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İKTİSAT ANABİLİM DALI
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STRUCTURAL CONVERGENCE AND ITS IMPACTS ON TRADE AND GROWTH IN AFRICAN COUNTRIES.

YAPISAL YAKINLAŞMA VE AFRİKA ÜLKELERİNDE TİCARET VE BÜYÜME ÜZERİNDEKİ ETKİLERİ

Ph.D. thesis

Doktora Tezi

ALI BAKO OUSMANE

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ÖZET

YAPISAL YAKINLAŞMA VE AFRİKA ÜLKELERİNDE TİCARET VE BÜYÜME ÜZERİNDEKİ ETKİLERİ

Birkaç ülke arasındaki ekonomik yakınlaşma, gerçek ya da nominal ve ya yapısal olsun, iktisatçıların 18. yüzyıldan günümüze kadar özel ilgilerine giren önemli bir konudur. Bu nedenle, konuyla ilgili çok sayıda teorik ve ampirik literatür bulunmaktadır. Literatürde gerçek ve nominal yakınsama daha fazla ilgi görmüş ancak eşzamanlı yapısal dönüşümün bir sonucu olan ve ülkeler arasındaki sektörel yapısal benzerlik veya konjonktür senkronizasyonuna odaklanan yapısal yakınsama, 2000'li yılların başında ortaya çıkmış ve o günlerden beri literatürde artan bir ilgi görmüştür. Bu çıkışa rağmen Afrika ülkelerinin bu konuya çok az ilgi gösterdiği açıktır. Ayrıca Afrika, gençlerin büyük bir bölümünü göç etmeye iten, büyük bir işsizlik ve eksik istihdam sorunuyla karşı karşıyadır. Her yıl işgücüne katılan yaklaşık 12 milyon genç vardır (Afrika Kalkınma Bankası. 2018).

Afrika Kalkınma Bankası'na (2019) göre, mevcut işgücü piyasası durumu Afrika'nın 2016 ve 2063 yılları arasında büyük bir istihdam sorunuyla karşı karşıya kalacağını göstermektedir. Sabit istihdam oranları varsayıldığında, Afrika ülkelerinin sabit işsizlik oranlarını korumak için dönem boyunca toplu olarak ayda 1,7 milyon iş yaratması gerekecektir. Bu zorluğun üstesinden gelmek için Afrika ülkeleri, bu işsizliği absorbe edebilmek ve ekonomik büyüme yaratabilmek için ekonomilerini yapısal olarak dönüştürmek zorundadır. Bu nedenle, bu tez, Afrika ülkeleri arasındaki yapısal yakınsama olgusunu araştırmak ve yapısal yakınsamanın ekonomik ve ticari büyümeyi nasıl etkilediğini incelemek amacıyla genel bir amaç olan bu boşluğu (Afrika ülkeleri arasındaki yapısal yakınlaşmaya çok az dikkat ederek) doldurmaya çalışmaktadır. Bu amaçla, 1994'ten 2019'a kadar 48 Afrika ülkesinden oluşan dengesiz bir panel veri seti kullanıyoruz. Basit regresyon, panel düzeltilmiş standart hatalar (PCSE), uygulanabilir genelleştirilmiş en küçük kareler (FGL'ler), TOBIT modeli, Enstrümantal değişken apriş ve Granger nedensel olmayan test gibi çeşitli tahmin yöntemleri kullanmak, ana bulgular, Kişi başına GSYİH arttıkça emek ve katma değerin tarım sektöründen sırasıyla hizmet ve sanayi sektörlerine kaymasıdır. Sanayi sektörünün göreli verimlilik düzeyi, 2005'ten bu yana düşüş eğilimine rağmen Afrika'da en yüksek düzeydedir. Bunu, hafif bir düşüş eğilimi gösteren hizmet sektörünün ve son olarak, tüm dönem boyunca sabit görünen tarım sektörünün göreli verimlilik düzeyi izlemektedir. Sonuçlar ayrıca Afrika'da sektörel yapısal yakınsama olgusunun varlığını, yani gelir uçurumları daralırken sektörel yapılarda daha fazla benzerlik olduğunu göstermektedir. Son olarak sonuçlar, yapısal dönüşümün Granger'ın ekonomik büyümeye neden olduğu gibi göründüğünü göstermektedir. Aynı zamanda, yapısal dönüşüm ve ithalat büyümesi arasında ters bir Granger-nedensellik gösterir, ancak yapısal dönüşümün ithalat büyümesi üzerindeki etkisi tersinden daha derindir. İthalat büyümesinin aksine sonuçlar, yapısal dönüşüm ile ihracat büyümesi arasında ters bir Granger-nedensellik olduğunu, ancak ihracat büyümesinin yapısal dönüşüm üzerinde tersinden daha derin bir etkiye sahip olduğunu göstermektedir. Bu bulgular bazı politika çıkarımlarına işaret etmektedir. Gelişme sürücüsü olan sanayi ve hizmet sektörlerinin verimliliğini arttırmak için fiziksel sermayenin elde edilmesi, eğitim, teknik ve mesleki eğitim yoluyla beşeri sermayenin geliştirilmesi ve özellikle finansal kaynaklara düşük maliyetli erişim ve pazarlara erişim açısından iş ortamının iyileştirilmesi Afrika'da politika olarak uygulanmalıdır. Afrika

ülkeleri arasında yapısal yakınlaşmanın ortaya çıkması, küresel olarak bu ülkelerin benzer sektörlerin yükselişi ve düşüşü ile karakterize edilen benzer gelişme aşamalarını takip ettiğini ve bu ülkelerin yapısal bir 'istikrarlı duruma' yakınlaşabileceğini ima etmektedir. Böylece Afrika ülkeleri, dinamik karşılaştırmalı üstünlüklerini elde etmek için ortak politikalar geliştirme fırsatına sahiptir.

GENERAL INFORMATION

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ABSTRACT

STRUCTURAL CONVERGENCE AND ITS IMPLICATIONS ON TRADE AND GROWTH IN AFRICAN COUNTRIES

Economic convergence between several countries, whether real, nominal, or structural, is an important issue, as evidenced by economists' special interest in it from the 18th century to the present. This is why there is a plethora of theoretical and empirical literature on the subject. Real and nominal convergence has received more attention in the literature, but structural convergence, which is the result of simultaneous structural transformation and focuses on sectoral structural similarity or business cycles synchronization between countries, appears to have emerged and has received increasing attention in the literature since the beginning of the 2000s. Despite this emergence, it is clear that African countries have received very little attention on this topic. In addition, Africa faces a major problem of unemployment and underemployment, which pushes a large proportion of young people to opt for immigration. There is about 12 million young

people who join its labor force every year (African Development Bank. 2018). According to African Development Bank. (2019) the current labor market situation suggests that Africa will face a huge employment challenge between 2016 and 2063. Assuming constant employment rates, African countries will have to collectively create 1.7 million jobs per month over the period to maintain constant unemployment rates. To meet this challenge, African countries must structurally transform their economies to be able to absorb this unemployment and create economic growth. For these reasons, this thesis attempts to fill this gap (little attention to structural convergence between African countries) with the general objective of investigating the phenomenon of structural convergence between African countries and to examine how structural convergence is affecting economic and trade growth. To that end, we employ an unbalanced panel data set comprised of 48 African countries from 1994 to 2019. Using several estimation methods such as simple regression, Panel-Corrected Standard Errors (PCSE), Feasible Generalized Least Squares (FGLS), Tobit model, instrumental variable, and Granger non-causality test, the main findings are that labor and value-added shifts from the agricultural sector to the service and industrial sectors respectively as GDP per capita increases. The relative productivity level of the industrial sector is the highest in Africa, despite a downward trend since 2005. It is followed by the relative productivity level of the service sector which shows a slight downward trend and finally that of the agricultural sector which seems to be constant over the whole period. The results also show the existence of the phenomenon of sectoral structural convergence in Africa, i.e. a greater similarity in sectoral structures while income gaps are narrowing. Finally, the results show that structural transformation appears to Granger-cause economic growth. It also shows a reverse Granger-causality between structural transformation and import growth, but with a deeper impact of structural transformation on import growth than the other way around. In contrast to import growth, the results show a reverse Granger-causality between structural transformation and export growth, but with a deeper impact of export growth on structural transformation than the other way around. These findings imply some policy implications. The acquisition of physical capital, the development of human capital through education and technical and vocational training, coupled with the improvement of the business environment, especially in terms of low-cost access to financial resources and access to markets, should be implemented as a policy in Africa

in order to increase the productivity of the industrial and service sectors that drive development. The occurrence of structural convergence among African countries implies that globally these countries follow similar stages of development characterized by the rise and fall of similar sectors, and those countries can converge towards a structural 'steady state'. Thus, African countries have the opportunity to develop common policies to achieve their latent comparative advantage.

This thesis is dedicated to my entire family (especially my late father, my mother, my wife, my brothers and sisters, my children, and my nephews).

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LIST OF ABBREVIATIONS

AMU	Arab Maghreb Union
ASEAN	Association of Southeast Asian Nations
AU	African Union
CIS	Commonwealth of Independent States
CEEC	Central and Eastern European Countries
EAC	East African Community
ECCAS	Economic Community of Central African States
ECLAC	Economic Commission for Latin America and the Caribbean
ECOWAS	Economic Community of West African States
EMU	European Monetary Union
EU	European Union
FGLS	Feasible Generalized Least Squares
GDP	Gross Domestic Product
GGDC	Groningen Growth and Development Center
IGAD	Intergovernmental Authority on Development
ILO	International Labor Organization
ISIC	International Standard Industrial Classification
OECD	Organization for Economic Cooperation and Development
PCSE	Panel-Corrected Standard Errors
SADC	Southern African Development Community
UNIDO	United Nations Industrial Development Organization
WDI	World Development Indicators

INTRODUCTION

Economic convergence in a zone composed of different countries or in a region is the increasing rapprochement of the economic variables studied, due to a more rapid progression of the lagging countries or regions, and not due to the deterioration of variables of the most advanced countries or regions. If the increasing rapprochement of the economic variables studied is due to the deterioration of variables of the most advanced countries or regions, the convergence is said to be perverse (Diop L. 2002). Depending on the economic variables studied, one can distinguish real, nominal, and, more recently, structural convergence. Real convergence is a catch-up mechanism for rich countries by poor countries in terms of standard of living generally captured by per capita GDP or unemployment rate or social protection expenditure/GDP. Nominal convergence is a catch-up mechanism for countries ahead by lagging countries regarding certain nominal macroeconomic variables that show whether certain thresholds or macroeconomic stability are met (inflation rate, budget deficit, exchange rate, public debt/GDP ratio, etc.). For countries experiencing real convergence, structural convergence is a catch-up mechanism for countries ahead by lagging countries regarding certain variables (gross fixed capital formation, technological level measured by the Solow residual, labor shares by sector, value-added by sector...) indicative of the structure of economies (demand and supply structures).

Some important economic questions are whether lagging countries (regions) are more likely to grow faster than leading countries (regions)? Are there systematic economic forces or pressures that lead to the convergence of per capita income and output levels over time? Different authors have debated these questions with varying views. Some favor the convergence hypothesis, others favor convergence under certain conditions, and others favor non-convergence. The origins of this theoretical debate, "convergence or divergence between lagging and leading countries", can be traced back to 18th century Scotland and the publication of an essay by David Hume in 1742. Thus, one of the first major doctrinal debates in economic thought began between David Hume on the convergence side and Josiah Tucker and James Oswald on the non-convergence side (Elmslie, 1995). Hume's used general principles predicting the decline of the arts and

sciences in each society after its peak. He begins with the assumption that rich countries have advantages over poor countries, but he believes that these advantages will erode over time, while the poorest countries will experience rapid progress, resulting in inevitable convergence, as defined in his "theory of endogenous retrogradation". Tucker, on his side, claims that the rich countries can maintain their technological, economic and commercial superiority over the poor countries for a very long period of time, which might be unlimited. He believes that no one can pretend to draw the limits on the progress that can still be made in both agriculture and manufacturing; and that our children can indeed surpass us as much as we overtook our ancestors. He believes that the poorer countries, equally eager to learn, will not be able to make the same progress in learning as the richer ones, because the richer ones also continue to progress and with more technical and financial means.

Following this first debate, the topic of convergence has been widely addressed in neoclassical growth models. Ramsey (1928) mathematically proves that with a closed or open economy the per capita growth rate tends to be inversely related to the starting level of output per person. More clearly, if all countries are relatively uniform in terms of preferences and technology, then poor countries tend to grow faster than rich countries, which leads to real convergence between these countries. Viner (1950) starts from the international economy and the integration process to theorize the real convergence between countries. Indeed, the opening of a country - as happens in an economic integration process - will speed up financial capital flow from richer to poorer countries, and thus accelerate the convergence process, as capital should flow to countries with scarce capital to benefit from higher returns. The convergence hypothesis has also been highlighted in the neoclassical approach to the Solow growth model (Solow 1956, 1957), which is one of the most important and widely cited in the field. Solow's model is based on the assumption of constant returns to scale and decreasing marginal productivity of factors of production. The per capita growth rate is then equal in the long run to the rate of technical progress, assumed to be exogenous. If we admit that technical progress is a public good, this growth model leads to a result of real convergence, in the sense that the economies reach the same per capita growth rate in the long term. Based on the Solow model, Gerschenkron (1962) and then Abramovitz (1979, 1986) highlight the catch-up

effect and the 'advantages of relative backwardness'. By considering that imitation is cheaper than innovation, they conclude that convergence through technological diffusion is a likely outcome. They argue that initially poor economies have experienced higher per capita growth rates than initially rich economies. This phenomenon allows the poorest countries to catch up with the richest countries. But this phenomenon occurs if the countries have the same structural characteristics (rate of investment, rate of population growth, mastery of techniques and technology, political and financial institutions, etc.). Thus, the idea of conditional convergence emerges and diverges from that of unconditional convergence, which predicts convergence with no conditions.

Alternative endogenous growth models take the opposite view of traditional neoclassical growth models in that they endogenise technical progress and thus negate the hypothesis of decreasing marginal productivity of production factors. This situation of endogenised technical progress therefore allows for possible strong long-term growth and makes the phenomenon of catching up (convergence) of the richest countries by the poorest less obvious. The model proposed by Romer (1986), who is the most cited in this field, takes the opposite view of neoclassical growth models. His model is based on the assumption of increasing returns on capital and thus makes possible unlimited growth in per capita income, without resorting to the assumption of exogenous technical progress: It is even possible that the growth rate will rise continuously, instead of falling as predicted by neoclassical growth models. He brings statistical support to his thesis, which highlights a tendency for the growth rate of per capita income to increase. Romer presents a theoretical endogenous technical progress model, based on the accumulation of knowledge, which allows for an infinite increase in the growth rate of GDP per capita whatever its initial level. Thus, the Roomer model mathematically theorizes the early views of the non-convergence of Josiah Tucker and James Oswald. But the controversy over the convergence hypothesis exists even in endogenous growth models. By introducing an external effect of human capital in the investment sector which eliminates the heterogeneity of human capital, Tamura (1991) proves the convergence of incomes in an endogenous growth model. Similarly, Kelly (1992) proves that when the productivity of stochastic factors is introduced, non-convergence is an artifact of the deterministic structure of endogenous growth models. Pursuing a separate argument, the new literature

on economic geography developed by Krugman (1991) and examined in Ottaviano and Puga (1998) has advanced several reasons including the existence of agglomeration economies to explain why economic integration unlike Viner's (1950) idea can lead to income inequalities between countries. The neo-Marxist theory of dependency based on the idea that resources flow from the 'periphery' (poor and underdeveloped states) to the 'core' (rich states) and enrich the latter at the detriment of the former also favor the non-convergence hypothesis. According to this theory, it is the design and the structure of the global economic and political system that ensures and perpetuates the fact that rich countries get richer at the detriment of poor countries. The foundations of this theory emerged in the 1950s based on the work of researchers such as Raul Prebisch from the research of the Economic Commission for Latin America and the Caribbean (ECLAC) (Prebisch, R. 1962).

On the empirical side, multiple studies have been conducted to test the convergence hypothesis through various criteria. The σ-convergence criterion defined as the reduction in the dispersion of the distribution of GDP per capita and the β-convergence criterion defined as the unconditional or conditional catching up are often used to highlight the convergence phenomenon. Works such as Abramovitz (1986), Baumol (1986), De Long (1988), Baumol and Wolff (1988), Barro (1991), Mankiw, Romer and Weil (1992), Evans (1996) and Marelli and Signorelli (2010) tested this hypothesis over different time periods and country groups. The results are mixed as some confirm the convergence hypothesis, others confirm the hypothesis but with conditions, while others reject it.

On another aspect, authors such as Fisher, (1939; 1952); Clark, (1940); Fourastié, (1949); Lewis (1954); Machlup (1963); Chenery et al (1986); Kuznets (1972) have addressed the issues of sectoral structures of economies and the processes of structural transformation that enable economies to engage in development. Thus, theories such as the three sectors hypothesis, Lewis's hypothesis of the elastic supply of labor and many others have identified the three main sectors (agricultural, industrial and service) of the economy and have explained the conditions under which labor moves from one sector to the others. More recently, authors such as Krugman (1991) focused on the structural

similarity between economies through the Krugman Specialization Index (KSI). This index allows the comparison of sectoral structures between two countries, or between a country and a group of countries. Wacziarg (2001) focused on structural convergence, another equally interesting aspect of convergence. According to Wacziarg (2001), "*two countries are said to converge structurally if convergence in their per capita incomes is accompanied by convergence in their sectoral structure*". This definition refers to structural sectoral convergence, limited to the similarity of sectoral structures. Absolute structural convergence refers to a process that goes beyond sectoral similarity and includes business cycle synchronization and foreign trade integration (Alexoaei and Robu 2018). Theoretical arguments in favor of structural (intersectoral) convergence can be derived from the combination of the three sectors hypothesis (Fisher, 1939, 1952; Clark, 1940; Fourastié, 1949) and the Chenery (1960) convergence hypothesis, followed by some theoretical extensions made to those hypothesis by several authors like the market forces on the demand and the supply side that lead to structural convergence. Empirically, authors such as Wacziarg (2001); Barrios, Barry, and Strobl (2002); Raiser, Schaffer, and Schuchhardt (2004); Marelli E. (2004); Musolesi (2007); Sassi, M. (2007); Abegaz, B. (2007); Marelli, E., & Signorelli, M. (2010); Longhi & Palan & Schmiedeberg (2010); Crespo, N., & Fontoura, M. P. (2010); Albu (2012); Beck, K. (2013); Popovici OC (2015); Fertő, I. (2016); Chong et al. (2017); Di Berardinopaci & al. (2017) have investigated the structural convergence between several countries in the European, Asian and American continents. Their results show an overall trend towards structural convergence, but the work of authors such as Fertő, I. (2016) does not confirm the structural convergence hypothesis. According to Doyle, E. & E. O'Leary. (1999), structural transformation or structural change would largely explain structural convergence processes and also productivity convergence. We can then say that structural convergence is a simultaneous process of structural transformation in several countries which results in a rapprochement or similarity between the sectoral structures of these countries while they are experiencing the phenomenon of real convergence. According to Lewis. (1954); and McMillan and Rodrik .(2011) structural transformation of a country's economy is one of the main factors in economic development. Several authors, including Denison (1967), Echevarria (1997), Kaniovski and Peneder (2002), Dietrich (2012), Van Ark and Timmer (2003), and Vu KM (2017), have empirically shown the positive effect

of structural transformation on economic growth. However, as highlighted by Baumol (1967); Meckl (2002); Ngai and Pissarides (2007); McMillan, Dani, and Íñigo (2014); De Vries, Timmer, and De Vries (2015); Adegboye and Ighodaro (2020), structural change does not always prove conducive to economic growth.

There are many reasons to be interested in the phenomenon of structural convergence.

First, the structural transformation of a country's economy is one of the main factors in economic development (Lewis 1954; McMillan and Rodrik 2011). Structural convergence is only the result of multiple converging structural transformations in several countries.

Second, structural convergence suggests that countries follow similar development paths characterized by increases and decreases by types of similar sectors as per capita incomes increase and those countries can converge towards a structural "steady-state", in which the sectoral composition of production becomes more uniform across countries.

Third, if shocks to the macro economy are sector-specific, structural convergence has implications on the international transmission of business cycles: it should give rise to increased international business cycle correlations (Imbs 2000).

Fourth, understanding the factors that induce structural convergence can advance theory on long-term dynamic model of specialization and international trade. The identification of links between the increase in structural similarity and changes in the relative abundance of factors can help to advance theoretical knowledge on the Heckscher-Ohlin model of trade. Similarly, if the intensity of bilateral trade has a negative impact on sectoral similarity, this can be considered as evidence of traditional specialization, if it affects it positively, it can be interpreted as an indication of the expansion of trade between similar countries (intra-industry).

Despite the importance of this topic, it has received little attention within the context of Africa. On the one hand, there are several studies that address structural

transformation issues in Africa, such as De Vries, Timmer, and De Vries (2015), McMillan and Harttgen (2014), Rodrik (2014), Barrett et al. (2017) but without empirically and explicitly studying structural convergence of African economies. On the other hand, there are also several studies on real and nominal convergence issues in Africa such as Cunado and De Gracia (2006) and, Hammouda et al. (2009) but did not focus on structural convergence. In addition, Africa faces a major problem of unemployment and underemployment, which pushes a large proportion of young people to opt for immigration. There is about 12 million young people who join its labor force every year (African Development Bank, 2018). According to African Development Bank. (2019) the current labor market situation suggests that Africa will face a huge employment challenge between 2016 and 2063. Assuming constant employment rates, African countries will have to collectively create 1.7 million jobs per month over the period to maintain constant unemployment rates. To meet this challenge, African countries must structurally transform their economies to be able to absorb this unemployment and create economic growth.

For these reasons, this thesis attempts to fill this gap with the general objective of investigating the phenomenon of structural convergence between African countries and to examine how structural convergence is affecting economic and trade growth. This study will therefore contribute to a better understanding of the phenomena of structural transformation and structural convergence underway in Africa, which will undoubtedly help to refine economic and industrial policies for more effective economic development.

Specifically, the purpose of this thesi is:

First: To analyze the structural transformation processes underway in African countries and to identify sectors according to their low or high levels of relative productivity.

Second: To investigate whether there is a phenomenon of sectoral structural convergence among African countries using employment and value-added data in agricultural, industrial, and service sectors.

Third: To investigate the reverse predictability or causality in Africa between:

- structural transformation and economic growth,

- structural transformation and trade growth.

Based on theories such as the three-sector hypothesis, Lewis' elastic labor supply hypothesis, Chenery's convergence hypothesis, the demand and supply-side market forces hypothesis, the following three hypotheses are tested:

Hypothesis 1: The shift of labor and value-added in Africa is from the agricultural sector to the industrial sector, and then from the industrial sector to the service sector.

Hypothesis 2: African countries tend towards sectoral similarity as they experience real convergence.

Hypothesis 3: The ongoing process of structural transformation in Africa does cause economic and trade growth.

The rest of the thesis is thus organized as follows:

Chapter 1 addresses the statistical, theoretical and empirical aspects of convergence. The first part of this chapter is dedicated to some statistical aspects of convergence. The second part, after defining the different types of convergence, focuses on its theoretical literature. Finally, the third part addresses the empirical literature of convergence with a focus on real convergence, which is required for structural convergence.

Chapter 2 addresses the theoretical and empirical literature on structural convergence and its implications for trade and growth. The first part of this chapter addresses the theoretical and empirical literature of structural transformation by mentioning some stylized facts from recent literature specific to Africa. The second part addresses first the theoretical and empirical literature on structural convergence, and then the theoretical and empirical literature on its implications for trade and growth.

Based on econometric analysis, chapter 3 presents our empirical findings in relation to the ongoing structural transformation process in Africa and structural

convergence between African economies. The first part of this chapter presents the data, methodology, results and analysis of the structural transformation process in Africa and the different sectoral relative productivity levels of the African economy. The second part of the chapter presents first data, methodology, results and analysis of structural convergence between African economies, and then presents data, methodology, results and analysis on the implications of structural convergence for growth and trade.

We conclude the study with a general conclusion and policy recommendations based on our findings.

CHAPTER 1: THE CONCEPT OF CONVERGENCE IN ECONOMICS: STATISTICAL ASPECTS, THEORETICAL AND EMPIRICAL LITERATURE

The concept of convergence is discussed in many areas of economics, whether it's economic integration or the theme of development. The concept is frequently used in economic analysis. West African integration (ECOWAS and UEMOA), Southern African Integration (SADEC) and European integration (EU), for example, refers to the convergence of a set of macroeconomic indicators. The founding treaties of these entities impose specific conditions for convergence of inflation rates, interest rates, public deficit and public debt, between countries. The themes of development and growth also introduce issues of convergence of income, standard of living or productivity between countries. Microeconomic analysis is sometimes based on this type of notion. For example, collusion between firms located in different markets can result in price convergence between these markets. The question of convergence therefore arises in many domains, and for a multitude of economic variables. In this chapter, we first present some statistical aspect of the concept of convergence, then we present its theoretical and empirical literature

1.1 STATISTICAL ASPECT OF THE CONCEPT OF CONVERGENCE

In this section, we discuss some statistical aspects of the notion of convergence. First, we discuss the definitions and differences between series that have already converged and series that are in a process of convergence. Second, we characterize statistically the converging series.

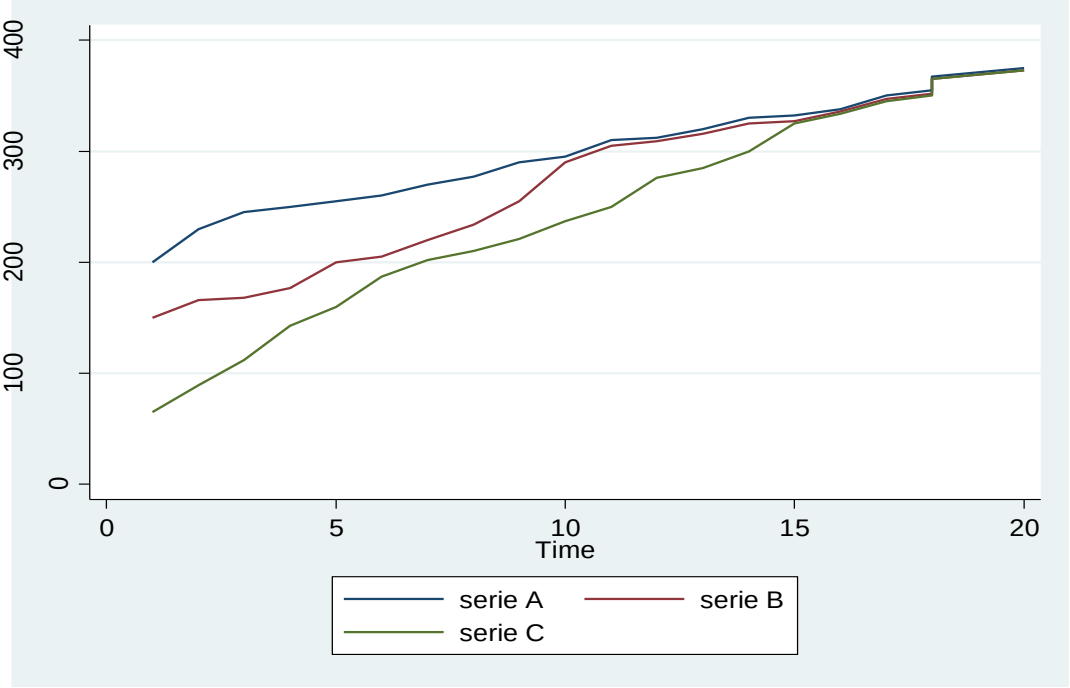
1.1.1 Definition

Different definitions of convergence can be used, distinguishing converging series from those that have converged, the series converging towards a constant from those tending towards equality.

