement of capital allocation through the production of ex ante information about investment opportunities; and (iv) the increase of investors' willingness to finance new projects through ex post monitoring and corporate governance.

Another key policy implication of the analysis is that developing countries need to build traditional infrastructure, such as those in transportation that contribute significantly to economic growth. Infrastructure development is important and necessary for industrial lift-off and economic growth.

At the macro level, infrastructure investment can contribute to economic growth directly as an input factor and indirectly by increasing the total factor productivity (TFP) through its scale and network effects (Zhang et al. 2022). At the micro level, infrastructure investment can help improve the technical efficiency of enterprises, by reducing their operating and inventory cost (Paul et al. 2004, Shirley et al. 2004, Zhang et al. 2022)

Developing countries must also strive to increase research and development efforts. Research and Development (R&D) is one of the most important variables that affect a country's economic growth and development through increasing technological capabilities, enlargement of the resource base and promoting the capability of resource utilisation (Ildırar et al. 2016,). Policy makers could employ several measures to promote local technological capabilities, including the establishment of public R&D institutes, as well as conditional subsidies for public and private R&D.

The analysis has focused on the dynamics of the internal convergence process, i.e., between the countries in the sample. Further research is needed to analyse whether the developing countries in the study, as a whole, have shown a process of external convergence, i.e., towards countries that are at a more advanced stage of development.

## Bibliography


1. Abramovitz, M. (1986). Catching Up, Forging Ahead, and Falling Behind. The Journal of Economic History,46, 385-406.
2. Barro, R. & Sala-i-Martin, X. (1992). Convergence. Journal of Political Economy, 100(2), 223- 251.
3. Barro, R. (1991). Economic Growth in a Cross-Section of Countries. Quarterly Journal of Economics, 106(2), 407-443.
4. Barro, R. J. and J.-W. Lee. (2010) "A New Dataset of Educational Attainment in the World, 1950– 2010." NBER Working Paper No. 15902. Cambridge, MA: National Bureau of Economic Research.
5. Bau, Natalie, and Adrien Matray. 2020. "Misallocation and Capital Market Integration: Evidence from India." NBER Working Paper No. 27955.
6. Baumol, R. & Lee, J.W. (1994). Sources of Economic Growth. Carnegie-Rochester Conference Series on Public Policy, 40,1-46.
7. Baumol, W.J. (1986). Productivity growth, convergence, and welfare: what the long-run data show. American Economic Review, 76,1072-1085.
8. Beck, Thorsten, and Ross Levine, eds. 2018. Handbook of finance and development [in English]. Northampton, MA: Edward Elgar Publishing.
9. Buera, Francisco, Joseph Kaboski, and Yongseok Shin. 2011. "Finance and Development: A Tale of Two Sectors." American Economic Review 101 (5): 1964–2002.
10. Du, X.; Zhang, H.; Han, Y. How Does New Infrastructure Investment Affect Economic Growth Quality? Empirical Evidence from China. Sustainability 2022, 14, 3511. https://doi.org/10.3390/su14063511
11. Fernandes, A.M.; Isgut, A. 2005. Learning-by-doing, learning-by-exporting, and productivity: Evidence from Colombia, Working Paper No. 3544 (Washington, DC, World Bank).
12. Fonseca, J and A Matray (2021), "The Real Effects of Banking the Poor: Evidence from Brazil", CEPR Discussion Paper 16798.
13. Fortunato, Piergiuseppe and Carlos Razo (2014) 'Export sophistication, growth and the middle-income trap'
14. Grant, C. (2017). The Contribution of Education to Economic Growth. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies.

**15.** IASA (2008) Economic Growth in Developing Countries: Education Proves Key, Policy Brief

**16.** Ildırar et al. (2016), The Effect of Research and Development Expenditures on Economic Growth: New Evidences, International Conference on Eurasian Economies 2016

**17.** Imbs, J.; Wacziarg, R. 2003. "Stages of diversification", in The American Economic Review, Vol. 93, No. 1, pp. 63-86.

**18.** Jerzmanowski, M. 2006. "Empirics of hills, plateaus, mountains and plains: A Markov-switching approach to growth," in Journal of Development Economics, Vol. 81, No. 2, pp. 357-385

**19.** Konya, Laszlo & Guisan, Maria-Carmen, 2008. "What Does The Human Development Index Tell Us About Convergence?" Applied Econometrics and International Development, Euro-American Association of Economic Development, vol. 8(1), pages 19-40.

**20.** Kuznets, S (1955), "Economic growth and income inequality", American Economic Review

**21.** Magrini, S. (2004), "Regional (Di)Convergence", in Henderson, J. V. and Thisse, J.-F. (eds.) Handbook of Regional and Urban Economics, Amsterdam et al, Elsevier, 2741-2796

**22.** Mankiw, N., Romer, D., & Weil, D. (1992). A Contribution to the Empirics of Economic Growth. Quarterly Journal of Economics, 107(2), 407-437.

**23.** Mazumdar, K. (2002): A Note on Cross-Country Divergence in Standard of Living, Applied Economics Letters, vol. 9, pp. 87-90.

**24.** Mensah, Portia, "Growth Convergence Across Countries and Regions in the Long Run: An Empirical Study Using Panel Analysis (1980-2018)" (2020). Masters Theses. 4829.

**25.** Miller, S. M., & Upadhyay, M. P. (2002). Total Factor Productivity and Convergence Hypothesis. Journal of Macroeconomics, 24, 267-28

**26.** Moubarack Lô (2017), "Emergence économique des Nations: Definition and measurement", Ed. Harmattan, March 2017

**27.** Moubarack Lô and Amaye Sy (2021), "Manuel de l'émergence économique", Harmattan Senegal, January 2021

**28.** Nelson, R.R.; Winter, S.G. 1982. An evolutionary theory of economic change, Belknap Press Series, Vol. 93 (Cambridge, MA, Harvard University Press).

**29.** Noorbakhsh, F. (2006): International Convergence or Higher Inequality in Human Development? Evidence from 1975 to 2002, Research Paper, No. 2006/15, United Nations University, World Institute of Development Economics Research.

**30.** Paprotny D. Convergence Between Developed and Developing Countries: A Centennial Perspective. Soc Indic Res. 2021;153(1):193-225. doi: 10.1007/s11205-020-02488-4. Epub 2020 Sep 14. PMID: 32952263; PMCID: PMC7487265.

**31.** Paprotny D. Measuring Central and Eastern Europe's socio-economic development using time lags. Social Indicators Research. 2016;127(3):939–957. doi: 10.1007/s11205-015-0991-9. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

**32.** Paprotny D. Poziom rozwoju Polski w relacji do państw zachodnich. The Polish Statistician. 2014;59(3):48–65. [Google Scholar]

**33.** Paul, J.P.; Paul, C.J.M. Public Infrastructure Investment, Interstate Spatial Spillovers, and Manufacturing Costs. Rev. Econ. Stat. 2004, 86, 551–560.

**34.** Philippe Monfort (2008) "Convergence of EU Regions: Measures and Evolution", European Commission, Regional Policy, 2008

**35.** Quah Danny (1993). Galton's fallacy and tests of the convergence hypothesis. The Scandinavian Journal of Economics

**36.** Quah, D. (1996), "Empirics for Economic Growth and Convergence", European Economic Review, 40, 1353-1375.

**37.** Shirley, C.; Winston, C. Firm inventory behavior and the returns from highway infrastructure investments. J. Urban Econ. 2004, 55, 398–415. [CrossRef]

**38.** Solow, R. M., (1956). A Contribution to the Theory of Economic Growth. The Quarterly Journal of Economics, 70(1), 65-94.