At first glance, the concept of convergence is relatively easy to define. We can say that there is convergence when the difference between two or more series or their dispersion is reduced over time. However, there are different patterns of convergence. Their precise characterization can be sought by distinguishing between series that have converged and series that are converging, and between the series converging towards a constant from those tending towards equality.

The graphs below illustrate these different concepts. In figure 1, it is clear that the series A, B and C converge, the difference between the series and their dispersion decreases over time. We can speak of catch-up: series B and C starting from a level lower than A "catch up" with the level of A. The dispersion between the series tends towards zero, there is convergence towards the same level. If we refine the analysis by considering two sub-samples, from 0 to 10 and from 10 to 20, we note that, over the period [10, 20], the difference and dispersion between series A and B is zero, also over the period [15, 20] the difference and dispersion between series A, B and C is zero, series A, B and C have converged.

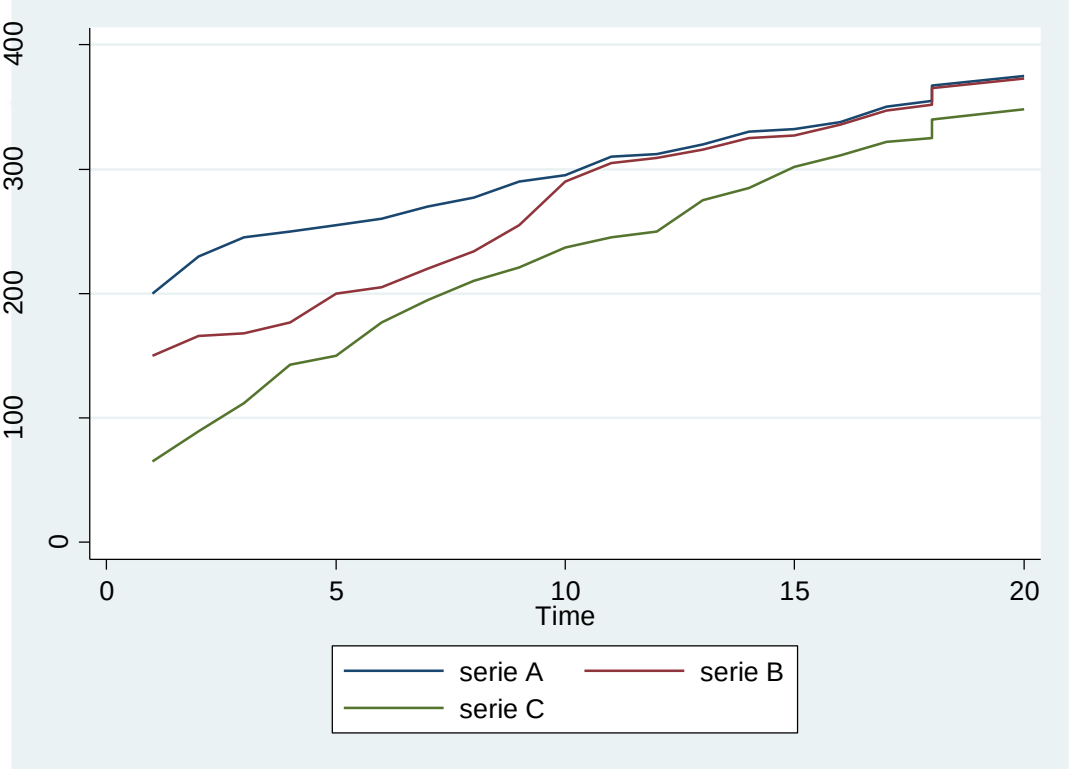
Figure 1: Converged series



author's calculations

In figure 2, the gap between A and C is decreasing over time; it is constant over the period [15, 20]. A strict convergence criterion, requiring the difference between the series to tend towards zero, would conclude that divergence is taking place. A more flexible criterion, requiring that the dispersion decrease, would conclude that the series are converging. The series converge to within one constant; over the period [15, 20], they converged to within one constant.

Figure 2: Converged series to within one constant



author's calculations

We can already see from these graphs that a distinction can be made between converging series, series that have converged, converging series to within one constant, and series that have converged to within one constant. Convergence to within one constant can be justified in a large number of practical cases. For example, the Maastricht Treaty required economic indicators to lie within a defined range, i.e. to converge to within a constant, provided that the constant does not exceed the Maastricht standard. In another area, Stigler and Sherwin (1985) define an economic market by the stability of the ratio of prices in different markets, i.e., by the convergence of prices to within a

constant. The constant can be interpreted in terms of transport and other arbitrage costs between markets. In finance, arbitrage between two assets implies that the rates of return between these assets converge to within a constant, where the constant can represent the risk premium differential.

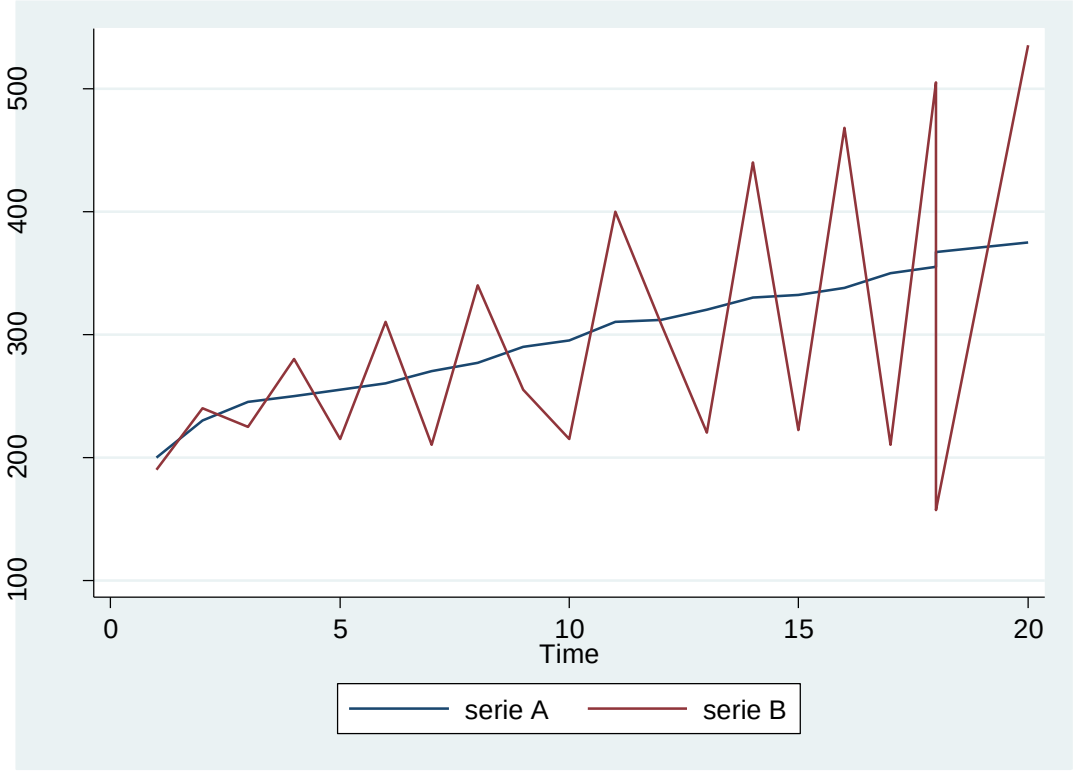
Just as there are different ways to converge, there are also different ways to diverge. In figure 3, series A, B and C diverge. B "exceeds" series A. The difference and dispersion between A and B decreases and then increases from 5. C stays below A and never "catches up" with series A, the difference and dispersion between A and C's deepen over time. The case of series B in figure 4 is a bit particular. On average B is equal to A. However, we cannot speak of convergence because the dispersion between A and B increases over time, the series B may deviate more and more from series A. B is not only more volatile than A, but moreover its volatility increases over time. The relationship between A and B is unstable.

Figure 3: Diverging series type 1



author's calculations

Figure 4: Diverging series type 2



author's calculations

1.1.2 Statistical characterization of converging series

Broadly speaking, we can identify two ways of defining convergence: according to the average evolution of their difference, or according to the evolution of their dispersion. The two concepts are not equivalent. Analysing the difference on average leads to neglecting the occasional deviations of the series from the mean. On the other hand, the dispersion of a set of series takes into account the fluctuations of the series, i.e. their volatility. More formally, an adaptation of the Hall, Robertson, and Wickens (1993) classification provides the following definitions:

(i) Two series y_t and y_t^* converge point-to-point if their difference tends towards one constant:

$$\lim_{t\to\infty}(y_t - y_t^*) = a$$

(ii) Two series y_t and y_t^* converge in expectation if the expectation of their difference tends towards a constant:

$$\lim_{t\to\infty} E(y_t - y_t^*) = a$$

(iii) Two series y_t and y_t^* converge in probability if the expectation of their difference tends towards one constant:

$$\lim_{t\to\infty} E(y_t - y_t^*) = a$$

And if the variance of their difference tends towards zero:

$$\lim_{t\to\infty} VAR(y_t - y_t^*) = 0$$

Case (i) corresponds to the case of Series A and B in figure 1, these series tend to be equal, and are equal as of date K. Series A and E converge point-to-point to within one constant. This definition is too strict for the analysis of economic series that can be affected by different economic shocks with temporary effects. Convergence in expectation leaves more flexibility in the analysis and allows series to deviate from each other provided that on average they are equal. In other words, random shocks can influence each series separately, as long as these shocks have zero mathematical expectation. This criterion may be too flexible. It would lead, for example, to accept the assumption that series A and G in figure 4 converge since they are equal on average. On the other hand, applying the probability convergence criterion would lead to rejecting convergence between series A and G since it requires that the variance of the difference between the series tend towards zero.

The convergence criterion in probability is extremely restrictive since it requires that the dispersion between the series tends towards zero, that is to say that the series

tends to converge point to point. For economic series which are subject to the effect of different transient random shocks, this criterion is too strict. The dispersion is more likely to tend towards a constant, rather than zero.

Consequently FUSS C. (1999) suggests a criterion located halfway between convergence in expectation and convergence in probability:

two series y_t and y_t^* converge if the expectation of their difference tends towards a constant: if

$$\lim_{t\to\infty} E(y_t - y_t^*) = a$$

and if the variance of their difference tends towards a constant, σ^2:

$$\lim_{t\to\infty} VAR(y_t - y_t^*) = \sigma^2$$

In that case,

(*) the series have converged (toward a constant) if the expectation of their difference and the variance of their difference are constant:

$E(y_t - y_t^*)$ =a and VAR$(y_t - y_t^*)$= σ^2

(**) the series are converging if the expectation of their difference tends towards a constant and if the variance of their relation is constant:

$$\lim_{t\to\infty} E(y_t - y_t^*) = a \text{ and } \mathrm{VAR}(y_t - b.y_t^* - a) = \sigma^2$$

or if the expectation of their difference tends towards a constant and if the variance in their relationship tends to a constant:

$\lim_{t\to\infty} E(y_t - y_t^*) = a$ and $\lim_{t\to\infty} VAR(y_t - b.y_t^* - a) = \sigma^2$

The importance of the condition on the variance becomes clear when these criteria are applied to non-stationary series.

1.2 THE CONCEPT OF CONVERGENCE İN ECONOMİCS: SURVEY OF THE THEORETİCAL LİTERATURE

In this section, we first define the term "economic convergence".. We distinguish between nominal, real, and structural convergence. We then survey the broad theoretical literature on real convergence, which has received the most attention and is of particular interest to us because it is a kind of condition for achieving structural convergence.

1.2.1 Definition

As presented in the statistical aspects, convergence is a process of rapprochement over time between several series, but from the economic point of view, two concepts of convergence emerge according to the economic growth between countries or regions. According to the first point of view (Barro [1984, Ch. 12], Baumol [1986], De Long [1988, Barro [1991]), there is convergence - all other things being equal - if a poor country tends to grow faster than a rich country, as a result, the poor country tends to get closer to the rich country in terms of income level or per capita GDP.

The second (Easterlin [1960], Borts and Stein [1964, Ch. 21, Streissler [1979], Barro [1984, Ch. 12], Baumol [1986], Dowrick and Nguyen [1989]) is about transverse dispersion. From this perspective, convergence happens when the dispersion or standard deviation of the logarithm of per capita income or product across a group of countries or regions decreases over time. Convergence of the first type (catching up of the richest by the poorest) contributes to convergence of the second type (reduction in income or per capita dispersion), but it is offset by new disturbances that tend to increase dispersion..

More recently authors like Martin, and Velazquez (2001), Diop L. (2002), Bamba L (2004) and Drastichova (2012) define convergence as a process of approximation or a gradual narrowing of gaps (catch-up mechanism) between economies regarding certain macroeconomic variables such as the exchange rate, the inflation rate, the interest rate, the debt ratio, or the public deficit in relation to the Gross Domestic Product (GDP), GDP per capita,...

This last definition (wider than the previous ones) broadens the notion of convergence to all economic indicators and allows an analysis beyond GDP or incomes, thus indicators such as the unemployment rate and social protection expenditure/GDP are used to test convergence (Martin, and Velazquez 2001).

To complete this last definition by excluding the rapprochement due to the deterioration of the variables of the countries or regions in advance, we can then say that economic convergence in a zone composed of different countries or in a region, is the increasing rapprochement of the economic variables studied, due to a more rapid progression of the lagging countries or regions, and not due to the deterioration of variables of the most advanced countries or regions.

If the increasing rapprochement of the economic variables studied is due to the deterioration of variables of the most advanced countries or regions, the convergence is said to be perverse Diop L. (2002).

Depending on the economic variables studied, we can distinguish real, nominal, and, more recently, structural convergence.

Real convergence is a catch-up mechanism for rich countries by poor countries in terms of standard of living generally captured by per capita GDP or unemployment rate or social protection expenditure/GDP.

Nominal convergence is a catch-up mechanism for countries ahead by lagging countries regarding certain nominal macroeconomic variables that show whether certain thresholds or macroeconomic stability are met (inflation rate, budget deficit, exchange rate, public debt/GDP ratio, etc.).

For countries experiencing real convergence, structural convergence is a catch-up mechanism for countries ahead by lagging countries regarding certain variables (gross fixed capital formation, technological level measured by the Solow residual, labor shares by sector, value-added by sector...) indicative of the structure of economies (demand and supply structures).

All these different forms of convergence have received particular attention in the abundant economic literature, but real convergence has received more attention than the others, and it interests us the most because of being a kind of condition for structural convergence.

1.2.2 Survey of the theoretical literature on real covergence

An important economic question is whether lagging countries (regions) are more likely to grow faster than leading countries (regions)? Are there systematic economic forces or pressures that drive the convergence of per capita income and output levels over time? This debate on convergence and divergence between lagging and leading countries is often thought to have begun with Veblen's (1915) assertion that laggards have a development advantage because early developed countries make mistakes and create technologies from which later developing countries can learn and borrow. Gerschenkron (1962) updates the perspective that development is easier or less difficult for late developing countries as 'advantages of relative backwardness'. However, the origins of this modern debate, "convergence or divergence between lagging and leading countries", can be traced back to 18th century Scotland and the publication of an essay by David Hume in 1742. Thus, one of the first major doctrinal debates in economic thought began between David Hume on the convergence side and Josiah Tucker and James Oswald on the non-convergence side (Elmslie, 1995).

1.2.2.1 The convergence debate between david hume and josiah tucker

The debate began following the publication of Hume's essay "On the Rise and Progress of the Arts and Sciences" in 1742, and in 1750 when Hume sent a copy of his manuscript "On the Balance of the trade"to James Oswald1.

According to Hume, progress sets its own natural limits, both in natural bodies and in political bodies. He used general principles predicting the decline of the arts and sciences in each society after its peak to make it a specific economic argument. He starts from the principle that rich countries have of course advantages over poor countries but believes that on the one hand these advantages will erode over time, and on the other hand the poorest countries will experience rapid progress which will result necessarily in a convergence, this is what is designated by Hume's Theory of endogenous retrogradation.

Tucker on his side argues that rich countries can perpetuate their technological, wealth and trade lead over poor countries for a very long period of time, which could be infinite. He believes that no man can claim to set limits to the progress that can still be made both in agriculture and in manufacturing; and that our children can indeed surpass us as much as we have surpassed our ancestors. he thinks that the poorest countries, also willing to learn, will not be able to make the same progress in learning with the rich, for lack of equal means of education because the richest also continue to advance and with more technical and financial means. according to its logic, continuous improvement, centered on the progress of science and innovation in the field of agriculture and manufacturing at a speed greater than that of poor countries, forms the basis of the argument for non- convergence, this is what is designated by Tucker's Belief in Continual Advancement.

After an exchange of letters in 1750, David Hume's position changed considerably. His original conviction was that convergence is the result of the poor country progressing towards the level of the rich and the rich country retrogressing towards the level of the poor countries. In the late 1750s, although he still supported a

[1] This story is recounted in Low (1952), Hont (1983) and Elmslie (1995).

natural tendency towards convergence, the necessary regression of the rich countries was removed from his writings.

We can keep from the exchanges between these two authors that the rich and advanced countries can always continue to progress because the technological advances which have no limits will continue to boost this progress as predicted by Tuker and accepted by Hume. Poor or backward countries can also progress at their own pace, if they have a faster rate of progression than rich countries, then the convergence predicted by Hume will be achieved, as with poor countries such as South Korea, which have been able to catch up with the richest countries, if they have a slower rate of progress than that of the rich countries then the non-convergence predicted by Tuker will persist, this is the case for several developing countries, notably in Africa who have not yet been able to catch up with the richest.

Following this first debate, different authors have developed a whole long theoretical literature on convergence, particularly neoclassical models of growth and new alternative models of endogenous growth.

1.2.2.2 Convergence in the neoclassical growth model

The notion of convergence and catch-up in the Neoclassical Growth Model has been dealt with by many authors, we will make a chronological overview of the principal authors and their contributions to this important topic.

Thorstein Veblen is recognized as the first development economist to work on issues like national economic development and the income gap between nations (Cypher;2009 and Brainerd;2014). In his book Imperial Germany and the Industrial Revolution (1915) he pioneered ideas on development economics. Veblen insists on the propagation of ideas for development, he thinks that according to a historical perspective, growth does not come exclusively through state action, but much more through training, and the propagation of ideas through education. He mentions the importance of literacy, printing and communication. Through education, training, and communication, scientific interaction with other civilizations and countries becomes possible, which will enable development. Veblen is also known for having introduced the theory of late

industrialization. The foundation of the late industrialization theory refers to the borrowing of technology: societies that develop after those that have developed before can adopt and imitate scientific know-how and discoveries without having to go through the laborious process of experimentation. With the adoption and imitation of technologies, the convergence of lagging countries to technologically more advanced countries becomes much more rapid than to follow the process of technological development and discovery. Another important reason why developing countries are catching up so quickly is Veblen's (1915, 241) affirmation that developing countries can borrow new technologies without adopting the institutions that govern the design of that technology. Germany was in a position to adopt the industrial arts, with no need to embrace the wasteful institutions that Veblen considered as belonging to the older industrial culture of the British. Also, Veblen (1915, 264) points out the great dichotomy between developed countries which devote a lot of time and resources in activities like sports and entertainment which he considers wastage, while developing countries use these resources for activities of production and progress. In other words, developing countries are using time and resources to pursue the growth that developed countries have linked to wasteful habits.

Following Veblen, Ramsey (1928) mathematically proves that with a closed or open economy the per capita growth rate tends to be inversely related to the starting level of output per worker. More clearly, if all countries are relatively uniform in terms of preferences and technology, then poor countries tend to grow faster than rich countries, which leads to real convergence between these countries. Cass (1965) and Koopmans (1965) are in line with Ramsey (1928), which is why some authors talk about the Ramsey-Cass-Koopmans model. The Ramsey - Cass - Koopmans model is based mainly on the work of Frank P. Ramsey, with significant extensions by David Cass and Tjalling Koopmans. This model is a neoclassical model of economic growth that differs from the Solow-Swan model (which we will discuss later) in that the choice of consumption is explicitly microfounded at a given point in time and endogenizes as well as the savings rate, so, unlike the Solow-Swan model, the savings rate may not be constant throughout the transition to the long-run steady state.

Following Ramsey, Viner (1950) starts from the international economy and the integration process to theorize the real convergence between countries. Indeed, the opening of a country - as happens in an economic integration process - will speed up financial capital flow from richer to poorer countries, and thus accelerate the convergence process, as capital should flow to countries with scarce capital to benefit from higher returns. Thus, Viner's model - sharing the assumptions of higher returns in countries with scarce capital with neoclassical growth theory - predicts a trend towards convergence in prices, costs and income levels, trade and international factor mobility acting as mechanisms leading to convergence. This process of real convergence is further enhanced with monetary union by reducing transaction costs and eliminating exchange rate uncertainties.

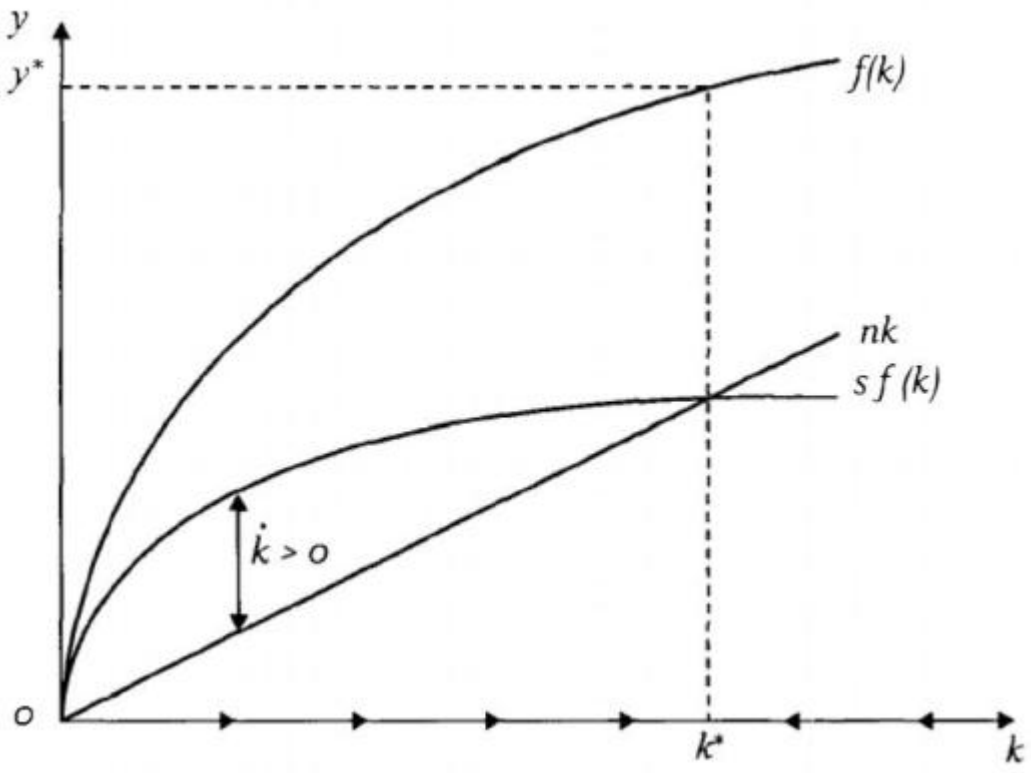
We can also deduce the convergence hypothesis from the neoclassical approach of Solowian growth model (Solow 1956, 1957) which is one of the most important and most cited in this field. Solow's model is based on the hypothesis of constant returns to scale and decreasing marginal productivity of the factors of production. The growth rate per capita is then equal in the long term to the rate of technical progress, assumed to be exogenous. If we accept that technical progress is a public good, this growth modeling leads to a result of real convergence, in the sense that the economies achieve the same growth rate per capita in the long run. Moreover, in this model, countries with identical rates of physical capital accumulation and population growth rates will achieve the same level of per capita income in the long run.

More comprehensively[2], Robert Solow describes his model as an extension of those constructed by Roy Harrod in 1939 and Evsey Domar in 1946. These two Keynesian authors came to the same conclusion: steady growth is a razor's edge, a path whose realization is hazardous. The reasoning can be summarised very briefly as follows. Production takes place with a fixed proportion of capital and labour: one worker on v machines produces one unit of product. The regular growth of the product is compatible with full employment of factors if the number of machines adjusts to the increase in the number of workers, i.e. the active population. However, the latter is conditioned by

[2] Greffe and al (2002), Dictionnaire des grandes œuvres économiques, Dalloz.

exogenous population growth at the rate n, whereas capital accumulation results from the saving of a fraction s of the product. No obvious economic mechanism allows the realisation of the equilibrium n = s/v, for which the demand for capital would be perfectly covered by the supply of savings. Steady growth with full employment is hypothetical; instability is the rule even in the long run. Solow challenges this conclusion on the grounds that it depends on a crucial assumption: the fixity of the capital coefficient v. If the latter adjusts - i.e. if substitutions take place in response to changes in factor costs - then the equilibrium between demand for capital and supply of savings is assured in the long run: regular growth takes place with full employment of factors.

Figure 5: Function of economic growth in the Solow model



Source: Greffe and al (2002)

The formal proof starts from a differential equation which governs the evolution of the stock of capital per worker k: dk/dt + nk = sf (k).