**39.** Sutcliffe, B. (2004): World Inequality and Globalization, Oxford Review of Economic Policy, vol. 20, pp. 15-37.

**40.** Varblane, U., Vahter, P. (2005). An analysis of the economic convergence process in the transition countries. (Unpublished master thesis). University of Tartu. Tartu university press

**41.** WILLIAMSON J.G. (1965) Regional inequality and the process of national development: a description of the patterns, Economic and Cultural Change.

## Annexes

- **ISEME construction methodology**

ISEME consists of four dimensions. Formally, for a country i, let us note Ik(i) the sub index measuring dimension k (the method of calculating Ik will be specified later), the ISEME formula for country i is given by:

$$ISEME(i) = \left[ \frac{1}{\sum_{k=1}^{m} \lambda_k} \sum_{k=1}^{m} \lambda_k I_k^{\alpha}(i) \right]^{\frac{1}{\alpha}}$$

Where

- m is the number of dimensions (here m is equal to 4).
- α, which is a non-zero real number, is chosen by simulation. This simulation consists of finding a value of α such that the ISEME is relatively robust to a small variation in α. Note also, that α allows us to measure the degree of substitutability of the different components of the ISEME.
- $\lambda_k$ is the weight of the k-dimension of the emergence. This weight is determined by the factor analysis. According to the Multifactorial Analysis Theory (MFA), $\lambda_k$ can be estimated from the first partial eigenvalues from the Principal Component Analysis (PCA) of dimension k.

The choice of the functional form of ISEME can be justified by its good properties, namely:

- The ISEME is strictly increasing with respect to each of its components (when a country improves one of its dimensions of emergence, then its final level of emergence increases).
- The ISEME is convex with respect to each of the components, which means that it increases the faster the situation in any of its dimensions improves
- The variation in one component may more or less compensate for the variation in another component in the final ISEME measure. In fact, the sub-indices are constructed to have comparable dispersions and levels
- The ISEME is not swallowed up by the variation of any of its components. The elasticity of the indicator, with respect to a component, is equal to the relative share of that component in the sum of the components. The components are comparable in level and variation. Therefore, the size of the change in the ISEME

due to the change, in only one of its components, respects certain constraints, such as the a priori equity between components,

- Note that when α is positive (and the higher it is), the elasticity of the index with respect to one of the components is all the greater, as this component has a high value in relation to the others. Such a behaviour will be desired if we consider that the emergence should be dominated, including in terms of variations, by its strongest component. That is, for positive and high α, one tends to conclude that the country is emerging as soon as one of its emergence dimensions has a very high value (minimal risk aversion approach to declare a country as emerging, when it is not)
- On the contrary, when α is negative, and all the more so when its absolute value is high, the variations of the index will be dominated by those of its component with the lowest value (maximum risk aversion perspective of declaring a country as emerging, when it is not),
- These two situations are very attenuated in our case, on the one hand because the ISEME components are comparable in mean and variance, on the other hand because they only occur for a very large α.

The calculation of the ISEME(i) requires knowledge of Ik(i). The calculation method used to evaluate Ik(i) is discussed in the next section.

To construct the sub-indices (wealth, dynamism, transformation and insertion) of the ISEME, we used Principal Components Analysis (PCA). This method corresponds well to the structure of the data (a set of individuals described by quantitative variables). The aim is to quantify the different dimensions.