To the left of this equation is the demand for capital intended to increase the stock of capital per worker dk/dt and to equip new workers from population growth operating at rate n. On the right, we find the savings supply, which is a constant fraction s of the product per worker f (k). This product depends on the capital stock via the neoclassical production function f (.), which is supposed to be flexible as opposed to the fixed Harrod-Domar technology. Thus the capital coefficient v = k/f(k) increases with k expressing the decrease in the average productivity of capital. The dynamics are shown in above figure 1. At the capital stock k *, the savings that have been made are just equal to what is needed to maintain the capital stock: the economy has reached its stationary state and the product per capita is y*. This stationary state is stable because the capital stock increases (k> o) below k * and decreases above. The economy has thus adapted to the exogenous source of growth represented by demographic growth. Convergence to the steady state means that per capita quantities are constant - not increasing - in the long run. Sustained per capita growth requires the introduction of exogenous technical progress improving the efficiency of factors of production. This is done at the end of the article and will be repeated in the 1957 article. In Solow's mind, the presence of growth is an incidental problem, the main thing being the disappearance of Harrod-Domar's razor edge. In the long term, the economy returns to a stable path. Solow carefully indicates the technological assumptions necessary to obtain the stability result. On the contrary, it exhibits situations of multiple equilibrium resulting from a convex-concave technology, of the disappearance of the economy for lack of productive technology, or even of unbounded growth in the case of a hyper-productive technology. Solow interprets the dynamics of quantities as the achievement of a competitive equilibrium and describes the underlying price movements. Despite the passive role of the markets in the model, he insists on the balancing virtues of price adjustment: a shortage of workers relative to the capital factor induces a persistent fall in the real wage until the economy is brought back to normal steady-state. Extensions of the model are then described, illustrating the fertility of the framework: introduction of technical progress, endogenous labor supply, savings rate varying ad hoc, taxation and variable demography. In the conclusion, Solow, faithful to the spirit of synthetic macroeconomics, shows that his neoclassical framework accommodates rigidities or imperfections of a rather Keynesian nature. He thus describes

rigidities in nominal wages or interest rates which refer to the approach of Harrod and Domard.

Solow's article takes part with those of Trevor Swan (1956) and Tobin (1955) in the construction of the neoclassical theory of growth. This approach is characterized by the use of the aggregate production function and by the desire to apply in the long term the developments of the theory of static general equilibrium. It is thus describing a world in which growth is organized harmoniously under the influence of the markets. Solow thus leaves aside the problem of instability induced by the expectations of entrepreneurs, which constitutes the major problem for Harrod. According to Solow, the stabilized growth thus has two sources: first, technical progress, the origin of which is exogenous; second, the accumulation of capital which is regulated by the markets.

The neoclassical approach faced strong criticism during the sixties. Critics have focused on the notions of production function and aggregate capital stock. Cambridge economists such as Nicholas Kaldor and Joan Robinson consider that factor substitution adjustments cannot be conceived at the aggregate level. Kaldor puts forward an alternative mechanism that involves savings and income distribution. These economists share the idea that long-term equilibrium does not happen spontaneously. During the sixties, work in the neoclassical theory of growth began in many areas. First, the notion of technical progress has become more refined. Arrow Kenneth (1962), partially endogenizes its rhythm by analyzing the phenomena of learning by doing. Charles Kennedy is concerned with its orientation by introducing a possibility of choosing the factor saved by technical progress. Work has focused on the hypothesis of the incorporation of technical progress into capital goods. Then the savings question was enriched. Diamond Peter (1965) incorporates the nested generations approach into the model, while Cass David (1965) and Koopmans Tjalling (1965) build the optimal growth model, which will then be interpreted as the model with representative agent on the horizon of infinite life. Finally, we can also cite the work of Tobin (1965) and Miguel Sidrauski (1967) on the role of money.

Solow's model allowed the development of contemporary macroeconomics. The capital accumulation model in its aggregated version is a simple and effective tool

today used in a large number of fields. It is widely used by real cycle theorists who use a stochastic version of the model, in which the technology is affected by shocks, to reproduce fluctuations. Some economists today are wary of the highly aggregated approach, of which Solow's model is representative, preferring more analytical formulations in which microeconomic heterogeneity plays a more important role. This movement is fueled by the appearance of microeconomic databases describing the behavior of firms and households. It is obviously in the area of growth that we can judge the posterity of Solow's model.

Gregory Mankiw, David Romer and David Weil (1992) construct a test of Solow's model by assuming the identity of technologies and the perfect diffusion of technical progress among economies. This involves evaluating the "conditional convergence" hypothesis according to which economies sharing common characteristics (savings rate, population growth rate, etc.) are moving towards the same long-term path, the rate of which is growth is determined exogenously. They then show that the model constitutes a reasonable approximation of reality when it is "augmented" by a new accumulable factor: human capital. This result, given the work on endogenous growth, illustrates that the neoclassical approach to exogenous technical progress remains relevant.

Based on the Solow model, Gerschenkron (1962) and then Abramovitz (1979, 1986) highlight the catch-up effect and the advantage of backwardness. By considering that imitation is cheaper than innovation, they conclude that convergence through technological diffusion is a likely outcome. They argue that initially poor economies have experienced higher per capita growth rates than initially rich economies. This phenomenon allows the poorest countries to catch up with the richest countries. But this phenomenon occurs if the countries have the same structural characteristics (rate of investment, rate of population growth, mastery of techniques and technology, political and financial institutions, etc.) since it is these characteristics that determine, according to Solow's model, the paths of long-term equilibrium. With a log-linear approximation of Solow's growth model around its stationary state, we speak of beta-convergence in which β measures the speed of convergence towards the stationary state.

Neoclassical models of economic growth, in particular, that of Solow, predict a trend towards real convergence between countries mainly because of the assumption of constant returns to scale and the decreasing marginal productivity of factors of production. The primary engine of growth is the accumulation of physical capital. But technical progress (exogenous to the model), largely escaping theoretical and empirical analysis, nevertheless plays a determining role. Constant rate growth is the natural horizon of the models. The interpretation of this growth is however neglected, since the long-term growth rate, is resulting only from those of the population and of technical progress, both considered as exogenous quantities to the model.

Since the mid-1980s, under the leadership of Robert Lucas and Paul Romer, growth theories have been significantly renewed, in particular by abandoning the hypothesis of exogenous technical progress. We then speak of "new growth theories" or even "alternative models of endogenous growth" which will not necessarily predict convergence as in the traditional models.

1.2.2.3 Non-convergence in alternative models of endogenous growth

Alternative models of endogenous growth take the opposite course to traditional neoclassical growth models in that they endogenise technical progress and thus negate the hypothesis of decreasing marginal productivity of factors of production. This situation of endogenized technical progress therefore allows a possible strong growth in the long term and makes less obvious the phenomenon of catching up (convergence) of the richest countries by the poorest.

Romer (1986), who is the most cited in this field, highlights the inadequacies of neoclassical models and offers an alternative vision. In particular, he underlines the role played by the hypothesis of decreasing returns on capital. By implying a negative correlation between growth rate and the level of per capita capital, it induces a process of convergence of per capita incomes in the different countries. All countries should converge on the same growth path and the same level of per capita production, the effects of initial conditions and accidental shocks being only temporary. The decrease in yields also excludes the accumulation of capital from constituting a permanent engine of growth.

In the absence of exogenous technical progress, the growth in production and per capita income would decline to the point of being canceled out.

The model proposed by Romer takes the opposite view of these properties. It is based on the assumption of increasing returns on capital and thus makes possible unlimited growth in per capita income, without resorting to the assumption of exogenous technical progress: It is even possible that the growth rate will rise continuously, instead of falling as predicted by traditional theories. A section of his article brings together statistics in support of this thesis, which highlight a tendency for the growth rate of per capita income to increase. Romer intends to present a theory of endogenous technical progress, based on the accumulation of knowledge. It thus emphasizes knowledge capital, rather than physical capital. He would later write that the production and exchange of ideas play a more important role in the modern world than the production or exchange of physical goods. The accumulation of this capital of a particular type responds to the usual mechanisms. It is the work of rational agents, concerned about the profitability of their investments. But it also presents an important peculiarity. It has external effects on the production capacities of other firms, since technological innovations can neither remain secret nor be fully protected by patents. The presence of these externalities obviously prevents the competitive equilibrium from coinciding with the optimum, and it opens the door to the implementation of corrective fiscal policies. Romer himself puts his model into perspective by presenting an in-depth discussion of previous attempts to introduce increasing returns and endogenous technical progress in the analysis of growth. Arrow's (1962) article on Learning by Doing appears to be the closest precursor to his analysis. It indeed incorporates a phenomenon of increasing returns linked to the accumulation of knowledge acquired through learning and considers that this accumulation acts as an externality at the level of the entire economy. Arrow's modeling is very different, however, if only because for him knowledge is embodied in physical capital. As the two models are very much in the same spirit, it has become common to talk about Learning by Doing in connection with Romer's model, seeing it as the support for the accumulation of knowledge. However, this is pushing the synthesis a little too far because Romer's article applies to describe a voluntary accumulation of knowledge by firms, rather than learning by doing from which they would benefit from this presentation.

Romer article marked the beginning of a veritable explosion of research on growth. Alongside those of Romer, the articles of Lucas (1988) and of Aghion and Howitt (1992) have played an essential role and also appear as pillars of the new theories. Both present endogenous growth models based, for the first, on the accumulation of human capital and, for the second, on the links between innovation and creative destruction from a clearly Schumpeterian perspective. Many works followed. Often theoretical but also very suggestive, they highlight the reciprocal links that the growth process maintains with learning, education, innovation, infrastructure development, international exchanges, financial organization ... They describe an economy where external effects play an important role, where comparative advantage must be dynamically assessed, where inequalities often tend to increase, but also where the presence of monopolies does not only have harmful effects since 'they are often at the origin of innovation, according to the argument already developed by Schumpeter. Public policies then have an important role to play in getting the economy to take advantage of externalities and strengthen incentives for innovation and the accumulation of knowledge and human capital. Empirical work has been carried out to quantify the effects of all these mechanisms and to explain the growth differences between countries. The task is delicate because, in short, it is a question of attempting an econometric analysis of mechanisms which escape the market and are of a structural and historical nature. A fairly normal return of the theoretical pendulum then led to new empirical tests of the traditional model of exogenous growth à la Solow, however extended to take into account a more extensive notion of capital. We now have sufficient hindsight to better put into perspective the contributions of new theories of endogenous growth. They reside more in the enrichment of the analysis of the mechanisms of growth than in the affirmation of the endogenous character of the long-term growth rate. This movement has made development a central issue in economic analysis, which cannot be separated from the analysis of growth or confined to the case of so-called developing countries.

Finally, certain endogenous growth models which, in the same spirit as Romer (1990), show the importance of R&D (Research and Development) efforts to boost production and trade as the main engine of growth, may also explain the existence of the persistence of income disparities between countries. Pursuing a separate argument, the

new literature on economic geography developed by Krugman (1991) and examined in Ottaviano and Puga (1998) has advanced several reasons including the existence of agglomeration economies to explain why economic integration unlike Viner's (1950) idea can lead to income inequalities between countries. But the controversy over the convergence hypothesis exists even in endogenous growth models. By introducing an external effect of human capital in the investment sector which eliminates the heterogeneity of human capital, Tamura (1991) proves the convergence of incomes in an endogenous growth model. Similarly, Kelly (1992) proves that when the productivity of stochastic factors is introduced, non-convergence is an artifact of the deterministic structure of endogenous growth models.

As we have seen, the theoretical literature on the convergence hypothesis is abundant, varied, old, and controversial. In the end of 1980s, several authors adopted an empirical approach to measure and verify the convergence hypothesis, since then abundant literature has been developed.

1.2.2.4 Non-convergence in the dependency theory

The neo-Marxist theory[3] of dependency is based on the idea that resources flow from the 'periphery' (poor and underdeveloped states) to the 'core' (rich states) and enrich the latter at the detriment of the former. According to this theory, it is the design and the structure of the global economic and political system that ensures and perpetuates the fact that rich countries get richer at the detriment of poor countries. The foundations of this theory emerged in the 1950s based on the work of researchers such as Raul Prebisch from the research of the Economic Commission for Latin America and the Caribbean (ECLAC) (Prebisch, R. 1962).

The dependence of the periphery (poor or developing countries) according to this theory is caused by several factors:

[3] Although dependency theorists are broadly classified into two groups: liberal reformists and neo-Marxists. Liberal reformists generally favor targeted policy interventions, whereas neo-Marxists advocate a command-and-control economy.

- Poor countries lack the capital to make the necessary investments for their development, so they are dependent on the capital of developed countries and other institutions (banks, international organisations...) controlled by the rich countries. This capital reaches the poor countries in the form of aid and loans with political and economic conditionalities which accentuate the dependence;

- The process of production in poor countries is generally controlled by multinationals controlled by rich countries and strategic production decisions are taken in the interests of the multinationals and rich countries without taking into account the needs of poor countries;

- Poor countries' exports are concentrated on a small number of primary products with little value-added and for which they have no control over market prices in the rich countries;

- Poor countries are very dependent on the rich countries for technology, which are far ahead of them in this area. The imported technologies are also very capital-intensive and do not correspond to the factor endowments of poor countries, which creates or aggravates employment problems;

- Poor countries are caught up in the economic cycles of rich countries, as they are dependent on the economic situation in rich countries, as their export earnings come from there;

- Most poor countries cannot produce enough food for their own needs, so they have to import large quantities of agricultural goods (cereals) and are dependent on the large producers in the rich countries;

- The consumption patterns of the privileged classes in poor countries are modeled on those of rich countries and imposed by multinational companies, which implies an extreme concentration of income.

-International trade maintains the gaps between poor and rich countries, through the deterioration of the terms of trade, the maintenance of poor countries in primary

specializations, through an unequal exchange, and through the repatriation of profits to rich countries.

To create conditions for development within poor countries, Prebisch recommends:

- Controlling the monetary exchange rate, with a greater emphasis on fiscal policy than on monetary policy;

-Promote a more effective government role in national development;

-Create investment platforms, giving a preferential role to domestic capital

-Allow the entry of external capital, according to the priorities already established in the national development plans;

-Promote a more efficient internal demand in terms of domestic markets as a basis for strengthening the industrialization process in Latin America;

-Generate greater domestic demand by increasing

wages, which in turn will have a positive impact on aggregate demand in domestic markets;

-Develop more effective coverage of government social services, especially to the poorest sectors;

-Developing more effective coverage of government social services

Substitution model, protecting domestic production by establishing quotas and tariffs on external markets.

Following a number of failures of the ECLAC and Prebish plans, dependency theory through other authors such as Andre Gunder Frank, Raul Prebisch, Theotonio Dos Santos, Enrique Cardozo, Edelberto Torres-Rivas and Samir Amin evolved to combine elements of a neo-Marxist perspective with Keynes' economic theory.The new dependency theory embodies four main points to end the dependency of poor countries:

a) Develop significant domestic effective demand in terms of domestic markets;

b) Recognising that the industrial sector is crucial to achieving higher levels of national development, especially since this sector, compared to the agricultural sector, can add more value to products;

c) Increase the income of workers as a means of generating more aggregate demand in national market conditions;

d) Promote a more effective role for government in order to strengthen national development conditions and increase national living standards (Reyes-Ortiz, G. E. 2001).

Thus, According to the dependency theory, as long as the global political-economic system exists and effective development measures are not implemented, poor countries will remain dependent on rich countries, they will not develop, and they will never catch up with the rich countries that benefit from this system. From the standpoint of that theory, the only possible convergence is the convergence clubs. Rich countries can converge on each other, just as poor countries can converge on each other.

However, several criticisms have been formulated against the dependency theory by various authors (Bauer, P. T. 1981; 1984, Allen, R. C. 2011). According to economic historian Robert C. Allen, "*dependency theory's claims are "debatable" due to fact that the protectionism that was implemented in Latin America as a solution ended up failing*"[4].

1.3 REAL CONVERGENCE: MEASUREMENT AND EMPİRİCAL LİTERATURE[5]

In this section, we will discuss various criteria that are commonly used to accept or reject the real convergence hypothesis. These criteria are diverse and numerous, and

[4] Allen, Robert C. "Global Economic History: A Very Short Introduction". Oxford University Press. pp. 127–129.

[5] This section is inspired by Le Pen (1997) "Convergence internationale des revenus par tête : un tour d'horizon" Revue d'économie politique , novembre-décembre 1997, Vol. 107, No. 6 (novembre-décembre 1997), pp. 715-756.

they necessitate specifications on the data to which they are applied. We will begin by defining these criteria before looking at the authors' various approaches to estimating them.

1.3.1 Definition of the convergence hypothesis criteria

We present and define here the main criteria used to highlight the convergence hypothesis. Among others, we mention the σ-convergence criterion, the β-convergence criterion, the convergence criteria such as the persistence of differences in GDP per capita, the convergence criterion measured by changes in the relative position of countries, and the criterion of the convergence clubs hypothesis.

1.3.1.1 The criterion of σ-convergence or convergence defined as the reduction of the dispersion of the distribution of gdp per capita

The dynamic evolution of the dispersion indicator of the logarithmic distribution of GDP per capita is examined in this criterion. This type of convergence is commonly referred to as σ-convergence. The hypothesis of σ-convergence is accepted when this indicator decreases between the initial and final dates for a sample of countries considered. As a drawback, we can note that this is a purely descriptive criterion. A Fisher test is often recommended to determine whether the variance at the end of the period is significantly lower than the variance at the beginning of the period (Lichtenberg 1994). Evans (1996) suggests using time series econometric methods to determine the trend in the cross-sectional variance of GDP per capita in log. Depending on the trajectories followed by the log of GDP per capita, a difference emerges in the trends of the cross-sectional variance. It is stationary around a positive constant if we are in the case of a neoclassical growth model, where the log of GDP per capita follows parallel trajectories in the long run. It is integrated of order 1 around an increasing quadratic trend if we are in the case of endogenous growth models where GDP per capita has different trend growth rates. We can also say that σ-convergence measures the level of approximation, through time, among various countries regarding some criteria. Its interest is that it allows to study the variation of the dispersion of the variables studied. Convergence of the whole sample occurs if the dispersion declines over time. The

measure of dispersion often used is the variance or standard deviation of the variables studied. If $X_{i,t}$ denotes the rank of the variable X for the individual i, at time t (with i = 1… n and t = 1… p), the variance can be defined by the following formula:

$$(VarX_{i,t}) = \frac{1}{n}\sum_{i=1}^{n}(X_{i,t} - \mu)^2 \text{ with } \mu = \frac{1}{n}\sum_{i=1}^{n} X_{i,t}$$

A chart of the trend in the variance throughout the time period of analysis (t = 1... p), could reveal a tendency towards convergence through the decrease in dispersion, in relation to the variable X. The tendency towards a decrease in the dispersion indicator as well as a change in the mean of the variable considered would indicate the presence of a "good" convergence process. It would be possible to speak of a "perverse convergence" when, in the case of real convergence for example, the reduction in the standard deviation is the result of a drop in per capita GDP of the countries initially richer compared to to those in the poorest countries.

1.3.1.2 The criteria for unconditional or conditional β -convergence or convergence as catching up

Unconditional β-convergence is a process of convergence, across several economies over time, towards the same growth path or reference value. It investigates the link between the growth rate of GDP per capita and the starting point of GDP per capita. If, for a period and for some countries, the growth rate of GDP per capita is higher, the lower the starting GDP per capita, or the growth rate of GDP per capita is lower, the higher the starting GDP per capita, then the unconditional β-convergence hypothesis is accepted. The statistical method most often used to test this criterion is to regress the average or cumulative growth rate of GDP per capita over the period under consideration on a constant and the initial GDP per capita in logarithm. If the coefficient on initial GDP per capita is negative and significant, the assumption of unconditional β-convergence is accepted.

The conditional β-convergence hypothesis assumes that the reverse link between the GDP per capita growth rate and initial GDP per capita is satisfied on condition that the countries in the sample reach common levels for certain variables of an economic

nature or not. These variables are assumed to control for heterogeneity in long-run paths. Even if countries differ in their savings rates, population growth rates, and production functions as a result of unequal access to technology, they may eventually converge to different steady states with different capital-labor ratios and living standards. When countries' fundamental characteristics differ, the Solow model, for example, predicts possible conditional convergence. This implies that living standards will only converge within groups of countries that share certain characteristics. A country with a low income and a low savings rate, for example, may eventually catch up with a richer country with a low savings rate, but it will never catch up with a rich country with a high savings rate. Conditional β-convergence is therefore a much weaker hypothesis than unconditional β-convergence, since economies will not converge among themselves if the determinants of their long-term behavior differ. The method most often used to verify this hypothesis consists of regressing the growth rate per capita on the initial GDP per capita and the variables characterizing the long-term trajectories. We will see later that these variables are very diverse. If the initial GDP per capita coefficient is negative and significant, we will then accept the conditional β-convergence hypothesis.

The unconditional β-convergence and σ-convergence assumptions are related but not equivalent. Unconditional β-convergence does not imply σ-convergence (Barro and Sala-i-Martin 1990; Friedman 1992; Quah 1993b; and Hart 1995). Hénin and Le Pen (1995) propose an interpretation of the relationships between unconditional β-convergence and σ-convergence. Unconditional β-convergence indicates the presence of a tendency to narrow differences in GDP per capita. Random disturbances to national economies, on the other hand, can temporarily offset this tendency and raise the dispersion of the distribution of GDP per capita. When β-convergence overcomes the effects of these random shocks, σ-convergence occurs. This reasoning is extended to the case of conditional β-convergence by Lichtenberg (1994).

To model what we have already explained, we can say that β-convergence test consists in regressing the annual growth rate of GDP per capita of country i ($y_{i,t}$) to its initial level ($y_{i,0}$), while controlling for differences in steady-state, i.e., differences in preferences, savings rates, technologies, population growth rates, etc. All of these

variables are contained in the vector $Z_{i,t}$ of the equation below, which can be estimated using panel data.

$$\frac{\Delta y_{i,t}}{y_{i,t-1}} = \alpha + \beta^* \log(y_{i,0}) + \gamma . Z_{i,t} + \varepsilon_{i,t}$$

This estimated equation would lead to β-convergence if the coefficient β is negative and statistically different from zero. This β-convergence is said to be conditional if the parameter γ is different from zero (i.e. the zit are different from one country to another). On the other hand, β-convergence is said to be absolute when γ = 0 (i.e. the zit are identical).

1.3.1.3 The convergence criteria as the persistence of differences in gdp per capita

Using methods of time series econometrics Bernard (1991), Bernard and Durlauf (1992b, 1996), Quah (1992a) as well as Evans and Karras (1993, 1996) propose an approach to convergence based on the characterization of the deviations of GDP per capita in logarithm. The convergence hypothesis is accepted if the differences in the per capita GDP of the countries considered cannot deviate permanently from 0, which is to say if they are stationary with zero mean. It first assumes that the GDP per capita series in log have a stochastic trend in addition to a deterministic trend. Several empirical studies, including Nelson and Plosser (1982), Campbell and Mankiw (1989), and Cogley (1990), have confirmed this finding. The time series approach's challenge then is to investigate the relationships between the deterministic and stochastic trends that govern the movements of per capita GDP. The assumption of zero mean stationary deviations implies that GDP per capita follows the same deterministic and stochastic trends. As a result, the evolution of these GDP per capita is determined by the same factors. According to Le Pen (1997) a weaker hypothesis consists in verifying whether the changes in per capita GDP are not governed by a limited number of factors. From a technical point of view, we test the existence of cointegrating relationships between GDP per capita in log. The existence of r cointegrating relations between n series means that the movements of these n series are determined by n-r common stochastic tendencies. Thus, there would be

no growth mechanism specific to each country, but a greater or lesser number of factors acting simultaneously, but not always with the same intensity, on all the countries considered.

According to Bernard and Durlauf (1996), the approaches of convergence by persistence of gaps and β-convergence have fundamentally different perspectives on the properties of the data under consideration. In β-convergence tests, the data are assumed to be in transition towards a limiting distribution, and convergence is interpreted to mean that initial output differences between economies dissipate over a fixed time period. The persistence of gaps approach (time series tests) assumes that the data are generated by economies near their limiting distributions, and convergence is interpreted as meaning that initial conditions have no (statistically significant) effect on the expected value of output differences. As a result, depending on whether the data is better characterized by transition or steady state dynamics, one of the approaches is appropriate..

1.3.1.4 The convergence criterion measured from changes in the relative position of countries

Quah (1993b, 1993a, 1992b, 1996b, 1996a, 1996c) introduces an approach to convergence that focuses on the analysis of the dynamics of the distribution of total GDP per capita. According to Quah, the σ-convergence and β-convergence approaches (unconditional or conditional) appear inadequate to address the convergence issue. Thus, he accepts the convergence hypothesis if the distribution of GDP per capita tends toward an unimodal distribution. This approach also makes it possible to determine the trajectories and changes in the relative positions of countries within this distribution.

1.3.1.5 The criterion of the hypothesis of convergence clubs

When some economies (countries) have the same structural characteristics, they can converge if their initial conditions are similar. In this case, the group of countries for which the convergence hypothesis is accepted is called a convergence club. There may be different convergence clubs that do not converge with one another. Thus, if we are interested in a group of countries, it is not impossible that this group contains several convergence clubs depending on the structural characteristics of these

countries' economies. For endogenous growth models, it is not only necessary that the countries have identical structural characteristics, but also that their initial conditions are similar enough for convergence to be possible. Under certain specific assumptions, heterogeneity in savings behavior can favor the emergence of convergence clubs in the neoclassical growth model (Galor, 1996).

One of the difficulties of this approach is the a priori composition of this club, to subsequently seek to verify the convergence hypothesis. Two methods are adopted to solve the question of the composition of the club. The first is to determine the composition of the club according to a priori criteria. The second is to "indigenize" the selection of clubs: a method must then be found to extract the composition of convergence clubs. Once the composition has been acquired, it remains to test the convergence hypothesis criterion that would have been chosen for each of the highlighted clubs.

1.3.2 Empirical literature on the real convergence hypothesis

We present here the main empirical results of the convergence hypothesis. First, we present the empirical results from the σ-convergence and unconditional β-convergence approaches, and then we present the empirical literature for the conditional β-convergence approach.[6]

1.3.2.1 Tests of σ-convergence and of unconditional β-convergence

Using data from Maddison (1980), Abramovitz (1986) estimates the convergence of labor productivity levels for 16 industrialized countries from 1870 to 1979. The average of the productivity ratios of the 15 countries, compared to that of the United States (the leading country over the period), is relatively stable over time. Abramovitz deduces that these 15 countries did not succeed in reducing their gap with the United States despite the advantage of backwardness theorized by Gerschenkron (1962) and Abramovitz (1979). Abramovitz calculates the coefficient of variation of the 15 relative productivity levels, as well as the rank correlation between the labor productivity growth

[6] Le Pen Y (1997) "Convergence internationale des revenus par tête : un tour d'horizon" Revue d'économie politique , novembre-décembre 1997, Vol. 107, No. 6 (novembre-décembre 1997), pp. 715-756.

rate and its initial level for the 16 countries and for different sub-periods. These last two indicators allow him to draw conclusions in favor of the catching-up process. Indeed, the coefficients of variation decrease regularly over the period, except for the Second World War period, and the correlation is always negative, except for the period 1938-1950. Without making a clear distinction between the notions of σ-convergence and unconditional β-convergence, Abramovitz deduces that there is indeed a long-run trend towards narrowing productivity gaps. He notes that the intensity of the convergence process within the 15 countries varies over time: it is moderate, even weak, before 1950 and strong thereafter.

From the perspective of unconditional β-convergence, Baumol (1986) regresses the growth rate of labor productivity from 1870 to 1979 on the log of labor productivity in 1870. Data are from Maddison (1980). The estimated coefficient of productivity in 1870 is negative, but Baumol does not indicate whether it is significant or not. From this negative coefficient Baumol draws the following conclusion: "*The higher a country's productivity level in 1870 the more slowly that level grew in the following century*", thus confirming "the advantage of backwardness".

De Long (1988) raises two observations against the finding of Abramovitz (1986) and Baumol (1986). The first is related to the Maddison sample that Abramovitz and Baumol used. De long estimates that there is a selection bias in the composition of this sample, as Maddison (1980) only chose countries that had reached a high level of development in 1979. To overcome the selection bias, De Long proposes to investigate convergence in a more heterogeneous group of countries whose growth potential in 1870 can be considered important. The β-convergence test on this sample shows that the convergence hypothesis is still accepted, but with a lower coefficient of GDP per capita in absolute value. De Long's second remark concerns the measurement errors of GDP per capita in 1870. By creating an artificial negative correlation between the growth rate per capita and the initial GDP per capita, these errors would bias the estimates towards accepting the convergence hypothesis. The introduction of measurement error causes the coefficient of initial GDP per capita to become significantly positive as the measurement error increases. De Long shows that the standard deviation of the log GDP per capita

distribution decreases steadily for Maddison's group of 16 countries, but remains stable for his group of 22 countries. Baumol and Wolff (1988) acknowledge the relevance of De Long's (1988) criticisms. They then refer to the idea of a convergence club of the rich to explain these results. According to this idea, the convergence of GDP per capita would only occur within the richest countries. The poorest countries, on the other hand, would undergo a process of divergence.

Hénin and Le Pen (1995) test the unconditional ß-convergence and σ-convergence for a group of 14 European countries over periods of ten years between 1870 and 1990. Their results show that the variance of GDP per capita in log is stable from 1900 to 1950, decreases sharply from 1950 to 1973, and then is again stable from 1973 to 1990. Thus, they conclude that the period 1950-1980 was a phase of unconditional β-convergence and continuous σ-convergence for these countries. The other periods are characterised by β-divergence or by unconditional β-convergence and σ-divergence..

De Long (1988) shows that the chance of accepting the unconditional β-convergence hypothesis decreases when the sample includes more non-OECD countries. Based on graphical studies, Baumol (1986) and Baumol and Wolff (1988) reject the unconditional β-convergence hypothesis for 72 countries over the period 1950-1980. Barro (1991) estimates the correlation between the average per capita growth rate from 1960 to 1985 and GDP per capita in log in 1960 for a sample of 98 countries. The data are taken from Summers and Heston (1988). He obtains a slightly positive but insignificant correlation, which means that the hypothesis of unconditional β-convergence is rejected.

Considering three samples of countries from Summers and Heston (1988), Mankiw, Romer and Weil (1992) regress the difference in GDP per working age adult in log in 1960 and 1985 on a constant and the log of GDP per working age adult in 1960. The first group includes 98 countries with the particularity of being non-oil producers. The correlation between the growth rate and GDP per working-age adult in 1960 is then positive but not significant. This result by Mankiw, Romer and Weil (1992) is quite similar to that of Barro (1991). The second sample was obtained by eliminating countries with insufficient statistical data or a population of less than one million in 1960. As a

result of this selection, the coefficient on GDP per adult in 1960 is negative, but not significant. The third sample includes 22 OECD countries. The coefficient of GDP per working-age adult in 1960 is then negative and significant. Moreover, the coefficient of determination is much higher than that obtained for the first two groups.

Using a sample of 13 industrialized countries over the period 1870-1989, Evans (1996) found a confirmation of the neoclassical growth model. Indeed, he accepts the hypothesis of a stationary variance around a positive constant for this sample. On the other hand, for a sample of 51 countries, the tests do not allow him to state in favor of the neoclassical model or the endogenous growth models, because the behavior of the variance does not correspond to either of these hypotheses. The same tests, applied to a subgroup of 23 OECD countries and a second of 28 non-OECD countries, show that the cross-sectional variances are then stationary in level, which goes in the direction of the neoclassical growth model.

more recently with the 27 EU countries over the period 1990-2007, Marelli and Signorelli (2010) show a significant sigma convergence of GDP / capita in the new EU member countries and little divergence in the old ones.

1.3.2.2 Conditional β-convergence tests

In the previous section, the literature presented seems to show that unconditional β-convergence was mostly accepted for a club of countries including only rich countries, if poor countries are included, this hypothesis is generally rejected (Baumol 1986; Baumol and Wolff 1988; De Long 1988). Thus, the use of conditional β-convergence seems to be more consistent with the neoclassical growth model. We will discuss the empirical literature on β-convergence with the introduction of conditions such as the rates of accumulation in physical capital, human capital, and the average growth rate of the population. These variables are introduced into the model according to the extended Solow model approach proposed by Mankiw, Romer, and Weil (1992). We then describe the effects of other potential determinants of growth on the conditional convergence process.

1.3.2.2.1 Effects of variables such as the initial gdp per capita, the rate of accumulation of physical and human capital, and the rate of population growth

Based on a sample of 47 countries in Europe, America, and Asia, and covering the period from 1950 to 1977, Kormendi and Meguire (1985) examine various determinants of the average growth rate of real GDP, including initial GDP per capita, the average investment rate, and the population growth rate. Due to a lack of statistical data, the variable human capital accumulation rate is not included in their estimates. Their results show that the coefficient on the population growth rate is positive and significant, which is not surprising, as the explained variable is the aggregate GDP growth rate. The coefficient of the investment rate is positive and significant, and that of the initial GDP per capita is negative and significant. Introducing the population growth rate and the investment rate, thus shows a partial negative correlation between the growth rate and the initial GDP per capita.

Using a Cobb-Douglass production function with constant returns to scale, whose production factors are physical capital, human capital, and labor power, the seminal paper by Mankiw, Romer and Weil (1992) study the behavior of the economies of more than a hundred countries around their long-run trajectories. The authors regress the difference in GDP per working-age adult in 1960 and 1985 on a constant, and on the logs of GDP per working-age adult in 1960, the average rate of investment in physical capital, the average rate of investment in human capital, and the average rate of population growth. Mankiw, Romer, and Weil use the percentage of the population aged 15-19 with secondary education as a measure of the rate of human capital accumulation. This choice is somewhat restrictive as it excludes enrollment in primary education. In addition, this variable does not contain information on the quality of education. The results show that, for the groups of 98 and 75 countries, the coefficients are significant except for the population growth rate. They have the expected sign: positive for the rates of physical and human capital accumulation, negative for the initial level of GDP per working-age adult, and the population growth rate. Mankiw, Romer, and Weil, therefore, accept the hypothesis of conditional β-convergence for these two groups. The speed of convergence

to the steady-state path is equal to 1.37% for the group of 98 countries and 1.8% for the group of 75 countries.

For the group of 22 OECD countries, the coefficient of determination of convergence is significantly higher than for the previous two groups of countries. The coefficient of the population growth rate is in this case negative and significant, while that of the human capital accumulation rate is no longer significant. This non-significance of the human capital accumulation rate seems at first sight to be incongruous for the OECD countries, but the multicollinearity problem seems to be one of the explanations, as the schooling rates of all these countries are similar (Le pen 1997). The coefficient of the physical capital investment rate remains positive and significant. The estimated speed of convergence is equal to about 2%. Based on the Mankiw, Romer and Weil estimates, Cho and Graham (1996) show that, contrary to the most commonly accepted ideas, the poorest countries would be well above their long term trajectory. Conversely, the richest countries are far below their long-term path. For the poorest countries, the convergence process should result in a decline in their GDP per capita.

For 98 countries over the period 1960-1985, Barro (1991) studies the effect of the main determinants of the growth rate of GDP per capita. He introduced primary and secondary school enrollment rates in 1960 as a proxy for the initial stock of human capital, but these enrollment rates are introduced as flow variables. By introducing this variable, the hypothesis of conditional β-convergence is accepted for his sample of 98 countries. The coefficient of GDP per capita in 1960 in logarithm is negative and significant. The coefficients on school enrollment rates are positive and significant. The estimated speed of convergence is about 2%. Barro also introduces variables to capture the physical capital and fertility rate, as several theories refer to their determinant character for the growth rate of GDP per capita. The estimated coefficients of fertility and investment rates are all significant. For the fertility rate, its coefficient is negative, and for the investment rate positive. Barro notes that the initial coefficient of GDP per capita is not significantly different from that obtained without these variables. This suggests that the initial GDP per capita cannot be considered as a proxy for the investment rate or the fertility rate.

For 78 countries over the period 1965-1985, Benhabib and Spiegel (1994) regress the per capita growth rate on initial income, the growth rates of the population and the stocks of physical and human capital. The human capital stock series come from Kyriacou (1991) or Barro and Lee (1993). The coefficient of the initial per capita income is negative and significant, while that of the growth rate of the human capital stock is negative but not significant. This last result can be explained by the fact that some countries, in Africa in particular, experienced an increase in their human capital during the period when their growth was weak or even negative. On the other hand, the coefficient of the average level of human capital is positive and significant. In agreement with their theoretical analysis, they conclude that human capital intervenes in the process of convergence by facilitating the adoption of new technologies.

De Long and Summers (1991) show that there is a strong positive partial correlation between the growth rate per worker and investment in equipment and machinery for a sample of 60 countries over the period 1960-1985. De Long and Summers (1993) show that this result remains when industrialized countries are excluded from the sample.

Sala-i-Martin (1994, 1996) observes that numerous empirical studies on convergence between nations, but also between regions, lead to a speed of convergence of the order of 2%. This speed of convergence will only be compatible with the neoclassical growth model if the share of the return on capital in GDP is greater than 30%, a figure usually accepted. Only a broad interpretation of the concept of capital, including physical capital and human capital, then makes it possible to reconcile the estimates with the predictions of the neoclassical growth model. Sala-i-Martin then observes that this speed of convergence is very low: it takes 35 years for a country to halve its deviation from its long-term trajectory. Sala-i-Martin deduces from this that economic policy measures could have a lasting effect, even if in the long term the per capita growth rate remains exogenous.

1.3.2.2.2 Effects of other determinants of growth

The results presented in the previous paragraph showed that the introduction of the rates of accumulation of physical and human capital, as well as of the rate of population growth, revealed a partial negative correlation between the growth rate per capita and the Initial GDP per capita, thus making it possible to accept the conditional β-convergence hypothesis. The role of these rates is to control the heterogeneity of long-term trajectories. Also, work on conditional β-convergence will integrate other potential determinants of long-term growth. The aim is to assess the effect of these determinants on the convergence process. In a way, it would be a matter of establishing all the criteria that must be met for the process of convergence to take place.

Very often, the theoretical analysis of the effects of these variables is characterized by the duality of results already mentioned in the part of the theoretical analysis of convergence. Thus, for example, in the framework of neoclassical analysis, the amount and structure of public expenditure act on the level of per capita GDP, but not on its growth rate. On the other hand, in endogenous growth models, they can have a permanent effect on the long-term growth rate.

A first series of studies assess the effect of macroeconomic variables in the short or medium term.

Kormendi and Meguire (1985) and Barro (1991) estimate the effect of public consumption expenditure. Kormendi and Meguire get an estimated coefficient that is insignificant while, in the case of Barro, it is negative and significant.

The estimates of Easterly and Rebelo (1993) reveal that variables representative of taxation are not significant; their introduction, however, has the effect of making the initial per capita GDP insignificant. This result can be attributed to a multicollinearity problem.

Various authors seek to assess the effect of the inflation rate. Kormendi and Meguire (1985) obtain an estimated coefficient of the inflation rate that is negative and significant, just like Grier and Tullock (1989). Fisher (1993) confirms the negative relationship between growth and inflation.

The effect of cyclical fluctuations is assessed by Kormendi and Méguire (1985) and Grier and Tullock (1989). They show that the standard deviation of the real GDP growth rate has a positive and significant effect on growth. Ramey and Ramey (1994) obtain opposite results for a sample of 92 countries over the period 1950-1988, since GDP volatility then has a negative effect on growth. This contradiction again seems to be due to a problem of multicollinearity. The effect of structural variables on the convergence process has also been studied.

Kormendi and Meguire (1985) thus show that the share of exports in GDP has a favorable and significant effect on growth. For a sample of 95 countries over the period 1965-1980, Cho (1994) shows that the ratio of exports to GDP is not significantly correlated with the growth rate per capita while the growth rate of this ratio has a positive effect and significant. Ben-David (1993, 1994, 1996) concludes that the disappearance of barriers to international trade favors the convergence of economies, but his method remains essentially descriptive. Barro (1991) uses the deviations of purchasing power parities for capital goods from the average in 1960 as a measure of price distortions. The coefficient of this variable is negative and significant. Lee (1993) separately and jointly estimates the effect of exchange controls and tariffs on imports of capital and intermediate goods. The estimates, carried out over the period 1960-1985 for a sample of 81 countries, show that the coefficients of the variables representative of exchange controls and customs tariffs are negative and significant. Fisher (1991, 1993) obtains similar results.

Cho (1994) studies the effect of industrialization. He finds that the distribution of average growth rates per capita as a function of initial GDP per capita, for a sample of 95 countries taken from Summers and Heston (1988) over the period 1960-1985, follows a bell curve. However, the per capita growth rate of the richest countries is higher than that of the poorest countries. Cho notices that the usual β-convergence equations do not offer a very good representation of this distribution. Introducing the growth rate of the share of the active population in the manufacturing sector among the regressors makes it possible to get a regression that it considers satisfactory.

Finally, some authors seek to measure whether “non-economic” variables are likely to have an effect on the convergence process.

Kormendi and Meguire (1985) introduce a variable representative of civil liberties. It is not significant, but the sign of its coefficient indicates that an increase in civil liberties would have an unfavorable effect on growth.

De Long (1988) introduced an indicator variable for the level of democracy in 1870. Its coefficient is not significant. He concludes that the state of political and civil liberties in 1870 likely did not affect its subsequent growth.

Over the period 1960-1985, Barro. (1991) shows that variables representative of political instability have a negative and significant effect.

Finally, De Long (1988) introduces a dummy variable for the dominant religion in the country. Its coefficient is significant and indicates that belonging to the Protestant religion has a favorable effect on growth. De Long underlines how difficult it is to interpret this result.

The list of the various variables mentioned is not exhaustive, because it would be necessary to identify all the determinants of growth. The introduction of these variables makes the estimates much less robust due to multicollinearity issues. In addition, due to the problems of exogeneity and causality, we are exposed to estimation biases, in particular of the initial GDP per capita coefficient, which risks distorting the conclusions of the conditional β-convergence tests.

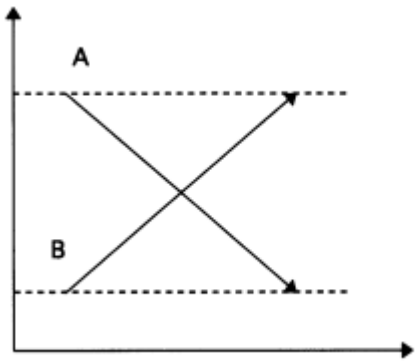
1.3.3 Criticism of the σ and β convergence approach

We have presented a number of seminal works on the empirical literature of real convergence, which Sala-I-Martin (1996) proposes to call "classical" since some of them are several years old. In this section, we presente the main criticisms of this approach to convergence. We will discuss afterwards convergence clubs because it is important enough to be treated separately. In addition, this issue uses different convergence criteria Le Pen (1997).

1.3.3.1 Criticism of the σ-convergence approach

Barro and Sala-i-Martin (1992) show that the dynamics of an indicator of dispersion of the distribution of GDP per capita can be misleading. Indeed, if the countries studied underwent an aggregate shock at the start of the period that temporarily reduced their standard deviation to make it below its long-term level, we will observe an increase in this standard deviation over time. This increase will occur even if we accept the hypothesis of unconditional β-convergence. This criticism does not however relate to the intrinsic qualities of the dispersion indicator but rather to the sensitivity of the results at the initial date. This is a criticism that can just as well be addressed to the β-convergence approach. In such a case, a study of the sensitivity of the estimates at the initial date would test the robustness of the results. Criticisms from Quah (1992b, 1993b, 1993a, 1996b, 1996a, 1996c) rejects the use of dispersion indicators because they do not provide relevant information on the dynamics of the distribution of GDP per capita. Consider the simple case of two countries. If the deviations of GDP per capita are stable over time, the standard deviation of this distribution will be constant. This case corresponds to figure 6. It will be the same if the countries exchange their relative positions between two successive observations, which is shown in figure 7[7]. In this case, neither of the two countries will not be systematically richer or poorer. The study of a dispersion indicator will not make it possible to distinguish these two cases.

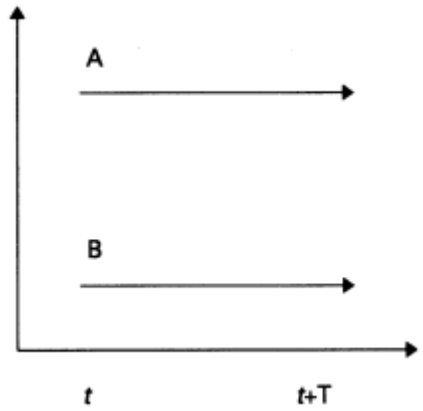
Figure 6:Stable GDP per capita deviation



Source: QUAH (1996b) and SALA-I-MARTIN (1996)

[7] These graphs are from QUAH (1996a) and SALA-I-MARTIN (1996)

Figure 7: Exchange of relative position



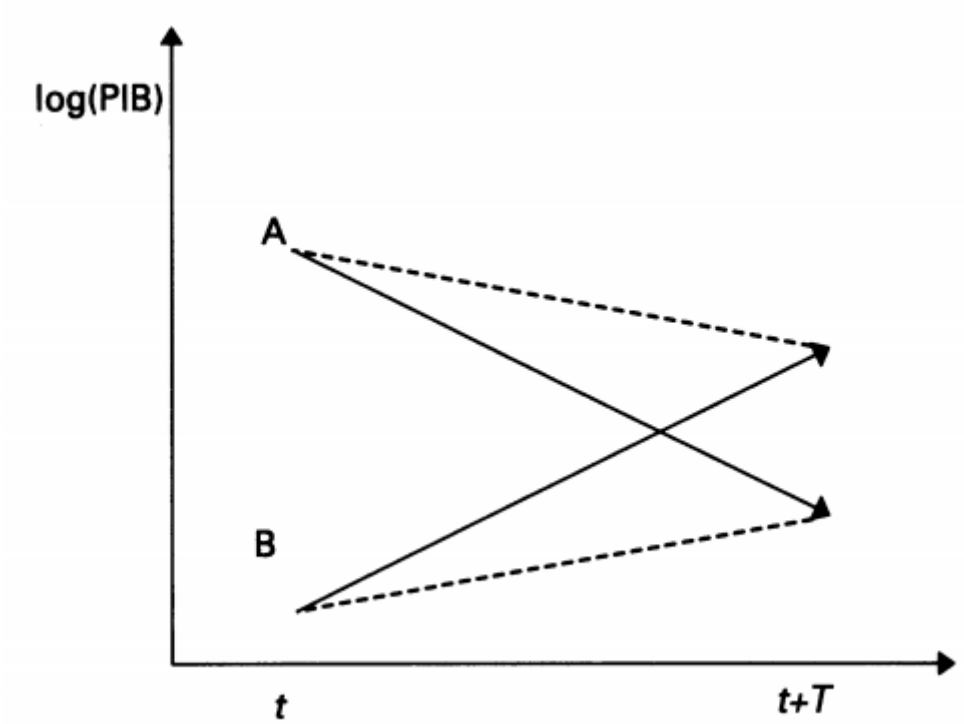
Source: QUAH (1996b) and SALA-I-MARTIN (1996)

1.3.3.2 Criticism of the β-convergence approach

Before presenting the major criticisms of the β-convergence approach, let us return to the previous example. The aim is to show an unconditional β-convergence limit. As shown in Figure 6, if the two countries reverse their relative positions between the initial and final observations, but the final gap is nevertheless smaller than the initial gap as in figure 8, then we will accept the β-convergence and σ-convergence assumptions. But can we really conclude that there has been convergence?

The series used to represent certain determinants of the long-term trajectory of the economy may also be inappropriate. The most obvious case concerns the enrollment rates used to represent the initial stock or the rate of accumulation of human capital. Edwards (1993) similarly considers that the ratio of exports to GDP is not necessarily an appropriate measure of the degree of liberalization of a country's trade policy.

Figure 8: Exchange of relative position, final gap smallet than initial one



Source: QUAH (1996b) and SALA-I-MARTIN (1996)

1.3.3.3 Lack of robustness of estimates

Levine and Renelt (1992) demonstrate, by modifications of the statistical series used to represent the determinants of the growth rate, that the estimates of the conditional B-convergence equations are not very robust (12). The data, taken from Summers and Heston (1988), cover 119 countries. Estimates are made for the period 1970-1989 or 1974-1989.

Levine and Renelt show that the positive correlation between the growth rate per capita and the investment rate is one of the few reliable results. The growth rate remains negatively correlated with the initial GDP per capita as long as the stock of human capital, represented by the secondary school enrollment rate, is among the regressors. This is one result highlighted by Barro (1991), Mankiw, Romer and Weil (1992) in particular. The conditional convergence hypothesis, therefore, appears to be confirmed. Others more in-depth studies show, however, that it is no longer accepted over the period 1974-1989 or if OECD countries are excluded from the sample. The correlation between the growth

rate of the population and the average growth rate per capita is considered to be not very robust to a modification of the other regressors. Evaluating the robustness of the variables used to reveal the effect on growth of budgetary or monetary policies, or of foreign trade, reveals the sensitivity of the partial correlations to a modification, however small, of the other explanatory variables. Thus, among other things, the robustness of the correlation between growth and public spending excluding education and defense highlighted by Barro (1991) is fragile.

Levine and Zervos (1993) also use the extreme bounds method to assess the robustness of the partial correlations between the growth rate per capita and various indicators of fiscal, monetary, trade, exchange rate or financial development policy. They use a sample of over 100 countries over the period 1960-1989. Their estimates confirm the fragility of the partial correlations, for the inflation rate in particular. However, some financial sector development indicators are exceptions. Finally, Levine and Zervos underline the sensitivity of the estimates to a change in the sample of countries.

Sala-i-Martin (1994) responds to criticisms from Levine and Renelt (1992) and Levine and Zervos (1993). According to him, since the support of the law of the coefficient of the variable whose robustness is tested probably includes positive and negative values, there is a non-negligible probability that the variable in question is not considered to be robust. Sala-i-Martin notes that there are strong correlations between regressors, especially when they represent economic policy. Considering these variables simultaneously then risks weakening their significance.

Andrés, Doménech and Molinas (1996) evaluate the robustness of the estimates of the conditional β-convergence equations in the case of OECD countries using a different method from that of Levine and Renelt (1992). They show that the estimates of the coefficients of the rates of accumulation in physical and human capital are not very robust to changes in estimation periods or in the sample. On the contrary, the coefficients of the macroeconomic indicators are robust, even, for some of them, more robust than those of the accumulation rates. This is particularly the case for the growth rate of exports, monetary growth, both positively correlated with growth. Likewise, inflation and the variability of inflation and monetary growth exert a negative and robust effect on growth.

The authors show that public sector consumption expenditure or the budget surplus is not robust. The introduction of these macroeconomic indicators does not make it possible to reduce the lack of robustness of the coefficients of the accumulation rates. This leads the authors to question the validity of the augmented Solow model as a representation of the growth process, mainly during periods of recession. Andrés, Doménech and Molinas (1996) consider that their results differ from those of Levine and Renelt (1992) in part because, being limited to OECD countries, they employ a more homogeneous sample of countries.

1.3.3.4 Insufficient explanatory diagrams

Barro (1991) notes that economic theory does not seem to be able to fully explain the low growth rates of African countries and some Latin American states since 1950. He adds two dummy variables for sub-Saharan African countries and Latin American countries to its conditional β-convergence equations. They have a negative and significant effect on growth, which suggests that the determinants of growth included in the conditional β-convergence regressions leave partly unexplained the poor performance of African or Latin American countries.

Similarly, Easterly, Kremer, Pritchett and Summers (1993) note that growth rates fluctuate considerably over time, which is not the case for the most commonly considered determinants of growth. They deduce that the explanatory power of these determinants is moderate, and that the growth performance of economies is largely explained by specific random shocks.

1.3.3.5 Failure to take causal relationships into account

A recurrent criticism relates to the insufficient study of the causal relationships between the growth rate per capita and the various explanatory variables considered. This problem has at least two implications. The first is of a statistical nature since an erroneous modeling of the causal relationships biases the estimates. The second relates to economic policy. It is a question of determining whether this or that instrument of economic policy is likely to act on growth, or if, on the contrary, it is influenced by the level of growth. Some authors try to reveal the meaning of these causal relationships. De Long and

Summers (1991, 1993) attempt to clarify the causal links between investment in equipment and growth. Their estimates lead them to conclude in favor of a causal relationship from investment to growth. Easterly and Rebelo (1993) conclude that public infrastructure spending affects the level of growth. Blomström, Lipsey and Zejan (1996) show, on the contrary, for 101 post-war countries that the causality is exerted from growth to investment in physical capital.

Cho (1996) examines the exogeneity of the investment rate and the population growth rate compared to the level of per capita GDP. The tests, carried out on a sample of 109 countries for the period 1960-1985, reject the hypothesis of exogeneity. There would be two consequences. First of all, the coefficient of the initial GDP per capita would be underestimated due to a simultaneity bias. The use of estimation methods taking into account such a bias leads to reject the hypothesis of unconditional β-convergence. In addition, the coefficient of GDP per capita would not measure the total effect of the initial GDP per capita on growth since it would also be necessary to take into account its indirect effect via the investment rate and the population growth rate. The estimates show that the cumulative effect is positive, which leads Cho to reject the convergence hypothesis.

Alenisa, Özler, Roubini and Swagel (1996) study the causal relationship between economic growth and the level of democracy. They show that political instability has a negative effect on growth, but that low growth does not increase the probability of government change.

1.3.3.6 Insufficient processing of information

The results which have just been presented were obtained by estimating the conditional β-convergence equations by cross-section regressions. This calls for two comments on the processing of the information provided by the statistical series.

Using final and initial observations obscures the trajectory of per capita GDP between these two dates. The econometrics of time series should provide a better understanding of the dynamics of the series.