For this purpose, the following method was used:

For a given dimension (e.g., economic dynamism), a PCA on all the variables of the dimension is performed (atypical individuals - if any - are added). Then, the interpretation of the axes guides us in the construction of the sub-index. Depending on the results of the PCA, the sub-index is based on one or more axes. In the latter case, the construction of the sub-index also involves the combination of several indices. The number of these indices used in the construction of the dimension index is the empirical dimension of the dimension.

$$\mathbf{I_k(i) = \sum_{i=1}^{T} C_t^j V_t^i}$$

The empirical dimension is the number of groups of variables correlated to a given axis of the PCA. For a set of variables correlated to a given axis j, the aspect of emergence referring to this axis is written:

Where $V^{(t,i)}$ is the value of the variable t for country i, Cj is the coordinate of the variable t on the axis j in question

At all levels of aggregation, it has to be taken into account that the result of the aggregation could be swallowed up by one or a few variables. For example, the Vt variables have to be brought to a comparable situation in terms of level and variability. For this purpose, indicators that should be normalised can be chosen.

The Min-Max normalisation method is used:

$$V_t^* \rightarrow \frac{V_t - MinV}{MaxV - MinV}$$

**Table 12: ISEME score of the sample countries in 1995, 2007 and 2019**

| Status 2019 | Rank 2019 | Country | 2019 | 2007 | 1995 |
|---|---|---|---|---|---|
| Emerged | 1 | Ireland | 0.957 | 0.882 | 0.822 |
| | 2 | Czech Republic | 0.883 | 0.878 | 0.697 |
| | 3 | Hungary | 0.865 | 0.800 | 0.619 |
| | 4 | Malaysia | 0.861 | 0.828 | 0.781 |
| | 5 | China | 0.850 | 0.796 | 0.674 |
| | 6 | Slovakia | 0.843 | 0.836 | 0.659 |
| | 7 | Romania | 0.838 | 0.706 | 0.568 |
| | 8 | Estonia | 0.805 | 0.746 | 0.631 |
| | 9 | Lithuania | 0.805 | 0.742 | 0.566 |
| | 10 | Israel | 0.798 | 0.788 | 0.729 |
| | 11 | Thailand | 0.777 | 0.785 | 0.672 |
| | 12 | Turkey | 0.772 | 0.723 | 0.580 |
| | 13 | Mexico | 0.772 | 0.759 | 0.665 |
| | 14 | Portugal | 0.765 | 0.667 | 0.657 |
| | 15 | Bulgaria | 0.762 | 0.666 | 0.503 |
| | 16 | Vietnam | 0.760 | 0.660 | 0.540 |

| | | | | | |
|---|---|---|---|---|---|
| **Emerging** | **17** | **Dominican Republic** | 0.727 | 0.698 | 0.521 |
| | **18** | **Serbia** | 0.715 | 0.651 | 0.599 |
| | **19** | **Saudi Arabia** | 0.710 | 0.722 | 0.534 |
| | **20** | **Panama** | 0.710 | 0.570 | 0.546 |
| | **21** | **Indonesia** | 0.685 | 0.644 | 0.598 |
| | **22** | **Qatar** | 0.678 | 0.735 | 0.661 |
| | **23** | **India** | 0.659 | 0.602 | 0.497 |
| | **24** | **Chile** | 0.643 | 0.716 | 0.639 |
| | **25** | **Cyprus** | 0.636 | 0.620 | 0.620 |
| | **26** | **Morocco** | 0.632 | 0.606 | 0.495 |
| | **27** | **Uruguay** | 0.620 | 0.637 | 0.574 |
| | **28** | **Kuwait** | 0.619 | 0.652 | 0.585 |
| | **29** | **Paraguay** | 0.616 | 0.509 | 0.506 |
| | **30** | **Kazakhstan** | 0.616 | 0.613 | 0.515 |
| | **31** | **Maurice** | 0.616 | 0.605 | 0.567 |
| | **32** | **Brazil** | 0.610 | 0.645 | 0.589 |
| | **33** | **Egypt** | 0.610 | 0.614 | 0.532 |
| | **34** | **Greece** | 0.606 | 0.660 | 0.599 |
| | **35** | **Argentina** | 0.600 | 0.727 | 0.629 |
| **Pré Emerging** | **36** | **Ukraine** | 0.588 | 0.706 | 0.551 |
| | **37** | **Jordan** | 0.586 | 0.655 | 0.547 |
| | **38** | **Peru** | 0.581 | 0.584 | 0.474 |
| | **39** | **South Africa** | 0.574 | 0.603 | 0.498 |
| | **40** | **Iran** | 0.566 | 0.567 | 0.461 |
| | **41** | **Gabon** | 0.564 | 0.509 | 0.443 |
| | **42** | **El Salvador** | 0.564 | 0.537 | 0.490 |
| | **43** | **Cambodia** | 0.564 | 0.512 | 0.297 |
| | **44** | **Tunisia** | 0.553 | 0.614 | 0.531 |
| | **45** | **Tajikistan** | 0.550 | 0.458 | 0.401 |
| | **46** | **Azerbaijan** | 0.544 | 0.600 | 0.373 |
| | **47** | **Albania** | 0.542 | 0.570 | 0.326 |
| | **48** | **Honduras** | 0.537 | 0.526 | 0.415 |
| | **49** | **Armenia** | 0.522 | 0.570 | 0.377 |
| | **50** | **Botswana** | 0.514 | 0.602 | 0.450 |
| | **51** | **Equatorial Guinea** | 0.509 | 0.579 | 0.447 |
| | **52** | **Fiji** | 0.508 | 0.458 | 0.404 |
| | **53** | **Senegal** | 0.504 | 0.446 | 0.372 |

| | | | | | |
|---|---|---|---|---|---|
| **Potentially emerging** | **54** | **Djibouti** | 0.494 | 0.407 | 0.366 |
| | **55** | **Lesotho** | 0.471 | 0.472 | 0.376 |
| | **56** | **Pakistan** | 0.470 | 0.488 | 0.439 |
| | **57** | **Ivory Coast** | 0.458 | 0.358 | 0.325 |
| | **58** | **Cape Verde** | 0.458 | 0.494 | 0.492 |
| | **59** | **Uganda** | 0.455 | 0.400 | 0.286 |
| | **60** | **Congo, Republic of the** | 0.454 | 0.457 | 0.357 |
| | **61** | **Tanzania** | 0.451 | 0.378 | 0.265 |
| | **62** | **Ghana** | 0.450 | 0.351 | 0.307 |
| | **63** | **Congo, DRC** | 0.448 | 0.387 | 0.240 |
| | **64** | **Jamaica** | 0.444 | 0.415 | 0.504 |
| | **65** | **Syria** | 0.444 | 0.542 | 0.466 |
| | **66** | **Ethiopia** | 0.443 | 0.307 | 0.195 |
| | **67** | **Zambia** | 0.442 | 0.416 | 0.350 |
| | **68** | **Mongolia** | 0.433 | 0.482 | 0.371 |
| | **69** | **Central African Republic** | 0.432 | 0.314 | 0.295 |
| | **70** | **Mauritania** | 0.430 | 0.418 | 0.343 |
| | **71** | **Namibia** | 0.430 | 0.544 | 0.456 |
| | **72** | **Madagascar** | 0.425 | 0.370 | 0.299 |
| | **73** | **Algeria** | 0.422 | 0.523 | 0.425 |
| | **74** | **Guinea** | 0.421 | 0.346 | 0.304 |
| | **75** | **Togo** | 0.415 | 0.338 | 0.286 |
| | **76** | **Kenya** | 0.405 | 0.387 | 0.334 |
| | **77** | **Venezuela** | 0.402 | 0.561 | 0.441 |
| | **78** | **Angola** | 0.401 | 0.433 | 0.282 |
| | **79** | **Cameroon** | 0.392 | 0.370 | 0.312 |
| | **80** | **Nigeria** | 0.379 | 0.442 | 0.391 |
| | **81** | **Rwanda** | 0.378 | 0.277 | 0.262 |
| | **82** | **Benin** | 0.367 | 0.317 | 0.237 |
| | **83** | **Niger** | 0.363 | 0.303 | 0.219 |
| | **84** | **Mozambique** | 0.363 | 0.344 | 0.256 |
| | **85** | **Mali** | 0.360 | 0.309 | 0.240 |
| | **86** | **Zimbabwe** | 0.357 | 0.320 | 0.396 |