In addition, the cross-sectional regressions force the parameters to be identical for all countries. This constraint appears to be excessive. There could very well be unobservable factors whose effect could be captured by an individualized constant. Thus, the homogeneity constraint wrongly imposed will have the effect of biasing the estimates. It, therefore, seems necessary to introduce more heterogeneity in the specification of the conditional β-convergence equations. A natural approach would then be to use the methods of panel econometrics, by particularizing the constant or all of the parameters. The work using this approach is presented in more detail in the next section. They show that the introduction of a certain degree of heterogeneity significantly modifies the results. The results of Canova and Marcet (1995) confirm this criticism. The authors test the hypothesis of heterogeneity of long-term trajectories and the speed of convergence towards these trajectories on a sample of European OECD countries from 1950 to 1985. Their conclusions do not reject the hypothesis of heterogeneity. Marcet and Canova deduce that the estimates by cross-sectional regressions are undoubtedly biased. They think in particular that the speed of convergence of 2% invariably obtained by cross-sectional regressions on different samples of countries and different periods can be explained by this bias.

Quah (1996b) also underlines the insufficient use of information. However, he considers that neither the methods of time series econometrics nor those of panel econometrics can resolve the issue of convergence. In time series econometrics, only a small number of countries can be considered simultaneously for lack of sufficiently long statistical data. In panel econometrics, the principle is to evaluate the behavior of a representative country, which does not shed light on the changes in the relative positions of the countries.

1.3.3.7 Too strong assumptions on per capita GDP

Evans and Karras (1993, 1996) and Evans (1996) show that the estimation of the conditional β-convergence equations by cross-sectional regressions is only valid under extremely constraining assumptions. More precisely, the deviations of GDP per capita from the cross-sectional average must follow identical first-order autoregressive processes. In addition, the permanent differences between economies must be fully

integrated in the conditional β-convergence regressions. Evans (1996) demonstrates that if these conditions are not met, the residual of the conditional β-convergence equation is correlated with the initial GDP per capita, which bias the estimation of the parameters of this equation. Evans and Karras (1996) show that these conditions are not verified for the GDP per capita of 54 countries over the period 1950-1990. Consequently, these authors propose to verify the convergence hypothesis by studying the persistence of the differences in GDP per capita. This method, which imposes fewer conditions on the series, seems to them more apt to reveal the existence of a process of convergence, absolute or conditional, or of divergence of economies.

1.3.4 Contribution of panel econometrics

The use of panel econometrics methods to estimate β-convergence equations is a response to some of the criticisms that have just been formulated. By particularizing the constant or the coefficients of the regressors, these estimates make it possible to introduce heterogeneity in the specification of the conditional β-convergence equations. Islam (1995) traced its study on Mankiw, Romer and Weil (1992). He re-estimates their conditional β-convergence equation by introducing an individual specific effect. This effect is supposed to measure the effect of unobservable factors that condition the efficiency with which each economy uses its factors of production. The individualized constant can however be correlated with the other regressors, which requires the use of adapted estimation methods. Islam considers three samples of countries as close as possible to those of Mankiw, Romer and Weil (1992). As, for the latter, the regressors include the initial GDP per capita, the rate of investment in physical capital and the rate of population growth to which Islam then adds the rate of accumulation of human capital. Unlike Mankiw, Romer and Weil, Islam uses the Barro and Lee (1993) database to represent human capital. The introduction of an individual specific effect raises the estimated value of the speed of convergence towards the long-run trajectory and lowers the estimated elasticity of output with respect to the stock of physical capital. Islam explains these results with a bias due to an omitted variable. He stresses that the degree of efficiency with which the factors of production are employed is an important source of heterogeneity. Another interesting result appears when the rate of human capital

accumulation is introduced. While the sign of this variable is positive in cross-sectional regressions, it becomes negative in panel estimates. Taking into account the dynamics of the rate of accumulation of human capital therefore leads to a result that contradicts theory and intuition. Benhabib and Spiegel (1994) obtain a similar result. Islam deduces from this that the statistics used, which do not contain information on the quality of education, overestimate the rate of accumulation of human capital.

Knight, Loayza and Villanueva (1993) also propose to re-estimate the conditional β-convergence equation of Mankiw, Romer and Weil (1992) by introducing an individual specific effect. In addition, they consider two other determinants of growth: the country's openness to international trade, measured by the weighted average of customs tariffs on intermediate goods and capital goods, and the stock of public infrastructure, represented by the public investment rate. The conditional convergence equation is estimated on a sample of 81 countries over the period 1960-1985. The coefficients are significant and have the expected sign: positive for the rates of accumulation in physical and human capital, negative for the rate of population growth. Introducing the public investment rate and the variable representative of customs tariffs has the effect of doubling the coefficient of the investment rate. The measure of the openness of the economy, or more precisely of its closure, is negatively and significantly correlated with the growth rate per capita. The coefficient of the variable measuring the stock of public infrastructure is positive, but not significant; Knight, Loayza and Villanueva assume that this lack of significance is explained by the use of a flow variable to measure a stock. The speed of convergence is higher than that of Barro (1991) and Mankiw, Romer and Weil (1992).

Unlike the previous articles, Caselli, Esquivel and Lefort (1996) simultaneously deal with two potential sources of bias in the estimates of conditional β-convergence: the existence of an individual specific effect correlated with the regressors and the presence of endogenous regressors. The conditional β-convergence equation, rewritten in the form of a dynamic model of GDP per capita in log, is estimated in first difference by the generalized moment's estimator. Estimates are made for a sample of 97 countries over the period 1960-1985 by considering intervals of 5 years. This method substantially

modifies the results. In the case where the regressors are the average population growth rate and the rate of investment in physical capital, the estimates differ markedly from those of Mankiw, Romer and Weil (1992). The estimated speed of convergence is twenty times higher than that of Mankiw and alii and the estimated share of the return on capital in the GDP is clearly lower than that of Mankiw and alii and also that, equal to about a third, that indicate national accounts data. The authors deduce that the "simple" or "extended" versions of Solow's model are not compatible with their estimates. Finally, the tests carried out show that the investment and population growth rates are not exogenous. The authors apply the same estimation method to regressions with a larger number of regressors (15). Here again the estimates differ markedly from the cross-sectional estimates. In particular, the estimated speed of convergence is now of the order of 10%. The coefficient of some regressors also changes. For example, the coefficient of the public consumption expenditure rate is now positive and significant while its sign was negative with cross-section regressions. The authors deduce that the failure to take into account the problems of exogeneity and specific individual effects significantly bias the estimates. In addition, given the particularly high level of the speed of convergence, the authors conclude that the differences in per capita GDP between countries are explained more by differences in long-term trajectories, than by low mobility towards a single long-term trajectory.

1.3.5 The approach by the persistence of per capita gdp differences

In this section, we present the approach to convergence by studying the differences in GDP per capita. This method breaks with the approaches by σ-convergence or β-convergence. It tackles convergence by focusing the interest on the statistical properties of the series of GDP per capita. The assumption of convergence now corresponds to that of stationarity of the differences in GDP per capita with a zero average. This definition has been suggested by Bernard (1991), Bernard and Durlauf (1992b, 1996) and Quah (1992a). This approach can be interpreted as a study of the links between the deterministic and stochastic trends in the series of GDP per capita.

The verification of this form of convergence involves the characterization of the series of deviations. Bernard (1991) and Bernard and Durlauf (1995) applied different unit root tests in univariate or multivariate to verify the hypothesis of convergence of GDP per capita of 15 OECD countries. Annual data are taken from Maddison (1989) and cover the period 1900-1987. Whatever test is used, the convergence hypothesis, in the absence's sense of persistence, is always rejected.

Quah (1992a) tests the unit root hypothesis for the per capita GDP deviations of various samples from over 100 countries over the periods 1960-1985 and 1970-1985. Whatever the sample or the period considered, the unit root hypothesis is never rejected. Note that Quah does not foresee in these tests the possibility of stationary deviations around a non-zero mean.

Greasley and Oxley, (1995) study the convergence between Australia, the United Kingdom and the United States from 1870 to 1992. Unlike Bernard (1991) and Bernard and Durlauf (1995), they do not reject cases where the differences are stationary around a deterministic trend, but interpret them as forms of catching up. They also accept the possibility that the deterministic component undergoes breaks in level or in trend, in accordance with the approaches developed by Perron (1989) or Zivot and Andrews (1992). The hypothesis of zero stationary deviations then corresponds for them to that of “long-term convergence”. Greasley and Oxley reject the “long-term convergence” hypothesis for the three deviations over the 1870-1992 period, but accept it between the UK and Australia over the 1892-1992 period. However, the introduction of breaks in the deterministic component makes it possible to reject the unit root hypothesis for each of the three deviations over the period 1870-1992. The authors then conclude that there are different forms of catching up between these economies. These latest results are however puzzling. From the point of view of the method, the unit root tests with rupture of the deterministic component pose formidable problems: how to choose the type of rupture, the number or the date of this one? The method of Zivot and Andrews presupposes a single break while the authors believe that there can be two. In addition, the notion of "catching up" adopted by these two authors seems erroneous. Indeed, if the difference between two countries is of the same sign as the slope of the deterministic trend, it is

increasing. Assuming on the contrary that they are of opposite signs, we can then predict with certainty in the more or less long term a reversal of the relative positions of these countries, except assuming that the deterministic tendency disappears once the two countries join themselves.

Note that unit root tests are relatively weak. We can then consider that the use of these tests is too unfavorable for the convergence hypothesis. Le Pen (1996) shows however that the application of the stationarity test of Kwiatkowski, Phillips, Schmidt and Shin (1992), which makes it possible to choose the convergence hypothesis as a null hypothesis, does not change the previous conclusions. We can therefore deduce that the use of a test supposed to favor the hypothesis of convergence confirms the rejection of this form of convergence. The result of per capita GDP deviations containing a unit root therefore seems robust.

Evans and Karras (1996) show, however, that the unit root test with panel data by Levin and Lin (1993) allows us to accept the hypothesis of stationary differences in GDP per capita around a non-zero mean for 54 countries over the period 1950-1988. Le Pen (1996) shows that the same conclusion was obtained for a sample of 20 OECD countries over the period 1950-1988. As a result, a unit root test more powerful than those usually employed in time series can change the conclusions about the differences in GDP per capita. These results can be interpreted as favorable to the conditional convergence hypothesis.

Faced with the frequent rejection of convergence defined as the absence of persistence of deviations in GDP per capita, a more flexible hypothesis consists in verifying the existence of cointegration relationships between GDP per capita.

Bernard (1991) tests the hypothesis of cointegration between each pair of GDPs per capita in log of the 15 OECD countries. It accepts the existence of cointegrating relationships for only 41 country pairs. Bernard and Durlauf (1995) accept the existence of 2 or 3 common stochastic trends for 15 OECD countries. They accept 4 or 5 common stochastic trends for a subgroup of 11 European countries.

In the same spirit, Serletis and Krichel (1992) accept the existence of 8 common stochastic trends between the quarterly series of industrial production per capita of 10 countries of the European Union over the period 1962-1990. Tavera (1993) accepts two common stochastic trends between the quarterly series of French, German, British and Italian real GDP over the periods 1970-1980 and 1980-1990.

The characterization of the differences in per capita GDP therefore often leads to rejecting this form of convergence. Bernard and Durlauf (1996) show that this method only makes sense if the economies have already reached their long-term trajectories, which may explain its failure. In addition, the lack of power of unit root tests is a non-negligible factor, as the work of Evans and Karras (1996) seems to confirm. The search for cointegrating relationships indicates that growth is not the result of purely national factors since there are common trends. This approach, as it is currently practiced, that is to say in univariate, does not make it possible to determine the reasons for the persistence of the gaps nor to identify the nature of the common stochastic trends.

Approach by the dynamics of the distribution of GDP per capita.

We present the dynamic approach to the distribution of GDP per capita. This method was notably proposed and implemented by Quah (1992b, 1993b, 1993a, 1996b, 1996a, 1996c). Its principle is to characterize two aspects of the dynamics of the distribution of GDP per capita. The first concerns the evolution of the shape of this distribution over time: if it is initially unimodal, does it remain so or does it become multimodal? The second aspect concerns the magnitude of the changes in relative positions within this distribution: do rich countries remain so, or are there many changes in relative positions over time?

Quah (1992b) proposes a theoretical framework for this approach. It amounts to evaluating how the distribution of per capita GDP changes over time by calculating transition probabilities from one class of country to another. This method also makes it possible to predict the future shape of the distribution function of GDP per capita.

Quah (1993a) applies this method to the GDP per capita of 118 countries taken from Summers and Heston (1991) between 1962 and 1984. The GDP per capita, divided

by their average in cross-section, are divided into five quantiles defined by the thresholds 1 / 4, 1/2, 1 and 2. Quah estimates the probabilities of going from one quantile to another between two dates. The passing probabilities for a one-year interval show a very strong persistence of relative positions. The mobility of economies is greater over the 23-year interval, but this mainly results in a reinforcement of inequalities. The richest economies remain so, while the likelihood of impoverishing economies in the middle quantiles is high. The long-run GDP per capita distribution function confirms that per capita GDPs tend to be concentrated at the ends. This result seems favorable to the hypothesis of convergence clubs: there would exist a club of rich countries and another of poor countries.

Quah (1993b, 1996b) uses more refined methods to assess the dynamics of the distribution of GDP per capita. The results of this work confirm those of Quah (1993a). They show that in the long run the distribution of GDP per capita splits into one group of rich countries and another of poor countries.

Quah (1996a) studies the persistence of the residuals of the regression of the annual growth rate of GDP per worker on the investment rate, the enrollment rate and a dummy variable for African countries. The equations are estimated by cross-sectional regressions on a sample of 116 countries for the period 1963-1985. The residues then appear to be very persistent: some countries therefore have systematically above or below average performance. Quah (1996a) interprets this result as a rejection of the conditional convergence hypothesis.

Cho (1994) estimates the density function of the average per capita growth rate conditional on the initial GDP per capita. It uses a sample of 95 countries over the period 1960-1985. It obtains a concave shape. The estimated density indicates that the growth rate is higher for the group of middle-income countries, then for high-income countries. The average per capita growth rate is the smallest for countries with the lowest GDP per capita in 1960.

Using non-parametric estimation methods, Desdoigts (1994) estimates the density of the distribution of GDP per capita or per worker for more than 100 countries

in 1960 and 1985. The densities appear to be clearly multimodal, with the possible exception of that of GDP per capita in 1960. The author considers that each of the modes reflects the existence of a convergence club. Regarding the mobility of countries, Desdoigts obtains different results from Quah since his assessment of the transition probabilities in the distribution of GDP per capita between 1960 and 1985 leads him to conclude that countries are relatively mobile.

Bianchi (1997) adopts an approach comparable to that of Quah and Desdoigts since it consists in studying the distribution of GDP per capita.

Using non-parametric estimation techniques, it estimates the distribution function of per capita GDP at different dates and tests whether, at each of these dates, it has one or more modes. This last point therefore makes it possible to verify the existence of convergence clubs. The study, carried out on a sample of 119 countries for the years 1970, 1980 and 1989, shows that the distribution of GDP per capita, initially unimodal, becomes more bimodal over time. The existence of a club of poor countries and a second of rich countries has therefore asserted itself over time. Moreover, the gap between these two clubs worsened during the period. Finally, the composition of these clubs shows that the mobility of the countries is low.

Unlike the work of Quah, the study of Bianchi (1997) corresponds to a juxtaposition of snapshots. It does not have a dynamic dimension, which prevents the author from formulating forecasts on the evolution of the distribution of GDP per capita. Thus, it cannot confirm whether the highlighted bimodality or multimodality will persist or disappear in the future.

As for the approach by the persistence of the gaps, this method proposes to reveal facts on the convergence or the absence of convergence, but it does not give an economic interpretation.

1.3.6 Local convergence or global convergence: are there "convergence clubs"?

This last section brings together the major results concerning the existence of convergence clubs.

The theory has questioned the extension that should be given to the process of convergence. In the neoclassical approach, economies are assumed to have access to the same production function at constant returns to scale. Romer (1986), in his poverty trap model, assumes that the externality linked to the accumulation of physical capital requires a minimum level of physical capital. In the model of Azariadis and Drazen (1990), a minimum threshold for the accumulation of human capital conditions access to a more efficient production function. Conditional on their initial stocks of physical or human capital, economies will have distinct long-run trajectories. Then emerges the picture of groups of countries within which a process of convergence takes place, but which do not come closer to each other.

The previous section has shown that the study of the dynamics of the distribution of per capita GDP made it possible to get conclusions favorable to the hypothesis of convergence clubs since it revealed the existence of a club of rich countries and another from poor countries.

The approach based on the persistence of per capita GDP differences makes it possible to characterize each of the per capita GDP differences one by one. In this sense, it could reveal the groups of countries for which the differences in GDP per capita are not persistent. These groups would then constitute a convergence club. However, this method requires a large number of temporal observations; moreover, it is relatively cumbersome to implement. Also, Bernard (1991) and Bernard and Durlauf (1995a) limit themselves, for example, to the 15 industrialized countries of Maddison (1988). They justify this choice for two reasons.

First of all, the unconditional β-convergence hypothesis, accepted for this sample of countries, is a necessary condition, but not sufficient, to reject the persistence of the gaps. Then, the rejection of the hypothesis of the absence of persistence of differences on such a sample of countries, whose composition is biased in favor of the hypothesis of convergence, should be interpreted as a strong sign of rejection of convergence.

However, conditional β-convergence is still the most frequently used form of convergence so far. It also comes up against the problem of the composition of convergence clubs. A first method consists in determining the possible convergence clubs according to one or more criteria chosen a priori and in verifying whether the conditional β-convergence hypothesis is accepted for each of these groups. We first present the results of this approach. The second method consists of applying procedures intended to endogenously select the composition of convergence clubs. We present in the second paragraph the results then obtained.

1.3.6.1 A priori selection of convergence clubs

Certain articles presented previously already introduced, implicitly at least, the problem of convergence clubs. The composition of the convergence clubs was fixed there on the basis of geographical or institutional criteria (OECD countries, centrally planned countries).

Abramovitz (1986) shows that he would undoubtedly reject the hypothesis of unconditional β-convergence if his sample of countries were larger and more heterogeneous than the 16 industrialized countries of Maddison (1980).

Baumol (1986) rejects unconditional β-convergence for a group of 72 countries over the period 1950-1980. He then distinguished 3 sub-groups: the 16 industrialized countries of Maddison (1980), countries with planned economies, capitalist countries with low or middle income. From the graphic study of the relationship between the growth rate and the initial GDP per capita, Baumol concludes that the first two groups constitute convergence clubs, while a process of divergence manifests itself within the third. This finding seems to corroborate the underdevelopment trap hypothesis. There is no catching-up trend between the group of 16 industrialized countries and that of centrally planned economies.

Grier and Tullock (1989) test the stability of the estimated coefficients of the regressions explaining the determinants of the growth rate between groups of countries. These groups are the 24 OECD countries and 89 other countries in the rest of the world. Among the 89 countries of the rest of the world, Grier and Tullock distinguish the

countries of Africa, Asia and America. The conditional β-convergence hypothesis is not accepted for all groups of countries. The initial GDP per capita coefficient is negative and significant for OECD countries, but it is positive and significant for the 89 countries in the rest of the world. The estimates for each of the three subgroups of non-OECD countries give different results. The coefficient of the initial GDP per capita is positive and significant for Asia and Africa, negative but not significant for America. Grier and Tullock conclude that the different explanations for growth they have studied seem to apply better to OECD countries than to the rest of the world. Their work reveals a persistent divergence between rich and poor countries.

The regressions of Mankiw, Romer and Weil (1992) suggest the existence of convergence clubs. Unconditional β-convergence is rejected for the samples from 98 and 75 countries, but not for the 22 OECD countries. The estimation of the conditional β-convergence equations with population growth rate, physical capital accumulation rate and human capital accumulation rate, shows that the behaviors of these three groups of countries differ significantly. Thus, for the OECD countries, the coefficients of the initial GDP per capita and of the population are higher in absolute value and that of the investment rate lower.

The works listed agree in accepting that a process of β-convergence has taken place among the OECD countries, which can therefore claim to form a convergence club. Specific studies carried out on this group of countries, such as those by Maddison (1991) or Dowrick and Nguyen (1988), confirm this result. For the other countries, the results are mixed but generally conclude that a process of divergence exists for the poorest countries.

1.3.6.2 Endogenous selection of convergence clubs

We present different approaches aiming to endogenize the composition of convergence clubs.

Durlauf and Johnson (1995) and Bernard and Durlauf (1996) underline one limitation of the usual procedure for estimating β-convergence equations by cross-section regressions. By imposing the uniqueness of the coefficients of the regressors, it cannot

reveal the existence of multiple long-term trajectories. If the correct assumption is that of multiple long-term equilibriums, the exact form of the β-convergence equation will have to have a particularized constant. If we wrongly impose the uniqueness of the coefficients, the estimates will be biased as demonstrated by Pesaran and Smith (1995). Bernard and Durlauf (1996) show in particular that there is a class of multiple long-term equilibrium models such that estimating a β-convergence equation by cross-sectional regressions produces an estimated negative value of the coefficient of PIIB per initial head. The β-convergence hypothesis for these countries would then be wrongly accepted. It is also possible that one variable of the conditional β-convergence equations is correlated with the long-term growth rate and that it thus makes it possible to implicitly discriminate between the different long-term trajectories. The estimated coefficient of the initial per capita GDP would then measure the speed of convergence within each of the convergence clubs, and we would wrongly accept the convergence hypothesis for all the countries. Using Monte-Carlo simulations, Bernard and Durlauf (1996) confirm that cross-sectional regressions do not reveal the existence of multiple long-term trajectories.

A first method of finding convergence clubs consists in estimating polynomial functions of the initial GDP per capita or of differentials of GDP per capita. Thus, Baumol and Wolff (1988) regress the difference in GDP per capita in log in 1950 and 1980 on the level and the square of GDP per capita in 1950 for a sample of 72 countries taken from Summers and Heston (1988). The coefficient of GDP per capita squared being negative and significant, Baumol and Wolff separate the countries into two groups: the rich countries form a convergence club. For poor countries, the growth rate is then positively correlated with the initial GDP per capita.

Chatterji (1992) adopts a similar approach since it decreases the gap in per capita GDP in log of each country compared to the United States in 1985 on a polynomial of order 3 of this gap in 1960 for 109 countries extracted from Summers and Heston (1988). Estimates show the existence of a club of rich countries, which should eventually equalize their GDP per capita with that of the United States, and a second of poor countries.

Cho (1994) regresses the average per capita growth rate on a quadratic function of the initial GDP per capita for 95 countries by Summers and Heston (1988) over the

period 1960-1985. Estimates show that the growth rate is higher and negatively correlated for rich or middle-income countries. In contrast, for low-income countries, the growth rate is positively correlated with initial income.

A second method will consist in using various algorithms in order to highlight the convergence clubs.

Durlauf and Johnson (1995) refer to Mankiw, Romer and Weil (1992) for whom they use the conditional β-convergence equation with investment rate, human capital accumulation rate and population growth rate. They want to show that the growth performances of the 98 countries of Summers and Heston (1988) from 1960 to 1985 are better explained by a multiple equilibrium model than by a single equilibrium model. They endogenize the selection of convergence clubs by applying the Quandt (1958) method then the decomposition of tree method of Breiman et al. (1984).

The Quandt method only allows one classification criterion and requires a priori to choose the number of convergence clubs. Durlauf and Johnson set the number of convergence clubs at three. When the PIIB per capita in 1960 is the classification criterion, the estimation of the conditional β-convergence equation on each of these three groups indicates a significant improvement in the results compared to Mankiw, Romer and Weil.

Durlauf and Johnson, however, get unusual results. Thus, the initial GDP per capita coefficient is negative and significant for the group of low-income countries, negative but not significant for the group of middle-income countries, and positive but not significant for the group of high-income countries. Much of the work already presented argued more in favor of β-convergence for rich countries and divergence for poor countries. Durlauf and Johnson compare their estimates to those of De Long (1988) who rejected β-convergence for a group of 22 countries. When the literacy rate in 1960 is the selection criterion, the explanatory power of the regressions is weaker except for the middle group. The coefficients of GDP per capita in 1960 are all negative and significant.

Unlike that of Quandt, the decomposition tree method of Breiman et al. (1984). Makes it possible to combine several criteria (the GDP per capita in 1960 and the literacy rate in this case) and to endogenize the number of convergence clubs. . Durlauf and Johnson get four groups of countries whose composition seems relatively homogeneous. The first consists exclusively of poor African countries, the second of the countries of Asia or African countries better endowed with natural resources, the third of the countries of Latin America and South-East Asia and the fourth of the major industrialized countries. Some results are surprising, however. Thus, Japan is classified in the third group with Madagascar.

The estimation of the conditional convergence equations on each of these groups confirms the heterogeneity of the estimated coefficients. There are some previous results. For the first and third groups, the coefficient of the initial GDP per capita is negative and significant. For the second group, the initial GDP per capita coefficient is negative but not significant. For the group of the richest countries, the coefficient is positive but not significant. This last result contradicts most other empirical work that generally accepts the conditional convergence hypothesis for the richer countries. The presence of Argentina, Chile and Venezuela in this group no doubt explains this rejection.

The impact of other determinants of the growth rate differs across country groups. The coefficient of the investment rate is not significant for the second group, but is positive and significant for the other three groups. The higher the level of development, the greater the effect of the investment rate on growth. The coefficient of the rate of human capital accumulation is positive and significant for the second and fourth groups, and negative, but not significant for the first and third groups.

Durlauf and Johnson are inspired by the model of Azariadis and Drazen (1990) to interpret this result. The change in production function would be conditioned by a minimum threshold of human capital. Beyond this threshold, a new production function would be implemented and the marginal productivity of human capital would be low. The first and third groups would be in this situation. The economy would then grow to a new threshold where production would have to be reorganized: a new need for human capital would then arise. The countries of the second and fourth groups would be in this phase.

Berthélemy and Varoudakis (1995) apply the decomposition tree method to 91 countries over the period 1960-1985. The selection criteria are the level of financial development and the initial human capital stock. The growth rate depends on the initial GDP per capita, the average level of public consumption expenditure as a percentage of GDP from 1960 to 1985, a variable reflecting political instability, a dummy variable for oil-producing countries.

The decomposition tree method reveals 5 convergence clubs. The initial stock of human capital appears to be a more decisive selection criterion than the level of financial development. Estimates show that the growth regimes are very different. In particular, the conditional β-convergence hypothesis is accepted for the three best endowed groups, but it is rejected for the last two. The coefficient of the initial GDP per capita of the group of the poorest countries is positive, which suggests the existence of an underdevelopment trap.

The growth performances of the different groups encourage Berthélemy and Varoudakis to reduce the number of clubs to 3. The groups from the richest countries, intermediate countries and the poorest countries would in fact be the only stable long-term equilibria. The countries belonging to the two groups being inserted between them would be in a situation of transition towards a “high” or “low” equilibrium.

Accardo (1994) criticizes the decomposition tree method used by Durlauf and Johnson (1992) and Berthélemy and Varoudakis (1995). A first criticism concerns the absence of a test of the number of convergence clubs. Accardo shows that Durlauf and Johnson suspect that the number of these clubs is overestimated; similarly, Berthélemy and Varoudakis (1995) do not consider intermediate groups as true convergence clubs. The second criticism formulated by Accardo concerns the absence of an underlying statistical model. Accardo assumes that Durlauf and Johnson implicitly adopt the hypothesis of a regression model with several regimes. He indicates that the estimates by partition and minimization of least squares criteria are biased in this case. Accardo interprets the positive and significant coefficient of the initial GDP per capita obtained by Durlauf and Johnson for the richest countries as a sign of this bias. It is indeed for these countries, the convergence hypothesis is most often accepted.

More resently, using a non-linear latent factor framework for 27 European countries between 1970 and 2010, Borsi and Metiu (2013) found evidence for convergence, but to different income levels, which refers to convergence clubs.

1.4 SUMMARY

The general objective of this chapter was to present the concept of convergence in economics. To do so, we divided it into three parts. The first part deals with the statistical aspects of convergence. We first define and distinguish converging series from those that have converged, the series converging towards a constant from those tending towards equality. Then second we present the statistical characterization of the convergent series. Thus, we distinguish convergence according to the average evolution of their difference, or according to the evolution of their dispersion. The second part of this chapter makes a survey of the theoretical literature of convergence in economics. This survey shows that the hypothesis of convergence between lagging and leading countries is a controversial topic that goes back to the 18th century. Neoclassical growth models broadly support the convergence hypothesis (conditional or unconditional). Alternative endogenous growth models to some extent, the new literature on economic geography and dependency theory support non-convergence. The third part of this chapter first presents the main criteria commonly used to measure real convergence, namely the σ-convergence and β-convergence. Then we survey the empirical literature on real convergence. The analysis of this literature shows that conditional convergence or convergence clubs seem to be more credible.

CHAPTER 2: STRUCTURAL CONVERGENCE, TRADE AND GROWTH: THEORETICAL AND EMPIRICAL LITERATURE

Structural convergence is a catch-up mechanism for countries ahead by lagging countries regarding certain variables (gross fixed capital formation, technological level measured by the Solow residual, sectoral employment, sectoral value-added ...) indicative of the structure of economies (demand and supply structures). This catching up can be achieved in the case where there is a structural transformation process in the lagging countries. According to Doyle, E. & E. O'Leary, (1999), structural transformation would largely explain structural convergence processes and also productivity convergence. Thus, in this chapter, we start by addressing the theoretical and empirical literature on structural transformation. Then we address the question of the theoretical and empirical literature of structural convergence. Finally, we discuss the theoretical and empirical literature on the implications of structural convergence for trade and economic growth.

2.1 STRCTURAL TRANSFORMATION

In this section, after an overview of the definition of structural transformation, we present its theoretical and empirical literature. Finally, we present stylized facts from recent literature on structural transformation and its impact on growth in Africa.

2.1.1 Definition

Also called structural change, structural transformation has been defined in various ways by authors because it refers to a set of upsets that occur in the fundaments of a society (country) and which affect consumption, production, trade with other countries, population...

According to Machlup (1963), one of the broadly recognized definitions of 'structural change' is that of a radical and substantive modification of the economic context, as opposed to the small changes that are usually the subject of equilibrium

analysis (such as a reduction in tax rates, an increase in import tariffs, a rise in wage rates).

More specificly, according to Chenery et al. (1986) Structural transformation refers to various aspects of development such as agricultural transformation, industrialization, demographic transition, and urbanization. These same authors said that structural transformation of a developing country's economy can be defined as the set of significant changes in the composition of demand, production, trade and factor use as per capita income increases. This fairly broad definition, takes into account the economic transformations that take place in a society as per capita income increases, but remains silent on the causes of the increase in per capita income. Definitions such as Timmer, De Vries, and De Vries (2014) who define structural transformation as the relocation of labour across sectors, does not include other factors of production, nor the growth of production which causes the growth of income per capita. Barrett, & al (2017) said that structural transformation describes the ongoing changes by which low-income countries, in which the primary sector (agriculture) employs most of the workforce and generates most of the value-added, become high-income countries distinguished by a relatively smaller primary sector in terms of workforce but more efficient in terms of production and value-added.

To complete the definition of Barrett & al (2017) which does not explain the process of transformation, we can say that structural transformation is the shift of labor and other production factors from low productivity economic sectors (such as agriculture) to higher productivity sectors (such as manufacturing and services). This shift makes it possible to increase productivity and therefore creates a surplus which will be used for more investment and therefore more and more productivity which will end up affecting positively per capita income. Supported by technological advances, themselves supported by investments in physical capital, this growing productivity will continue to attract labor from rural to urban areas. This virtuous circle, which is certainly not infinite, naturally

leads to urbanization, industrialization, demographic transition and chages in consumption, production and trade8.

The word "sector" coming from the three-sector-hypothesis9 [Fisher, (1939), (1952); Clark, (1940); Fourastié, (1949)] is used to refer to agriculture, industry and services. Other researchers designate them as primary, secondary and tertiary sectors respectively. These three sectors are also often subdivided in "industries". For example, the industrial sector contains manufacturing, mining, utilities and construction industries. Mining, utilities and construction industries are also referred to as non-manufacturing industries. Industries can also be subdivided into branches. For example, within the non-manufacturing industry, one can differentiate between branches like construction, water and electricity supply, etc. Within the manufacturing industry one can differentiate between branches like clothing, textiles, chemicals, metals, machinery, etc. The distinction between sectors, industries and branches is important in highly heterogeneous sectors such as industry and services, but becomes less important in the agricultural sector, which is distinguished by more homogeneous productivity levels[10].

In addition to the intersectoral structural transformation that we defined above, there is also the intra-sectoral or inter-industry structural transformation. Intra-sectoral structural transformation refers to the shift of labor and other factors of production within one of the 3 aggregated sectors, for example, an increase or decrease in the share of the textile industry in total manufacturing employment (or value-added).

From a historical perspective, the economy could only be dominated by agriculture. At the beginning of the 18th century the Physiocrats maintained that all real income came solely from agriculture. Refuting this view in the early 19th century, David Ricardo's model of comparative advantage still relied on two products that are also agricultural (wine and cloth) to demonstrate the gains from trade. At the start of the 20th

[8] In the next section, we will discuss the theoretical background of these definitions, notably Engel's law of the declining share of food in consumption and Lewis's hypothesis of the elastic supply of labor in most developing countries.
[9] We will present this hypothesis in detail in the part which deals with theoretical approaches to structural convergence.
[10] International Standard Industrial Classification (ISIC) of All Economic Activities Revision 4, 2008 Series M No. 4/Rev.4.

century, the co-inventor of modern national income accounts, Colin Clark (1940), made agriculture the "primary" industry and therefore the most important. Historically, it was difficult to imagine a world where agriculture did not dominate the economy. Just a hundred years ago, four out of five households in the world were primarily engaged in agriculture. Now, in advanced countries, farmers make up a tiny fraction of the workforce, less than 5%. As an extreme example, there are more lawyers in the United States than farmers, more dry cleaning establishments than farms. Structural transformation therefore leads a country towards less labor in agriculture and of course more in other sectors[11].

The phenomenon of structural transformation has been the subject of several theoretical studies, so we can identify several theoretical foundations that explain its occurrence.

2.1.2 Some theoretical foundations of structural change

According to Chenery et al (1986), there are several theoretical foundations that explain the structural transformation, among them:

• Engel's law of the declining share of food in consumption

• Lewis's hypothesis of the elastic supply of labor in most developing countries.

• Stages of comparative advantage.

2.1.2.1 *Engel's law of the declining share of food in consumption*[12]

The Engel's law, established by the German statistician and sociologist Ernst Engel in 1857 is based on observing the behavior of consumers as their budgets increase. Engel studies the budgets of workers in several European countries and comes to similar conclusions, but more extensive than those of Frédéric Le Play made earlier.

[11] C. Peter Timmer (2007): The Structural Transformation and the Changing Role of Agriculture in Economic Development: Empirics and Implications. Wendt Lecture, October 30, 2007 American Enterprise Institute Washington, DC.

[12] for more details see Beitone, Alain. Cazorla, Antoine. Medina, Estelle (2019) Dictionnaire de science économique. Edition Dunod and Silem, Ahmed (2018) Lexique d'économie édition Dalloz.

Engel's law (the first) states: “The relative share of food expenditure in consumption decreases when income increases. That means the income elasticity of food is less than 1 (Income elasticity designates the sensitivity of the consumption of a good to a change in income. In this specific case the value less than 1 implies that for an increase in income of 1, food expenditure will increase at most by less than 1). His study was based on the budgets of working families he collected in the book "The conditions of production and consumption of the Kingdom" of Saxe, 1857, and also used the data collected by E. Ducpetiaux in his book "The economic budgets of the working classes in Belgium" of 1855 and those of F. Le Play in his book "The European workers" of 1856. Subsequently, Engel has often attributed a second and third law, which are in fact the results of other authors who have continued the research like C. Wright who found in the United States, in 1875:

- A "second law of Engel" which states, "the share of expenditure devoted to clothing and housing is roughly the same regardless of income" That means the elasticity-income for clothing and the housing is equal to 1; (for an income increase of 1, clothing and housing expenses will increase by exactly 1)

- A "third law", which states "the share of miscellaneous expenses increases when income increases" that is to say the income elasticity for miscellaneous expenses is greater than 1.

While Engel's law (the first) has been universally verified, the others (the second and third) have been shown to be more fragile.

Engel's different laws show us how household consumption changes as their budget increases. This constitutes a theoretical explanation of the changes which occur in the composition of the demand for a country that is in a process of structural transformation.

2.1.2.2 Lewis's hypothesis of the elastic supply of labor[13]

This hypothesis is the work of the Nobel laureate in economics Arthur Lewis. Lewis (1954) studies the interactions between three foundations of development economics: dualism, accumulation and evolution in terms of trade.

Dualism is a notion introduced by Boeke (1953) and taken up by Lewis, which designates an economy with two systems (a precapitalist or agricultural system and a capitalist or industrial system) juxtaposed and characterizing underdeveloped countries. Lewis takes up this concept and considers a dualist economy in which a capitalist sector and a subsistence sector are opposed. Apart from the workforce, interactions between these two sectors are considered non-existent. The first includes the activities of commercial agriculture, manufacturing, mining, all carried out for the realization of profit. The second includes peasant agriculture and other informal subsistence-oriented activities. The subsistence sector is organized according to non-capitalist social relations where the workers produce the minimum subsistence. Due to rural underemployment, urban unemployment and population growth, this subsistence sector constitutes a source of unlimited supply of labor. The capitalist sector is the part of the economy whose capital is reproducible. Employment in the capitalist sector is defined by the equalization of institutional wages and marginal labor productivity. As with the classics, the increase in capitalist profits is the determining element in the accumulation of capital. By combining an unlimited supply of cheap labor (classic hypothesis) and a model where the rate of accumulation depends on reinvested profit, Lewis shows how there can be an economic take-off. The development of the economy is indeed achieved by the absorption of the workers of the subsistence sector by the capitalist sector: Lewis says "The central problem in the theory of development economics is to understand the process by which a community which previously saved and invested 4 or 5% of its national income or less transforms itself into an economy which voluntarily sees its savings grow by 12 or 15% of national income or more". Low-wage countries can therefore export their product resulting from their productivity growth to high-wage countries. It is the terms of trade of

[13] for more details see Beitone, Alain. Cazorla, Antoine. Medina, Estelle (2019) Dictionnaire de science économique. Edition Dunod and Silem, Ahmed (2018) Lexique d'économie édition Dalloz.

factors that determine the terms of the trade of goods and not the reverse. Lewis explains also that, as long as the unlimited supply of labor in the subsistence sector has the effect of keeping real wages low throughout the economy as a whole, any improvement in productivity in the export sector will probably benefit only importing countries.

So this Lewis hypothesis shows us how significant changes occur in the composition of supply, production, trade and factor use for a country during its structural transformation process.

2.1.2.3 Stages of comparative advantage: absolute, relative, and dynamic

International trade and its benefits for all economies have been a matter of debate among economists since Adam Smith. The notion of "absolute advantage", introduced by Adam Smith (1776) in his book The Wealth of Nations, explains that a country has an advantage over others (its competitors) in the production of some good if it can produce it with fewer resources (labor) per unit of this good produced. So according to Adam Smith, the principle of absolute advantage is based on the comparison of productivity between economies. According to the logic of absolute comparative advantage, it would not be impossible, nor even surprising to be in a situation where one country has this advantage for all the goods, while another (developing country) would be at an absolute comparative disadvantage for all goods, thus eliminating any possibility of bilateral trade.

In order to address this limitation of the 'absolute comparative advantage' theory, David Ricardo (1821) in his work on the principles of political economy and taxation, sets out his theory of "relative comparative advantage[14]". According to this theory, a country's welfare is optimised in a context of free trade as long as it focuses on the production of goods for which it has a relative comparative advantage, i.e. it can supply at a cheaper opportunity cost than its trading partners. Opportunity costs refer to the unit of one good that a country must give up to produce one unit of another good. Thus, the idea of relative comparative advantage is based on a comparison of relative productivity. When the opportunity cost is taken into account, international trade becomes

[14] This theory was in fact evoked 2 years before the writings of David Rcardo by Robert Torrens in his book Essay on the External Corn Trade, see Robert Torrens, Essay on the External Corn Trade, J. Hatchard, London, 1815.

advantageous because an economy can trade goods in which it holds a relative comparative advantage for goods that would be relatively more expensive to produce, given its endowment, resources and technology. This advantageous situation in international trade is valid irrespectively of the labor productivity of the other country. This means that although a country is absolutely superior at manufacturing all goods, it is still more advantageous to specialize in the production of the good for which it has a relative comparative advantage and import the others. Looking back at the position of less developed economies, the idea of relative comparative advantage explains trade between a developed and a developing country on the principle of lower opportunity costs. Based on this theory of relative comparative advantage, Eli Heckscher and Bertil Ohlin derived a theory of international trade, the Heckscher-Ohlin model. In this framework, international trade is driven by the gaps in the countries' resource endowments, and more precisely, by the interaction between the extent to which various production inputs are present in an economy, and the extent to which those inputs are used to produce various products. This interaction characterizes a country's specialization in international trade, as countries would export goods whose production is intensive for it due to the factors with which they are abundantly endowed (Krugman and Obstfeld 2012).

Certain authors like Lin and Chang (2009) have rightly criticized the theory of absolute and relative comparative advantage because both do not take into account important dynamics such as those linked to the process of structural transformation which are nevertheless crucial to understanding the development process of a country. Other authors like Krugman, (1987); Amsden, (1989); Grossman and Helpman, (1991); Redding, (1999) rightly explain that the comparative advantage of a country is not necessarily static, but that it evolves over time, that is to say that it is endogenous to its development. This led to the concept of “dynamic comparative advantage”. Dynamic comparative advantage would therefore be the comparative advantage that an economy can possibly acquire (and, indeed, should pursue) in the future (medium and long-term objective). Dynamic comparative advantage can result from the process of acquiring knowledge by practice, from the adoption of new technologies. On the basis of dynamic comparative advantage, if a country manufactures a good for which it does not have a

static comparative advantage, it could, over time, acquire a dynamic comparative advantage, as national companies could lower production costs and become more competitive in world trade, through technological development and innovation. The notion of dynamic comparative advantage could have important policy implications. Developing economies in an open international trade configuration may be forced to transfer their resources from sectors or branches with potential dynamic comparative advantage to sectors or branches with static comparative advantage because of strong international competition. If these economies are to continue to produce goods for which they are not yet internationally competitive, they will require industrial policy to support the economy in reaching and exploiting dynamic comparative advantages.

The concept of "latent comparative advantage" introduced by Lin and Monga, (2010) and Lin, (2011) is quite similar to the concept of dynamic comparative advantage. Latent comparative advantage refers to the comparative advantage that an economy can eventually reach, but is not reaching it because of significant transaction costs associated with logistics, transport, infrastructure, institutional barriers and, in most cases, difficulties in conducting business. To identify latent comparative advantage, Lin and Monga (2010) propose to look at goods produced over a 20-year period in developing economies with similar endowments and 100% higher per capita income than in the economy under analysis. Among these goods, priority can be given to those that are domestically produced. Public policies must encourage structural change by identifying and eliminating constraints that limit the competitiveness of these industries. If there are no companies manufacturing these goods in the economy, a variety of actions, such as inviting and promoting foreign direct investment and developing clusters, can drive for economic structural change.

Other theories such as the three-sector hypothesis of [Fisher, (1939), (1952); Clark, (1940); Fourastié, (1949)] also explains the process of structural transformation. According to Clark (1940) technological progress is accompanied by a decline in primary and secondary activities and an increase in tertiary activities. Over time, according to Clark, the tertiary sector will become the dominant sector within a country's economy.

The different stages of comparative advantage also show us how important changes occur in the allocation of factors, in production, and in exports of a country during its process of structural transformation.

2.1.3 Quantification or measurement of structural transformation

To measure the structural transformation of a country, authors use several approaches. In general, it is the employment shares by sector in total employment, the value added shares by sector in total value added and the production shares by sectors in total production and final consumption expenditure shares that are used to make this measurement Chenery H and al (1986), Van Ark (1995), Wacziarg, R. (2001), Barrios, Barry, and Strobl (2002); Albu (2012)[15]; Herrendorf, Rogerson, and Valentinyi (2014). A significant variation in employment shares by sector, or in value-added shares by sector, or in the production shares by sector, or in final consumption expenditure share then denotes a structural transformation of the economy of a country or a region. The availability of disaggregated data by sector and over a long period for certain countries are often one of the difficulties which arise for this method.

Employment shares are calculated based on the number of workers or hours worked per sector, value-added shares and production shares are commonly expressed in current prices ("nominal shares"), but they can also be expressed in constant prices ("real shares"). The share of exports by sector as a percentage of GDP can also be used to measure structural transformation Chenery H & al (1986), Crespo, N. & Fontoura, M.P. (2007), Lazarev V & Gregory P (2007).

Several indexes have been proposed by various authors to capture structural transformations in an economy using employment or value added data. Among these indexes are the shift-share method index (Fagerberg, 2000), the Norm of Absolute Values (NAV) (Stoikov V 1966), the Effective Structural Change Index (ESC), (Vu KM 2017), and the Modified Lilien Index (MLI) (Lilien 1982).

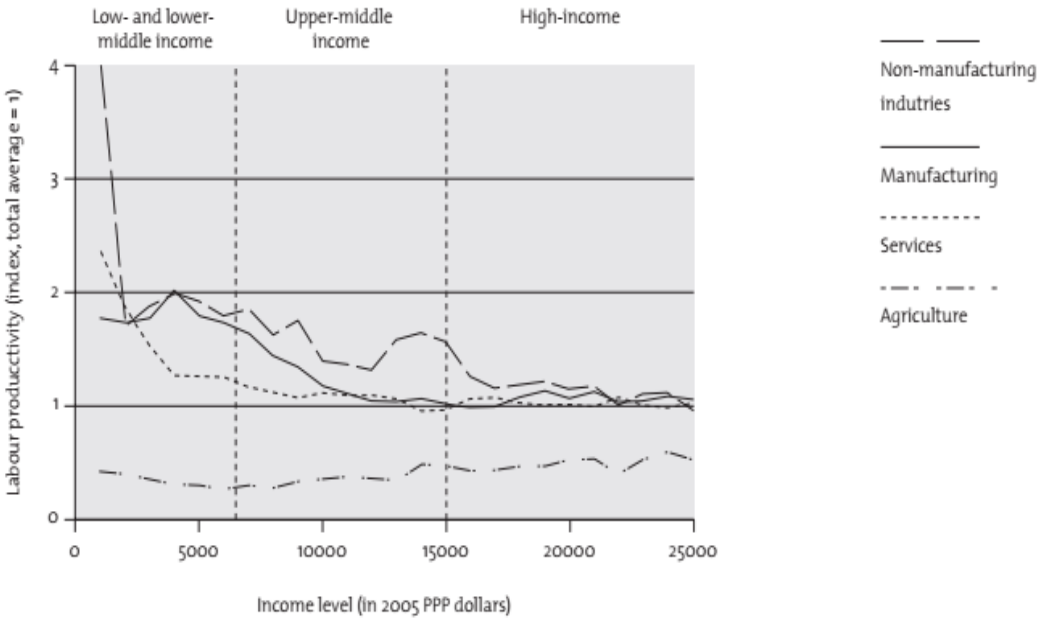
[15] some of these authors have used these data to highlight the structural convergence, which is nothing more than a simultaneous phenomenon of structural transformation between several countries.

2.1.4 Structural transformation : evidence for advanced, and developing economies

To understand the developmental differences between countries in terms of origins and speeds of growth requires an analysis of structural change process as a whole. Changes in the composition of demand and trade may impact the sources of growth as well as on changes in input composition demand. Structural transformation is especially advantageous for less developed economies due to their structural nonuniformity - the juxtaposition of large inter-sectoral productivity differences in which high-productivity sectors are rare and disconnected from the core of the economy - weighs on their growth process.

Figure 9 illustrates structural heterogeneity in the production sectors of developing economies. This figure shows relative labor productivity in agriculture, industry and services averaged over the years 1991 to 2010 and estimated with respect to income levels in 2005. Relative labor productivity is calculated as the ratio of output to labor (labor productivity) for each sector and for the economy as a whole. To obtain figures by income, the (weighted) average labor productivity is calculated for all countries in the same income group. As the figure shows, the significant differences in productivity are in low-income countries. In particular, non-manufacturing industries (i.e. utilities, construction and mining) are the most productive activities: because of their high capital intensity, labor productivity is likely to be extremely high. At higher income levels, the manufacturing sector is getting increasingly productive, achieving productivity levels in non-manufacturing industries. With increasing growth, productivity levels tend to converge.

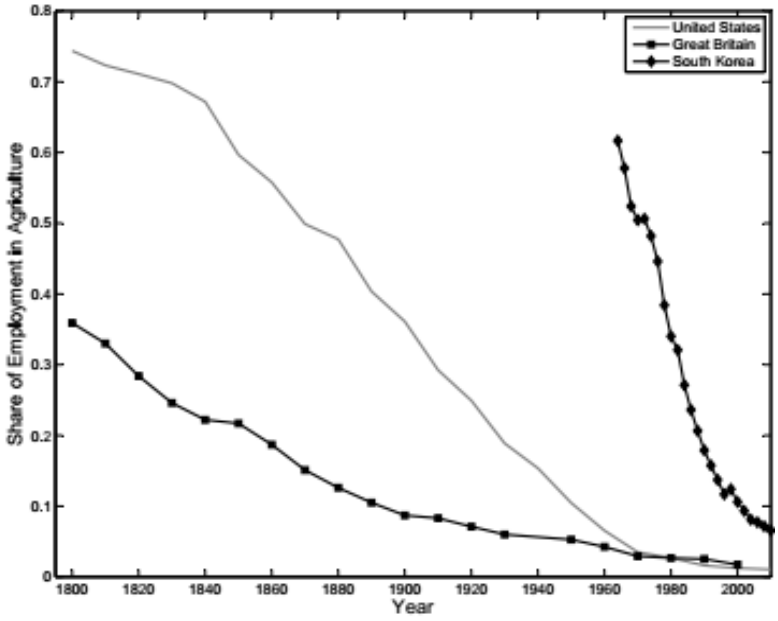
Figure 9:structural heterogeneity in the production sectors of developing economies.



Source: UNIDO (2013: 26).

Great Britain was among the very first countries to experience the industrial revolution (structural transformation). This industrial revolution was accompanied by a gradual reduction in the share of employment in agriculture. This gradual decrease is seen in almost all countries experiencing industrialization and therefore supports the designation of structural transformation as the movement of labor from the agricultural sector to more productive ones. Britain's agricultural sector (in terms of the share of employment in agriculture) has long been the lowest of almost all countries because of its pre-Scottish industrialization. This sector has also gradually and considerably fallen since the 1800s until stabilizing around 5% which is the rate in almost all industrialized countries. Figure 10 shows us the level and evolution of the share of employment in agriculture for 3 countries which have industrialized, South Korea a miracle of industrialization has quickly developed a competitive industrial sector, Its share of employment in agriculture which was around 65% in 1960 is now below the 5% threshold, a decline that has taken more than 150 years in the United States and Great Britain.

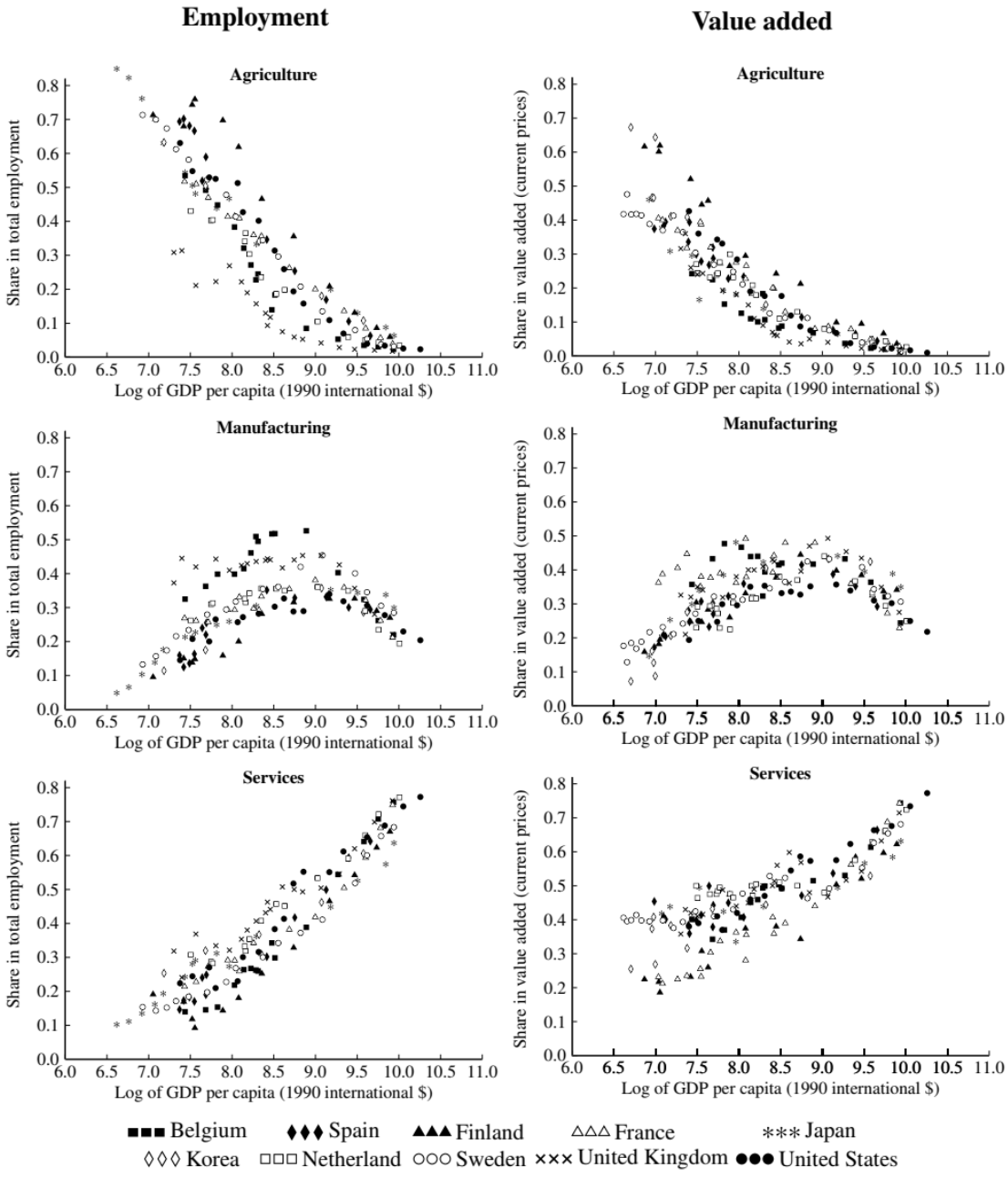
Figure 10: Level and evolution of the share of employment in agriculture for United States, Great Britain an South Korea



Source: Teignier, Marc, (2018)

The path taken by the economies currently advanced to reach this level is characterized by a shift of both labor and capital from agriculture to industry and services which create more added value. In that process, informal subsistence employment have declined in favor of formal wage employment. This transformation path is constructed schematically by Herrendorf, Rogerson, and Valentinyi (2014) using historical data on sectoral proportions of employment and value-added over the 19th and 20th centuries for ten developed economies. These series are presented in Figure 11. The vertical axes show the share of employment (left-hand panel) and the share of value-added in current prices (right-hand panel) in agriculture, manufacturing, and services. On the horizontal axes is the logarithm of GDP per capita in 1990 international dollars. It is clear that over the last two centuries economic expansion has been accompanied by a fall in the share of employment and the share of nominal value added in agriculture, compensated by an increase in the share of employment and value-added in services. Both the employment share and the value-added share of the manufacturing sector exhibited an inverted U shape, i.e. they increased at low levels of GDP per capita, peaked at medium levels of GDP per capita, and declined thereafter.