| | | | | | |
|---|---|---|---|---|---|
| **Under-developed** | **87** | **Burkina Faso** | 0.,345 | 0.285 | 0.251 |
| | **88** | **Gambia** | 0.319 | 0.261 | 0.328 |
| | **89** | **Chad** | 0.318 | 0.377 | 0.252 |
| | **90** | **Sudan** | 0.317 | 0.362 | 0.266 |
| | **91** | **Malawi** | 0.304 | 0.290 | 0.264 |
| | **92** | **Burundi** | 0.221 | 0.247 | 0.203 |
| | **93** | **Sierra Leone** | 0.200 | 0.249 | 0.243 |

**Table 13: List of the ICLE indicators**

| Dimension | Indicators | Source |
|---|---|---|
| **Business environment** | Control of corruption: Estimation | WDI |
| | Customs and other import duties (% of tax revenue) | WDI |
| | Obtaining building permits: time (days) | WDI |
| | Cost of enforcing contracts (% of claim) | WDI |
| | Enforcing contracts: Enforcing the judgment (days) | WDI |
| | Density of new businesses (new registrations per 1,000 people aged 15-64) | WDI |
| | Tax payments (number per year) | WDI |
| | Quality of regulation: score | WDI |
| | Solving insolvency: recovery rate (cents on the dollar) | WDI |
| | Rule of Law Index | WDI |
| | Tariff rate, applied, weighted average, all products (%) | WDI |
| | Tariff rate, applied, weighted average, manufactured products (%) | WDI |
| | Tax payments (cost) | WDI |
| | Foreign trade (% of GDP) | WDI |
| | Vulnerable employment, total (% of total employment) | WDI |
| | Index of the degree of competition | BTI[5] |
| | Anti-Monopoly Policy Index | BTI |
| | Foreign Trade Liberalisation Index | BTI |
| | Money and Price Stability Index | BTI |
| | Private Property Index | BTI |
| | Anti-Corruption Policy Index | WDI |

[5] Bertelsmann Transformation Index (BTI) database of the Bertelsmann Stiftung

| | | |
|---|---|---|
| **INFRASTRUCTURES** | Fixed broadband subscriptions (per 100 people) | WDI |
| | Logistics Performance Index | WDI |
| | People using basic drinking water services (% of population) | WDI |
| | People using basic health services (% of population) | WDI |
| | Railway Infrastructure Quality Index | WDI |
| | Number of secure Internet servers (per 1 million people) | WDI |
| **STATE EFFICIENCY** | Environmental Policy Index | WDI |
| | Government Effectiveness Index | WDI |
| | Indication of the state's monopoly on the use of force | BTI |
| | Quality Index of the Administration | BTI |
| | Index Defaulting state | BTI |
| **HUMAN CAPITAL** | Life expectancy at birth, total (years) | WDI |
| | Literacy rate, total adults | WDI |
| | Maternal mortality ratio (per 100,000 live births) | WDI |
| | Prevalence of undernourishment (% of population) | WDI |
| | Ratio of female to male activity rates (%) | WDI |
| | Secondary school enrolment (% gross) | WDI |
| | Tertiary enrolment (% gross) | WDI |
| | Social Protection Index | WDI |
| | Education and Research / R&D Policy Index | BTI |
| **INNOVATION** | Research and development expenditure (% of GDP) | WDI |
| | Researchers in R&D (per million people) | WDI |
| | Innovation Capacity Index | WEF[6] |
| | Business expenditure on research and development | WDI |
| **FINANCE** | Number of ATMs per 100,000 adults | WDI |
| | Domestic credit provided by the financial sector (% GDP) | WDI |
| | Interest rates on deposits | WDI |