Figure 11: Sectoral Shares of Employment and Value Added – Selected Developed Countries 1800–2000

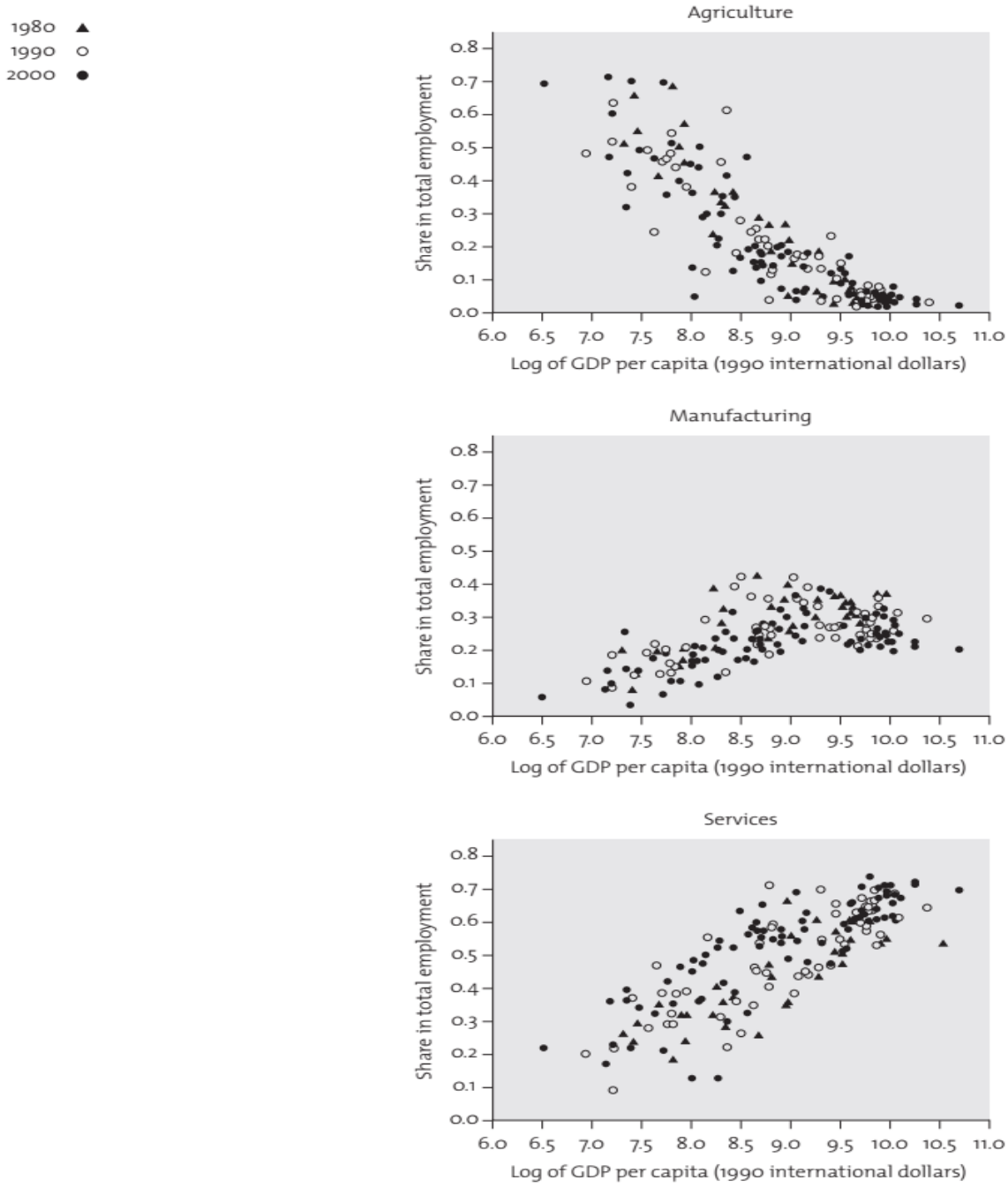


Source Herrendorf, Rogerson, and Valentinyi (2014)

To verify whether the structural transformation processes described for developed countries are also underway and similarly in developing countries, Herrendorf, Rogerson, and Valentinyi (2014) use the World Bank's World Development Indicators

(WDI) for employment by sector and United Nations Statistics Division national accounts for value added by sector. These databases include most of the developed and developing economies. Figure 12 represents the sectoral employment share of the WDI relative to the logarithm of income per capita. The graphs support, as in the case of developed countries, that agricultural employment shares decline with income, while service employment shares increase monotonously; the employment shares in the manufacturing sector follow an inverted U-shaped pattern as in the situation of developed countries, but in a more attenuated way. The declining share of employment in agriculture has many repercussions for an economy, two of them are very important. First, as the labor force shifts from agriculture (low productivity) to higher productivity activities (industries and services), the average productivity of the economy increases. Second, the increasingly higher incomes that are a consequence of this structural change generate further demand for processed products and services. This increasing demand allows the development of manufacturing and services sectors. Figure 12 likewise supports the view that the share of employment in manufacturing grows up to a critical point of about 30% of total employment. From that point on, its growth slows down and then declines. Although this broadly corresponds to the scheme outlined previously for developed countries, the downhill sloping portion is less accentuated in Figure 12 than in Figure 11. The comparatively smaller peak of about 30%, versus the earlier 40% for developed countries in Figure 11 suggests a movement in modern industrialisation trends in both developed and developing countries towards lower peaks of manufacturing employment in total employment. This finding has raised questions about the place and the importance of the manufacturing sector, as the main factor of economic growth in developing countries. Indeed, Figure 12 clearly indicates a significant and positive correlation between the share of employment in services and per capita income.

Figure 12: Sectoral shares of employment (developed and developing countries, 1980–2000)



Source: Herrendorf, Rogerson, and Valentinyi (2014)

Data from value-added shares in agriculture, manufacturing, and services against GDP per capita shows the same patterns documented above.

Structural transformation as we have presented it with historical and recent evidence allows a country to increase its productivity by devoting more labor to the more productive and high value-added sectors. This increase in productivity creates an increase in income which in turn creates additional demand for manufactured goods and services. This demand allows for more investment and therefore the expansion of manufacturing and services. Ultimately, if this process is accompanied by a favorable environment (infrastructure, industrial policy, human capital training, innovations, institutions favorable to business financing and trade development, etc.), this will normally lead this country to emergence and then development. This explains why some authors like Lewis (1954), Kuznets (1966), Margaret S McMillan and Dani Rodrik (2011) consider structural transformation to be one of the main factors leading to economic development.

In the next part, we focus on the specific case of Africa to deal with its own structural transformations and how it impacts economic growth in recent literature.

2.1.5 Structural transformation and its impact on growth in africa: stylized facts from recent literature

The African continent, like others, has also experienced in its own way processes of shift of labor and other factors of production from low productivity economic sectors to higher productivity sectors over the past decades. The African continent has also experienced, in its own way, but in a more moderate pattern, urbanization, industrialization, demographic transition and changes in consumption, production and trade. Thus, we can say that Africa has experienced processes of structural transformation. Several reports and articles in the recent literature point to these transformations. The Africa Center for Transformation Report (ACET 2014), the African Union Agenda 2063 (AU 2015), the African Development Bank (AfDB 2015), the 2013 report of the United Nations Economic Commission for Africa (UNECA 2013), UNCTAD's 2012 report on structural transformation (UNCTAD 2012), IMF documents (IMF 2013, among others), the McKinsey Global Institute report (McKinsey Global Institute 2010) which highlight the fact that Africa's recent progress is not exclusively due to natural resources. The World Bank report, World Bank, (2014) concludes that Africa's economies are developing unexpectedly, i.e. faster than what was projected.

Using a dataset from the Groeningen Growth and Development Centre's 10-sector database ("GGDC data") on Africa, Enache, M., & al. (2016) found two broad patterns of structural change in Africa. The first group of countries, known as "early reformers" experienced an early shift of labor out of agriculture and into manufacturing in the decades before the 1990s. The second group of countries is the so-called "late reformers" who experienced a late shift out of agriculture, but this time to the service sector in the 1990s and 2000s. Thus, we see that the pattern of structural transformation in Africa is not fully in line with the predictions and empirical findings of various authors [Fourastié, (1949), Herrendorf, Rogerson, and Valentinyi (2014)] according to which the shift of labor will first be from agriculture to industry and then from industry to services, Africa, as far as the so-called "last reformer" countries are concerned, has skipped the stage of the shift to the industrial sector, which is probably due to the low level of industrialization of the continent. Despite this movement of labor from agriculture to other sectors, in the first decade of the 21st-century overall value-added per worker in the agriculture sector (constant 2010 US$) increased by 2.4% per year for Africa as a whole, while cereal yields increased by 2.2% Barrett et al (2017). This implies that new techniques were introduced, which is why productivity and production increased despite the decline in the number of workers. These changes in sectoral structure (shift of labor and implementation of new techniques in agriculture) have in fact contributed to an increase in GDP per capita in sub-Saharan Africa of almost 35% in real terms between 2000 and 2014, in some countries GDP per capita has even doubled Barrett et al (2017). Between 1990 and 2013, the share of the population living with less than $1.9 a day fell from 54% to 41%, infant mortality rates fell significantly and access to education generally improved Page, J., & Shimeles, A. (2015). These different successes in various fields have led some authors like Margaret S. McMillan, & Kenneth Harttgen (2014) and Rodrik, D. (2014) to speak of an African miracle and to understand what is driving these feats. Among the most significant drivers of this African miracle is structural transformation (shift of labor from agriculture to other sectors). It is well known in the literature that African countries were characterized by very high employment shares in agriculture before the 1990s. Since the 1990s and especially in the early 2000s, the shift in labor has intensified in Africa. For a sample of 19 African countries, McMillan, & Kenneth Harttgen (2014) found that for the period 2000-2010:

-the share of the labor force active in the agricultural sector declined on average by 10.61 percentage points;

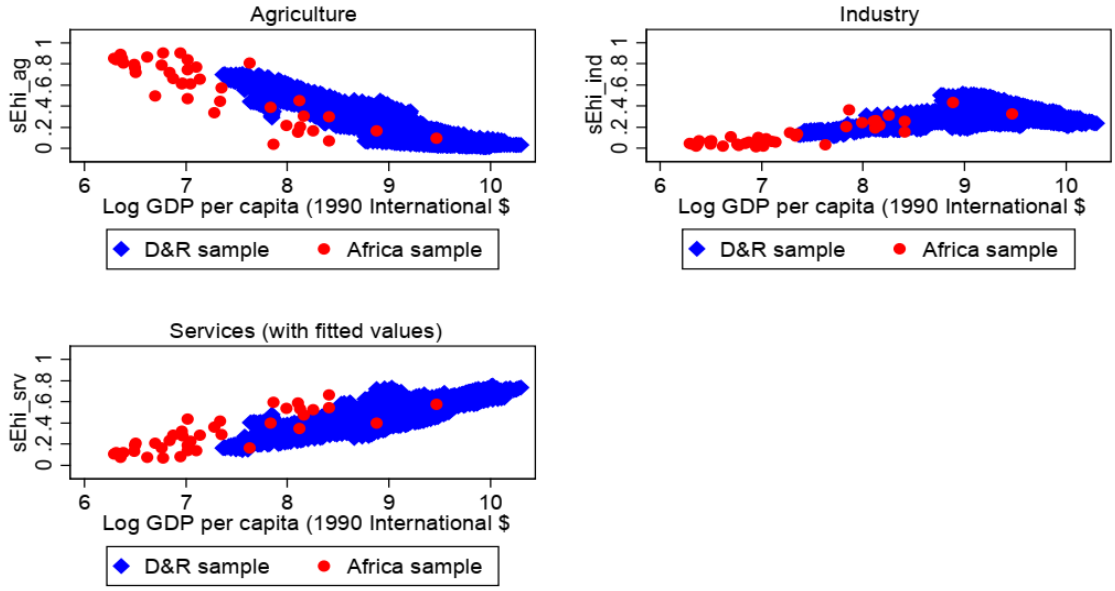
-the share of the labor force active in manufacturing increased on average by 2.15 percentage points;

-the share of the labor force employed in services increased on average by 8.23 percentage points;

Combining these data with value-added data, McMillan, & Kenneth Harttgen (2014) show that for the period 2000-2010, structural change accounted for about half of the growth in output per worker in Africa.

Also, according to McMillan, & Kenneth Harttgen (2014) as shown in figure 8, the shares of employment in agriculture, industry, and services, respectively, are plotted on the y-axis and the logarithm of GDP per capita on the x-axis for 19 African countries for the years 1990 and 2005. The share of employment in agriculture declines and the share in services increases significantly with income, and the share in manufacturing also increases monotonically. In other words, recent patterns of structural change in Africa resemble the stylized facts of historical structural change in other parts of the world, except that the manufacturing graph does not exhibit the inverted-U shape that is documented by several authors and that represents a phenomenon of industrialization and then deindustrialization, but this is due to the fact that the GDP per capita of each of these African countries is still below the threshold at which the rate of change of the share of industry employment goes from positive to negative (Or we can say, they are under-industrialized, so they cannot experience deindustrialization).

Figure 13: : Employment shares in 3 broad sectors Comparing sample from Duarte and Restuccia (2010) and African countries (sample from Jan 2013)



Note that Africa data measure sectoral share of total employment whereas D&R (Duarte and Restuccia) data measure share of total hours. Hours shares from Duarte and Restuccia (2010) cover 29 countries from 1950-2006Their data were accessed 07/24/2012 from Duarte's website GDP from Maddison (2010).

Source McMillan, & Kenneth Harttgen (2014)

According to De Vries, Timmer, and De Vries (2015) during the period 1960-1975 the manufacturing sub-sector developed as shown in table 1. The share of employment in the manufacturing sub-sector increased from 4.7 % in 1960 to 7.8 % in 1975. The share of manufacturing value-added (first columns of Table 1) also increased significantly over the same period, from 9.2 to 14.7 %. According to De Vries, Timmer, and De Vries (2015) This pattern of development reflects Lewis's dualistic model of the economy, in which workers leave subsistence or traditional activities (agriculture) and are absorbed into the capitalist or profit economy (modern manufacturing). Income differences between the traditional and capitalist sectors are a key element in explaining these labor reallocation dynamics. The last columns of table 1 show average productivity levels, where comparisons of average productivity within a sector can be made with these differences in relative wages (marginal products) between sectors. De Vries, Timmer, and

De Vries (2015) measure labor productivity as value-added divided by people employed. The relative productivity level is calculated here as the ratio of the productivity level of the sector to the productivity level of the whole economy. For instance, a relative productivity level of 0.5 for agriculture in 1960 implies that the average productivity level in agriculture is half that of the total economy. In 1960, the manufacturing sector was about 2.5 times the average productivity of the total economy (which is mainly determined by agriculture). Although the rapid growth of employment in manufacturing branches until 1975, productivity held up well and was 2.8 times average productivity. This suggests that the shift of workers to manufacturing accounted significantly to growth in Africa during its initial post-independence period. Following this successful period of African growth, the region was plunged into political and economic upheaval. The oil crises of the 1970s, currency instability, and related events led to a long term of economic recession (Gunning and Collier, 1999). Between 1975 and 1990, growth was low or negative throughout the continent. The share of employment in agriculture fell from 66 % in 1975 to 61.6 % in 1990, suggesting that reallocation was also slow, especially in the post-1990 period.

Table 1: GDP, employment, and relative productivity levels across countries and sectors, 1960 -2010

	Value added				Employment				Relative productivity levels			
	1960	1975	1990	2010	1960	1975	1990	2010	1960	1975	1990	2010
Agriculture	**37.6**	**29.2**	**24.9**	**22.4**	**72.7**	**66.0**	**61.6**	**49.8**	**0.5**	**0.4**	**0.4**	**0.4**
Industry	**24.3**	**30.0**	**32.6**	**27.8**	**9.3**	**13.1**	**14.3**	**13.4**	**4.4**	**3.7**	**3.5**	**2.6**
Mining	8.1	6.2	11.2	8.9	1.7	1.5	1.5	0.9	15.7	22.4	23.3	19.5
Manufacturing	9.2	14.7	14.0	10.1	4.7	7.8	8.9	8.3	2.5	2.8	2.4	1.6
Other industry	7.1	9.2	7.3	8.9	3.0	3.8	3.9	4.2	8.5	5.8	5.3	2.9
Services	**38.1**	**40.7**	**42.6**	**49.8**	**18.0**	**20.9**	**24.1**	**36.8**	**2.7**	**2.5**	**2.4**	**1.6**
Market services	24.5	25.5	28.1	34.0	8.8	10.3	12.9	23.5	4.5	3.4	3.0	1.8
Distribution services	*21.5*	*20.8*	*22.7*	*25.4*	*8.2*	*9.5*	*11.4*	*20.1*	*4.6*	*3.2*	*2.7*	*1.5*
Fin. and bus. ser.	*3.0*	*4.7*	*5.4*	*8.6*	*0.6*	*0.8*	*1.5*	*3.4*	*6.1*	*8.9*	*10.4*	*8.1*
Non-market services	13.6	15.2	14.4	15.8	9.2	10.6	11.2	13.3	1.8	1.7	1.8	1.3
Government services	*10.5*	*11.7*	*11.5*	*12.2*	*4.2*	*5.0*	*6.4*	*8.7*	*2.8*	*2.5*	*2.5*	*1.7*
Other services	*3.1*	*3.5*	*2.9*	*3.5*	*5.4*	*6.1*	*5.3*	*5.4*	*0.9*	*0.9*	*1.0*	*1.0*
Total economy	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.0**	**1.0**	**1.0**	**1.0**

Source : De Vries, Timmer, and De Vries (2015)

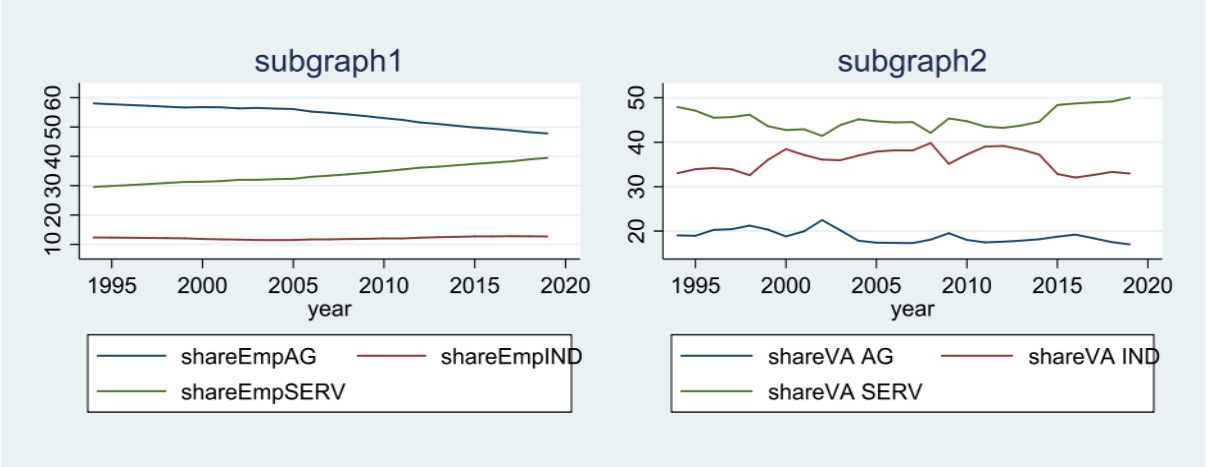
When growth restarted in the 1990s, there was a quick shift in labor between sectors. The share of agricultural employment fell from 61.6% in 1990 to 49.8% in 2010. What is surprising, therefore, is that the manufacturing sector has not grown over this

time period. The share of manufacturing employment fell from 8.9% in 1990 to 8.3% in 2010. Page (2012) argues that deindustrialization (privatization and subsequent bankruptcy of several state-owned industries in Africa) after the 1990s was characterised not only by a decline in manufacturing output and employment, but also by a decline in the diversity and sophistication of manufacturing sectors. Employees leaving agriculture and industry have been captured by the service sectors, particularly distribution services. Table 1 illustrates that the share of distribution services nearly doubled to 20.1% in 2010. In 2015, one-fifth of the African workforce was employed in the distribution sector, which is comparable to the levels observed in OECD economies. To conclude, De Vries, Timmer, and De Vries (2015) indicate that present development trends in Africa contrast significantly with those of previous periods. In particular, during the period from 1960 to 1975, when Africa also experienced strong growth, Africa took a step forward in the development of its manufacturing activities. This was linked to the structural transformation that favored growth. In contrast, after 1990, market services branches grew. Although productivity levels in market services were higher than the average for the economy, productivity growth was not. There are therefore static reallocation gains, but dynamic losses. The overall effect has been a limited role for structural transformation after 1990, which compares unfavorably with the earlier period of high growth in Africa. These patterns are likewise found in Latin America, but not in Asia.

Despite the dynamic losses highlighted by De Vries, Timmer, and De Vries (2015), Africa is slowly catching up with other continents compared to decades ago. According to Fine and Susan Lund. (2012) the demographic dividend (the potential economic growth linked to the evolution of the age pyramid of a population) will still make Africa's large workforce better than that of any country, including China or India if young African children could be better educated than in the past. Furthermore, the very low levels of industrialization and productivity in large parts of the continent show a huge potential for growth through structural change. To realize this potential, African countries will need to support activities in which large numbers of unskilled workers can be relatively more productive than in subsistence agriculture McMillan, M., Rodrik, D., & Verduzco-Gallo, Í. (2014). Recent trends in the global economy offer Africa unprecedented opportunities for emergence. Rising global food and commodity prices

due to strong demand, coupled with stable macroeconomic and political trends (except for the COVID-19 health crisis and armed conflicts in Africa in particular), have made foreign and local entrepreneurs more willing to invest in agribusiness in Africa. The increase in the world's need for natural resources and the multi-polarisation of the world with new emerging powers (China, Russia, India, etc.) have given African countries more room for maneuver in negotiations and then collecting more financial resources. Also, internal demands for greater transparency in Africa are leading to better use of resources, which will lead to structural changes.

Figure 14: Share of value-added/sectors and share of employement/sectors in Africa 1994-2019



Source: Author's calculation using data from WDI

Figure 14 shows the evolution of the sectoral shares of employment and value added in the three sectors (Agricultural, Industrial and Service) over the period 1994-2019. Figure 14 subgraph 1 shows that over the whole period the employment shares of the industrial sector are the lowest and have remained constant at around 12%, whereas the movements are from the agricultural sector, which is always in the lead, to the services sector, hence a kind of symmetry between the two curves. In terms of value-added in Figure 14 subgraph 2, we see almost the same symmetry between the service and industrial sectors, while the agricultural sector shows a slight decrease due to the movement of jobs to the service sector. In Africa, the predictions of the three-sector hypothesis do not appear to apply. Indeed, the shift in labor and value added does not

occur from agriculture to industry and from industry to services over time. The industrial sector's labor share has remained nearly constant and is the lowest over the entire period. As a result, the labor force shift is mainly between agriculture and service. In terms of value added, the agricultural sector's share has remained nearly constant and the lowest over the entire period. As a result, the shift in value added shares is mainly between industry and services.

Thus, Africa has, in its own way, experienced structural transformation phenomena which, depending on the period, have enabled it to increase its overall productivity and reduce poverty, but these transformations are still ongoing given the continent's low level of industrialization and still a high share of employment in the agricultural sector. This low level of industrialization, the demographic boom, and the global context of multi-polarization offer Africa an enormous potential for growth through the structural transformation that it should exploit in the 21st century to achieve emergence in the same way as some South-East Asian countries.

In the next part, we will discuss structural convergence, which is a simultaneous process of structural transformation for a group of countries experiencing the phenomenon of real convergence.

2.2 STRUCTURAL CONVERGENCE : THEORETICAL AND EMPIRICAL LITERATURE

In this section, after defining structural convergence, we present its theoretical and empirical literature.

2.2.1 Definition

Structural convergence refers to a process of rapprochement or catching up between the sectoral structures of different countries. This means that the agriculture, manufacturing, and service sectors between these countries will gradually develop a kind of rapprochement or similarity in terms of employment share or value-added share. According to one of the pioneering authors of structural convergence Wacziarg, R. (2001) "*two countries are said to structurally converge if convergence in their per capita incomes is accompanied by convergence in their sectoral structure*". To bring out the

aspect of structural transformation in the definition, we can say that structural convergence is a simultaneous process of structural transformation in several countries that results in a rapprochement or similarity between the sectoral structures of these countries as they are experiencing the phenomenon of real convergence. Structural convergence should not be confounded with productivity convergence. The latter refers to the approximation or similarity of the production functions of several countries. Several studies examine the impact of productivity convergence on economic structures, they conclude that there is a positive effect, but structural convergence occurs much more slowly than productivity convergence because of agglomeration and path-dependent economic developments Fagerberg, (2000); Gugler and Pfaffermayr, (2004).