[6] World Economic Forum

**Table 14: Estimation results from the ordered Probit model, estimated using the backward step method with a threshold determined by the BIC criterion.**

| Variable | Coefficient | Standard deviation | t value | p value | Significance |
|---|---|---|---|---|---|
| Customs and other import duties (% of tax revenue) | -0.373 | 0.135 | -2.767 | 5.65E-03 | *** |
| Interest rates on deposits | -0.576 | 0.136 | -4.229 | 2.35E-05 | *** |
| Cost of enforcing contracts (% of claim) | -0.628 | 0.206 | -3.041 | 2.36E-03 | *** |
| Logistics Performance Index | 0.888 | 0.201 | 4.409 | 1.04E-05 | *** |
| Railway Infrastructure Quality Index | 0.381 | 0.147 | 2.593 | 9.51E-03 | *** |
| Anti-Monopoly Policy Index | 0.441 | 0.158 | 2.786 | 5.33E-03 | *** |
| Business expenditure on research and development | 0.462 | 0.162 | 2.858 | 4.27E-03 | *** |
| Secondary school enrolment (% gross) | 1.217 | 0.207 | 5.872 | 4.31E-09 | *** |
| **The thresholds associated with the latent variable** | **Coefficient** | **Standard deviation** | **t value** | **p value** | **Significance** |
| 1\|2 | -1.451 | 0.195 | -7.424 | 1.13E-13 | *** |
| 2\|3 | 1.575 | 0.208 | 7.563 | 3.95E-14 | *** |
| 3\|4 | 4.453 | 0.339 | 13.122 | 2.48E-39 | *** |

| Marginal effects | Coefficient | Standard deviation | t value | p value | Significance |
|---|---|---|---|---|---|
| **Immerged Country Class** | | | | | |
| Customs and other import duties (% of tax revenue) | 0.057 | 0.021 | 2.732 | 7.00E-03 | *** |
| Interest rates on deposits | 0.089 | 0.022 | 3.947 | 0.00E+00 | *** |
| Cost of enforcing contracts (% of claim) | 0.097 | 0.035 | 2.771 | 6.00E-03 | *** |
| Logistics Performance Index | -0.137 | 0.032 | -4.335 | 0.00E+00 | *** |
| Railway Infrastructure Quality Index | -0.059 | 0.023 | -2.590 | 1.00E-02 | *** |
| Anti-Monopoly Policy Index | -0.068 | 0.025 | -2.704 | 7.00E-03 | *** |
| Business expenditure on research and development | -0.071 | 0.026 | -2.693 | 7.00E-03 | *** |
| Secondary school enrolment (% gross) | -0.187 | 0.036 | -5.197 | 0.00E+00 | *** |
| **Pre-Emerging Countries Class** | **Coefficient** | **Standard deviation** | **t value** | **p value** | **Significance** |
| Customs and other import duties (% of tax revenue) | -0.004 | 0.010 | -0.442 | 6.59E-01 | |
| Interest rates on deposits | -0.007 | 0.015 | -0.440 | 6.60E-01 | |
| Cost of enforcing contracts (% of claim) | -0.007 | 0.017 | -0.426 | 6.71E-01 | |
| Logistics Performance Index | 0.010 | 0.023 | 0.445 | 6.56E-01 | |

| | | | | | |
|---|---|---|---|---|---|
| Railway Infrastructure Quality Index | 0.004 | 0.010 | 0.443 | 6.58E-01 | |
| Anti-Monopoly Policy Index | 0.005 | 0.012 | 0.437 | 6.63E-01 | |
| Business expenditure on research and development | 0.005 | 0.012 | 0.434 | 6.64E-01 | |
| Secondary school enrolment (% gross) | 0.014 | 0.032 | 0.438 | 6.62E-01 | |
| **Emerging Countries Class** | **Coefficient** | **Standard deviation** | **t value** | **p value** | **Significance** |
| Customs and other import duties (% of tax revenue) | -0.049 | 0.019 | -2.604 | 1.00E-02 | *** |
| Interest rates on deposits | -0.075 | 0.020 | -3.792 | 0.00E+00 | *** |
| Cost of enforcing contracts (% of claim) | -0.082 | 0.027 | -2.997 | 3.00E-03 | *** |
| Logistics Performance Index | 0.116 | 0.030 | 3.835 | 0.00E+00 | *** |
| Railway Infrastructure Quality Index | 0.050 | 0.020 | 2.455 | 1.50E-02 | ** |
| Anti-Monopoly Policy Index | 0.058 | 0.022 | 2.652 | 8.00E-03 | *** |
| Business expenditure on research and development | 0.060 | 0.022 | 2.696 | 7.00E-03 | *** |
| Secondary school enrolment (% gross) | 0.159 | 0.030 | 5.336 | 0.00E+00 | *** |

| Emerged Countries Class | Coefficient | Standard deviation | t value | p value | Significance |
|---|---|---|---|---|---|
| Customs and other import duties (% of tax revenue) | -0.004 | 0.002 | -2.194 | 2.90E-02 | ** |
| Interest rates on deposits | -0.007 | 0.002 | -2.783 | 6.00E-03 | *** |
| Cost of enforcing contracts (% of claim) | -0.007 | 0.003 | -2.404 | 1.70E-02 | ** |
| Logistics Performance Index | 0.010 | 0.004 | 2.867 | 4.00E-03 | *** |
| Railway Infrastructure Quality Index | 0.004 | 0.002 | 2.104 | 3.60E-02 | ** |
| Anti-Monopoly Policy Index | 0.005 | 0.002 | 2.269 | 2.40E-02 | ** |
| Business expenditure on research and development | 0.005 | 0.002 | 2.258 | 2.50E-02 | ** |
| Secondary school enrolment (% gross) | 0.014 | 0.005 | 3.044 | 3.00E-03 | *** |

# ABOUT EMANES

The Euro-Mediterranean and African Network for Economic Studies (EMANES) is a network of research institutions and think tanks working on socio-economics policy in Europe, the Mediterranean and Africa. EMANES is coordinated by the Euro-Mediterranean Economists Association (EMEA).

The research conducted by EMANES Researchers, Associates and Fellows aims to design sound and innovative socio-economic models that are inclusive, sustainable and employment creative, to devise new models for regional integration and to provide policy recommendations towards this goal.

**EMANES research agenda** is organized around the following mutually reinforcing and interconnected themes led by EMANES researchers, associates and fellows:

- Governance, institutions and institutional reforms;
- Macroeconomic policies and employment creation;
- Private sector, micro, small and medium –sized enterprises development, entrepreneurship and social business;
- Digital economy;
- Healthcare policy;
- Human capital development, education, innovation, skill mismatch and migration;
- Labor markets, employment and employability;
- Finance, financial inclusion and the real economy;
- Sustainable development;
- Regional integration;
- Euro-Mediterranean economic partnership;
- Scenarios analysis and foresight.

EMANES performs **research activities**, disseminated through series of internal and external publications (studies, working papers, policy papers, policy-graphics and books) and the organization of **annual conferences**, and **policy workshop meetings and online webinars** to bring together leading researchers, policy makers and representatives of the civil society to discuss and debate optimal policies for the future of the region.

EMANES research and outputs are underpinned on the **four fundamental principles: Independence, Scientific Excellence, Policy Relevance and Deep Knowledge of European, the Mediterranean and African Affairs**.

EMNES acknowledges the financial assistance of the European Union within the context of the EU project “Support to economic research, studies and dialogue of the Euro-Mediterranean Partnership” under contract number ENPI/2014/354-488 (2014-2019).