The above-mentioned definition refers to minimal structural convergence, which is limited to sectoral structure similarity. Absolute structural convergence[16], which allows for the optimality of a monetary union and makes it resilient to asymmetric shocks, refers to a process that extends beyond sectoral similarity and includes economic cycle synchronization and foreign trade integration (Alexoaei, Robu, 2018).

2.2.2 Theoretical literature

According to Wacziarg, R. (2001), Palan, N. and Schmiedeberg, C. (2010) the concept of structural convergence has received little attention in the existing literature. Despite many following papers and books following Wacziarg, R. (2001), Palan, N. and Schmiedeberg, C. (2010), Structural convergence on the theoretical level is a rather complex concept and on the empirical level it is also a phenomenon quite difficult to highlight, which is what makes its definitions neither too strict nor too precise and refers to a wide range of conditions that must be fulfilled by structurally converging economies and still remain open to be completed (Alexoaei, Robu, 2018). Neverthelesst theoretical arguments in favor of structural (intersectoral) convergence can be derived from the combination of the three sectors hypothesis (Fisher, 1939, 1952; Clark, 1940; Fourastié, 1949) and the Chenery convergence hypothesis Chenery (1960) followed by some

[16] The term "absolute" is only relative here, because of differences in culture, size of countries, resource endowments, political or institutional characteristics, history ..., there will always be a certain level of structural differences between countries

theoretical extensions made to those hypothesis by several authors like the market forces on the demand and the supply side that lead to structural convergence. We will also mention the market forces on the demand and supply sides that maintain structural heterogeneity.

2.2.2.1 The three sectors hypothesis

The "three sectors hypothesis" [Fisher, (1939), (1952); Clark, (1940); Fourastié, (1949)] is an economic theory that identified the fundamental sectoral division by which the economic structure of a country is still widely accepted[17]. This hypothesis identifies three main sectors which are the primary, the secondary and the tertiary sector. The primary sector includes, within it, activities such as agriculture, mining and extractive industries linked to the natural environment. This sector is therefore characterized by the production of environmental and natural resources (agricultural, forestry, mining, fishing, etc.). The secondary sector includes within it various forms of manufacturing and activities that produce "goods" from products of the primary sector. This sector is therefore characterized by mechanical factors that allow the processing of products from the primary sector. The tertiary sector includes all services (banking and legal services, insurance, retail trade, hotels, etc.). This sector is therefore characterized by activities that produce intangible outcomes unlike the other two sectors and is based on human skill and expertise.

The three-sector hypothesis has inspired several works to understand and explain issues relating to economic growth and development of countries. Clark (1940) explains national economic growth through the prism of sectoral structures. Kuznets (1966) was also interested in sectoral structure, but in a more advanced way which would challenge the rather simplistic approach of Clark, and later researchers like Rostow (1971) explained the stages of economic growth according to the three-sector hypothesis.

The three-sector hypothesis has also been used to explain the process of structural transformation. Fourastié (1949) considers the process of shift of labor between

[17] Even nowadays, international organizations such as the World Bank, the International Labor Organization (ILO), the International Standard Industrial Classification (ISIC), ... refer to this hypothesis to classify economic activities.

sectors to be important for achieving economic development. He believes that the distribution of the workforce among the three sectors is changing through different stages:

First phase: traditional civilizations

Percentage of workforce by sector:

Primary sector: 64.5%

Secondary sector: 20%

Tertiary sector: 15.5%

This phase shows a traditional society which is not very well-developed scientifically, with little use of machines. This state of development corresponds to that of European countries at the beginning of the middle ages, or today to that of poor developing countries.

Second phase: transition period

Percentage of workforce by sector:

Primary sector: 40%

Secondary sector: 40%

Tertiary sector: 20%

More machines are used in the primary sector, which significantly reduces the number of workers needed to produce the necessary quantity of food and raw materials. Since the food requirements of a given population do not change significantly in the short term, employment in agriculture declines as a proportion of population.

At the same time, the increase in demand for machinery in the primary sector is increasing and workers in the primary sector are moving from agriculture to manufacturing. This period of transition marks the beginning of industrialization: a

mechanization (or automation) of manufacturing. The tertiary sector, for its part, is starting to develop, as is the financial sector.

Third phase: tertiary civilization

Percentage of workforce by sector:

Primary sector: 10%

Secondary sector: 20%

Tertiary sector: 70%

The primary and secondary sectors are increasingly dominated by mechanization and the demand for labor is decreasing in these two sectors to the benefit of the tertiary sector.

Several criticisms have been made on Fourastié's conclusions. According to World Bank data, the share of employment in the primary sector in developed countries stabilized around 5% in the 2000s, in 2019, this rate is barely 3%. The specific case of Germany as revealed by the German Federal Statistical Office is quite illustrative. The shares of workers for this country in 2014 are:

Primary sector at 1.5%,

Secondary sector at 24.6%,

Tertiary sector at 73.9%.

Fourastié predicted that workers shift from the secondary to the tertiary sector would eliminate the phenomenon of unemployment, which did not do so, as unemployment remains a significant problem even in countries with a high proportion of workers in the tertiary sector. Another of his conclusions criticized is that Fourastié affirmed that the tertiary sector would always impose strict requirements on workers in terms of education, this was not necessarily the case also, since service professions also

include security services, cleaning, parcel delivery, dry cleaning, etc., these types of service do not meet the requirement of a high level of education.

Despite several studies on the sectoral structure of economies with the desire to bring out other sectors (quaternary and quinary) Schafran, A & al., (2018), the theory or hypothesis of the three-sectors is still widely used by multilateral organizations (World Bank, ILO, ISIC ...), economists and political economists to study structural transformation in national economies [Streeck, Hollingsworth & Schmitter, (1994); Kongsamut & al., (2001); Wacziarg, R. (2001); Barrios, Barry, and Strobl (2002); Krüger, (2008a); Albu (2012); Herrendorf, Rogerson, and Valentinyi (2014); Eichengreen & Gupta, (2013); De Souza & al, (2016)].

The hypothesis of the three sectors predicted that countries with similar developmental levels, will experience rapprochement and then similarity in intersectoral structures, but of corse, whatever is the level of rapprochement, the structural convergence between several countries will never be absolute because of socioeconomic, cultural, and geographic differences (Chenery, 1960).

2.2.2.2 Chenery convergence hypothesis

Chenery convergence hypothesis (Chenery 1960), refers to the developmental model of countries, i.e. as per capita income increases in a country, production in the industrial sector, and then total production will also increase. This process will therefore lead to a convergence of the structure of economies of all countries experiencing an increase in per capita income, whether in terms of productivity by sector or in terms of the share of employees by sector.

Drawing on Engel's Law, Chenery highlighted the fact that an increase in per capita income in any country is accompanied by an increase in the share of industrial production and even in total production. The increase in income will induce changes in the composition of demand, especially with an increase in demand for manufactured goods. This surplus in demand will lead the manufacturing sector and the service sector to increase their production to meet the new demand, hence an increase in industrial and even overall production. This increase in production will generate a surplus of resources,

which will also serve in part for investments and recruitment of more labor in the secondary and tertiary sectors. This supply of labor will promote the phenomenon of the shift of labor from the primary sector to the secondary and then to the tertiary. Thus, all countries that have experienced this transformation should reach a stage where the tertiary sector would be the most important in the economy. However, some countries may find themselves in an intermediate situation where they are still undergoing a structural transformation process, so the tertiary sector is not yet the dominant sector. However, this accepted reality may not apply to the particular case of certain countries. Sometimes the change in the composition of domestic demand can be replaced by foreign trade. A country with a comparative advantage in the production of primary sector goods can achieve a high level of income without increasing the share of industry in total output. Due to the abundance of natural resources and external demand, production may increase and, therefore, growth patterns may vary from country to country.

Kuznets (1972) argued that the share of the primary sector is inversely correlated with per capita income, while the shares of other sectors are positively correlated. That is to say, an increase in per capita income induces a decrease in the share of the primary sector, and an increase in the share of the other two sectors. Consequently, the per capita income gap between countries is one of the key determinants of the heterogeneity of economic structures between countries and the rapprochement of incomes should firstly promote intersectoral convergence and, secondly, intra-sectoral convergence.

Economic integration with its corollaries which induce the drop in barriers between regions, the disappearance of national borders and the agglomeration of industries also under certain conditions favor per capita income increase and then the phenomenon of structural convergence. Regardless of the degree of structural convergence achieved by countries, a certain level of heterogeneity will remain because of differences in cultural and political frameworks, natural resource endowments and country's size (Chenery, 1960). As stated by models of the new economic geography (Krugman, 1991a, b), the impact of differences in the size of countries on the processes of structural divergence is quite significant. Likewise, (Puga, 1999) suggests that because of a lack of interregional labor mobility, integration can cause regional convergence both

in terms of real wages and production structures. Also the potential for foreign direct investment (capital-deepening) and technological catch-up, in the catching-up process of lagging countries and therefore its impact on structural convergence is very important (Pigliaru, 2003)

The Chenery convergence hypothesis extended by other authors explains very well how all countries that experience an increase in per capita income will also experience structural convergence.

2.2.2.3 Market forces on the demand and the supply side that lead to structural convergence

Like the structural transformation which concerns a country, the structural convergence which is a simultaneous structural transformation which allows the gradual rapprochement between the sectoral structures of several countries is driven by market processes, namely forces on the demand side and on the supply side. The way in which markets behave, of course, is determined by industrial and trade policies. Thus, according to Abegaz, B. (2002) and Palan, N. and Schmiedeberg, C. (2010) structural convergence on the demand side results from the following complementary effects:

Engel's Law of the declining share of food in consumption: An increase in per capita income in developing countries is associated with a decrease in the share of spending on food and therefore an increase in the share of spending on other goods and services. This increase in the share of spending on other goods and services creates a change (increase) in the composition of demand. To meet this increasing demand, production in non-primary sectors will have to adapt with more investment. Thus, the secondary and tertiary sectors to maintain the increase in production will have to call on more labor from the primary sector. Thus, in all the developing countries which will experience this increase in per capita income, a certain sectoral similarity will emerge from these structural changes (Syrquin and Chenery, 1989).

Lewis's hypothesis of the elastic supply of labor: This hypothesis is from Lewis (1954) who studies the interactions between three foundations of development

economics: dualism, accumulation, and evolution in terms of trade. Dualism designates an economy with two systems (a precapitalist or agricultural system and a capitalist or industrial system) juxtaposed and characterizing underdeveloped countries. Lewis takes up this concept and considers a dualist economy in which a capitalist sector and a subsistence sector are opposed. Apart from the workforce, interactions between these two sectors are considered non-existent. The subsistence sector is organized according to non-capitalist social relations, where the workers produce the minimum subsistence. Due to rural underemployment, urban unemployment, and population growth, this subsistence sector constitutes a source of an unlimited supply of labor. The capitalist sector is the part of the economy whose capital is reproducible. The increase in capitalist profits is the determining element in the accumulation of capital. By combining an unlimited supply of cheap labor, and a model where the rate of accumulation depends on reinvested profit, Lewis shows how there can be an economic take-off. The development of the economy is indeed achieved by the absorption of the workers of the subsistence sector by the capitalist sector. This absorption will substantially change the sectoral structure of the economies of the countries which will undergo this process towards a rapprochement which will lead to structural convergence.

International homogenization of consumption: Globalization having affected all countries in the world homogenizes preferences in terms of consumption. Thus, despite the persistent inequalities between poor and rich countries, the composition of demand for consumer goods, in particular manufactured goods and services, is becoming more homogeneous at the international level [World Bank, (1993); Ray, (1998)]. This new situation of homogenization of preferences acts in favor of structural convergence because productive structures all over the world have to adapt to this new demand.

Industrial policy: The industrial policies implemented by the States to either substitute imports or boost exports according to internal or external demand also act as a driver for structural convergence [Puga and Venables, (1999); Pack, H, (2000)]. In fact, these policies, which are somehow similar, act on sectoral structures and promote a certain convergence. Industrial policies can also be analyzed as drivers to structural convergence on the supply side.

In contrast to these factors that promote structural convergence through market processes on the demand side, there are factors that promote structural heterogeneity (Chenery, 1960).

Differences in culture and income act against homogeneity of preferences despite globalization. Thus, whatever the forces of globalization, cultural and income differences will persist and act against the homogenization of preferences.

Resource endowments. In general, there are significant differences between countries in terms of resource endowments. This difference contributes to maintaining a certain structural heterogeneity between countries. Some countries can, because of their endowments, maintain a relatively large primary sector.

Economic integration, which favors the lowering of transaction costs within areas and also gives the possibility to exploit economies of scale, also acts in favor of structural heterogeneity.

Differences in the size of economies and domestic markets, differences in political and institutional systems also act in the same direction.

On the supply side, structural convergence is favored by the following factors:

Dynamic or latent comparative advantage [Krugman, (1987); Amsden, (1989); Grossman and Helpman, (1991); Redding, (1999); Lin JY, & Monga C (2010) and Lin, (2011)]. Dynamic comparative advantage is the comparative advantage that an economy can potentially obtain (and, arguably, should seek) in the long run. A dynamic comparative advantage can result from learning by doing and the adoption of new technologies. The acquisition of physical capital and investments in human capital through the rate of savings, investment, and Foreign Investments is the way to achieve it. Countries that strive to achieve this dynamic comparative advantage will reduce their technological gap vis-à-vis advanced countries. Since factor endowments (physical and human) are the determinants of intersectoral structure, such changes on the supply side act in favor of structural convergence between countries [Forstner & Ballance, (1990: Ch.2); Lall, (1997); Timmer, (1998)].

Technology Diffusion: According to Veblen (1915, 241) developing countries can borrow new technologies without following the laborious process of building the institutions that govern the design of that technology. Gerschenkron (1962) and Abramovitz (1979, 1986) highlighted the catch-up effect through the advantage of latecomers. Considering that imitation is less expensive than innovation, therefore catching up by technological diffusion is a probable result. A significant number of developing countries have benefited from technological diffusion coupled with an increased capacity to assimilate it. Attracting foreign direct investment and many other trade and industrial policies have been used to speed up technological diffusion (Evenson and Westphal, 1995; Lall, 1997; Ruttan, 2001). This technological diffusion acts positively for the reduction of the technological gap between the countries and therefore promotes intersectoral convergence.

Production cycles: the rise in the cost of labor in advanced countries encourages companies to make foreign direct investments in processing activities in less advanced countries where wages are lower to maintain their competitiveness. The "flying geese" model of Japanese, Taiwanese, Korean, Hong Kong, and Singaporean investments in the less industrialized neighboring countries of Southeast Asia (Thailand, Malaysia, Indonesia, the Philippines, China, and Vietnam) is a good example (Vernon, 1989; World Bank, 1993).

Solowian-type growth models predict that for countries with similar steady-state conditions (rate of investment, population growth, and technological progress), the convergence of per capita income and then that of sectoral labor productivity will occur. Countries with production levels below their potential would attract more capital, and thus develop faster than those which are more advanced.

Unlike those factors which promote structural convergence through market processes on the supply side, there are also factors which promote structural heterogeneity.

Technological gap, which implies considerable comparative advantages for advanced countries. Despite the diffusion of technology, the gap is still existing and contribute to maintain a certain structural heterogeneity.

Externalities, which favor the concentration of production at the level of the cores to the detriment of the peripheries.

According to Wacziarg (2001), structural convergence in theory can arise from three major sources. First, demand-side effects, i.e. Engel's law effects arising from income growth, could engender sectoral similarities between couples of economies with converging per capita incomes. Second, on the supply side, convergence in sectoral labor productivity levels between pairs of countries would engender a pattern of increasing similar labor shares across sectors. Third, structural convergence could be related to trade issues. In particular, if countries whose per capita incomes are converging also experience convergence in the factors of comparative advantage such as relative factor abundance, they can be expected to converge structurally, as they will specialize in the production of gradually more closely related types of products. Thus, bilateral trade intensity will be negatively related to sectoral similarity in the case where bilateral trade is dominated by inter-industry trade.

From this review of the theoretical literature on structural convergence, we can observe that the theoretical arguments in favor of structural convergence can be derived from the three-sector hypothesis, Chenery's convergence hypothesis and its various extensions, and market forces on the supply and demand side. Several authors have also worked using different methodologies to empirically highlight structural convergence between several countries, notably European, Asian and American. Apart from the studies that deal with all the countries of the world, for the specific case of African countries, the literature on empirical evidence of structural convergence is rather silent.

2.2.3 Empirical literature

In this section, we present the empirical work of the authors who highlight the phenomenon of structural convergence between several countries, or between a country and a group of countries, or between several regions (supra or subnational). We present

and discuss these empirical results according to the variables used to highlight structural convergence. Thus, we first present structural convergence through sectoral employment, then structural convergence through sectoral productivity or sectoral value-added and finally structural convergence through other types of data.

2.2.3.1 Structural convergence through sectoral employment

Structural convergence through sectoral shares of employment refers to the fact that the sectoral structures of several countries move towards similarity or homogeneity in terms of employment shares by sector as per capita income in these countries converges. However, as will be mentioned, some authors limit themselves to inter-sectoral similarity without addressing the issue of income per capita convergence.

Empirical work in this direction includes the seminal paper by Wacziarg (2001). Wacziarg uses sectoral employment data from two sources to calculate bilateral correlations to show structural convergence across 141 countries for nearly 40 industries. The first source is single-digit economy-wide data from ILO (1997). These data are provided for 82 countries (or 3321 country pairs) and covers the years from 1969 to 1997. He refers to the bilateral correlation of employment shares for ILO data by ILOCORR. The second source is 3-digit manufacturing data from UNIDO (1997). The labor shares for the UNIDO data are computed for 128 countries (or 8128 pairs) over the years from 1963 to 1997, and the bilateral correlations of these shares are referred to as UNIDOCORR. A characteristic of the Wacziarg data is the vast range of data observations provided: 128,742 for the UNIDO sample and 31,207 for the ILO sample. The pairwise correlations he estimates reveal negative and statistically significant correlations between income differences and bilateral sectoral similarity measures (employment share). This suggests that narrower income gaps are associated with greater structural similarities. Furthermore, the magnitude of the correlation is more than twice as large (about 0.60) for the ILO data set as it is for the UNIDO data set (about 0.25). Because these correlations, besides being simple, pool between-pair and within-pair variations, they may not then show structural similarity dynamics. To ensure that the preceding correlations show a structural similarity, Wacziarg analyzes the dynamics of this bilateral similarity over time within pairs of countries. For that, he proceed by running

fixed-effect regressions of UNIDOCORR and ILOCORR on a simple time trend. ILO data shows a trend towards greater structural similarity, as the coefficient of the time trend is positive and highly significant. Unconditionally, when structure is measured using broad, economy-wide sectoral categories, country pairs exhibit more similar economic structures over time. The results are less robust when using UNIDO data, i.e., the data reveal a tendency towards less similarity when all the available observations are used without restriction (unrestricted sample), but the data reveal more similarity when the sample is limited to the observations available in the ILO and UNIDO samples (common sample). At all two levels, Wacziarg underlines that the trend towards estimated structural convergence is of a very low magnitude. He notes that it would take 10 years to increase the bilateral correlation of sectoral labor shares by 0.024 for the ILO dataset (the standard deviation of ILOCORR being equal to 0.329), and the same number of years to reduce the correlation of 0.008 for the ONIDO dataset (the standard deviation of UNIDOCORR is 0.282). Clearly, there is not a general tendency for consistent structural similarity over time. As a result, the phenomenon of structural convergence described by Wacziar below is unlikely to be explained by a broader trend affecting countries regardless of whether they converge in terms of per capita income. To investigate the occurrence of a sectoral similarity (structural convergence) in relation to real convergence, Wacziarg makes fixed-effect regressions of measures of structural similarity (bilateral correlations) on the difference in income (measure of income similarity) that he noted INCDIFF. Fixed-effect estimation isolates the within-pair variation in the data, i.e. the dynamic link between structural similarity and income convergence, as opposed to the transversal link. The coefficient of the variable INCDIFF represents the coefficient of structural convergence. Wacziarg recognizes that no causal significance should be attributed to that coefficient, because, a fixed-effect estimation must be analyzed as a partial correlation indicating the intra-pair link between income convergence and structural similarity. Evidently, the occurrence of structural convergence is indicated by a negative and significant value of this coefficient. For comparison purposes, whether or not the sample is restricted to observations common to the ILO and UNIDO datasets, a shrinking of the income gap is significantly linked with greater similarity in economic structure. Another relevant aspect of these results is the magnitude of the reduction in the income gap to explain the variation in ILOCORR - the R-squared statistic ranges between 0.37 and 0.47 according to the

sample - indicating that the convergence of income is significantly linked to the dynamics of structural similarity for broad sectoral categories at the scale of the economy. This is according to wacziarg consistent with the literature on structural transformation which emphasizes that, when examining the three major sets of "three sectors hypothesis" (agriculture, industry and services), economies tend to go through comparable phases of development, characterized by the initial fall in agriculture as a proportion of total employment, and the concomitant rise in industry and services, preceding the relative acceleration in service employment (Chenery and Syrquin 1986). The results for the UNIDO dataset show that structural convergence is also valid, although the reduction in the income gap represents a smaller part of the overall variance in UNIDOCORR. The significance of the convergence effect is similar for the ILO and UNIDO datasets. In fact, according to the results, the point estimate of the INCDIFF coefficient indicates that reducing the income gap between the richest country and the poorest country should lead to a log $2 \times 0.0725 = 0.05$ increase in ILOCORR (or 15.3% of its standard deviation) and a log $2 \times 0.04 = 0.028$ increase in UNIDOCORR (or 10% of its standard deviation) in the common sample (ILO / UNIDO). For robustness issues concerning the previous results on structural convergence, Wacziarg first investigates some geographical characteristics of structural convergence. He investigates whether his previous results hold for regional subsamples of the data. Second, he examines whether the intra-pair results presented above are robust to the use of inter-pair variation (which could capture longer-term phenomena), as well as to other changes in the estimation framework. Finally, he investigates whether the use of annual data could lead to a spurious relationship between sectoral similarity and the income gap. For the geographic features of structural convergence, Wacziarg first examines whether the evidence of structural convergence he obtained is driven by some subsets of the sample. A first division of the sample can be obtained by considering pairs of OECD countries. Pairs involving only OECD countries are likely to involve countries with relatively similar incomes, so the relationship between the income gap and sectoral similarity might be more difficult to assess. This is compounded by the fact that a fixed-effects estimator exacerbates the downward bias on the slope parameter when the regressor is autocorrelated, a problem which is likely to be worse when INCDIFF has a lower true variation and a lower average amplitude, as is the case for the OECD countries. Indeed, the results thus obtained show that structural

convergence no longer holds in the ILO dataset when only country pairs involving OECD countries are used. The INCDIFF always carries a significantly negative coefficient when considering the UNIDO dataset, suggesting evidence of structural convergence within narrowly defined manufacturing sectors within the OECD (the magnitude of the estimated coefficient is similar to that obtained for the full sample). Regarding country pairs involving at least one non-OECD country, he found evidence of structural convergence for the ILO and UNIDO datasets, with estimated coefficients of similar magnitudes to those of the full sample. Therefore, this first division of the sample suggests that the conclusion of structural convergence is robust for the UNIDO dataset and fragile for the ILO sub-sample of OECD countries. Another interesting division of the sample for Wacziarg is to consider geographic lines (Southeast Asia, Latin America, Sub-Saharan Africa and Europe). The results show the presence of structural convergence almost everywhere for all the ILO and UNIDO databases, with a particularly marked effect in terms of the countries of South-East Asia, where the growth of per capita income was very high during the period under study. As in the case of the previous OECD results presented above, structural convergence does not seem to hold for major economic sectors according to ILO data in Europe. But in the case of the UNIDO dataset, these results are robust. To sum up, the divisions of the sample carried out by Wacziarg give a number of lessons. First, structural convergence is particularly accentuated where structural change, in particular, has been rapid (South East Asia). Second, rich countries do not appear to be experiencing 1-digit economy-wide structural convergence. Finally, structural convergence in the 3-digit manufacturing sector appears to be almost universal, with Latin America being an exception. Regarding estimation problems, Wacziarg considers the use of some variation between pairs. In previous results, the use of intra-pair variation was justified by the objective of characterizing the dynamic relationship between the income gap and sectoral similarity, best assessed by isolating the variation over time, within the pairs of countries. However, the use of fixed effects estimation has at least two drawbacks. First, it exacerbates the effects of measurement error in the independent variables. This is because even with white noise measurement error, the error-truth variance ratio for an autocorrelated right-hand side variable becomes larger when the variable is differentiated, as is the case with fixed effects, the coefficient on INCDIFF would than be biased towards zero when the internal variation is isolated.

Second, estimating fixed effects over a period of at most 29 years (ILO) or 34 years (UNIDO) may not be sufficient to obtain a truly long-term view of structural convergence. By using the variation between pairs in the data, by using a random effects estimator (which optimally weights the intra and inter pair variations assuming that the pair specific effects are not correlated with the regressor), Wacziarg obtains results in conformity with his expectations: the magnitude of the coefficient estimated on INCDIFF is increased compared to the reference results. This is particularly the case for the ILO dataset, where the absolute value of the coefficient is at least doubled. For example, in the common sample, the marginal effect of INCDIFF on ILOCORR is estimated to be -0.073 under fixed effects and -0.156 under random effects. Wacziarg's application of Hausman' s tests for the null hypothesis that the estimates of the random and fixed effects do not differ significantly also shows that the null hypothesis is rejected for all specifications at very high confidence levels. This justifies considering the fixed effects results as a benchmark. To summarize, Wacziarg concludes that the use of pairwise variation yields parameter estimates that are larger in absolute value than under a fixed effect's regime. Structural convergence is therefore a robust feature of the data, even across the board, and fixed-effect estimates may underestimate its true magnitude. Another estimation problem according to Wacziarg is the fact that the dependent variable in this study (the two-way correlation of sectoral shares) is bounded by the values -1 and 1. First, this can be a problem for out-of-sample predictions, although with the estimates obtained above and the observed values of INCDIFF, predicted values of UNIDOCORR and ILOCORR that exceed the allowable limits are never obtained. Second, it can also lead to inconsistent parameter estimates if a linear model is fitted to a limited dependent variable, although obviously very few observations fall on the boundaries of ILOCORR and UNIDOCORR. To correct this potential problem, Wacziarg applies a twice censored tobit model with random effects. The results are very similar to those obtained with the random effects (linear) estimator. Structural convergence is still observed and the magnitude of the estimated coefficient is roughly unchanged. Wacziarg concludes that his basic results are not sensitive to an explicit consideration of the limited nature of the dependent variable in this study, and that the finding of structural convergence is not an artificial result of using a linear estimator. Finally, Wacziarg examines whether the use of annual data may have affected his baseline results. High-frequency variations in

sectoral similarity and income gap can generate a correlation between the two variables that would disappear at lower frequencies, a problem that may be more acute under a fixed-effects estimate (within a pair). Therefore, Wacziarg seeks to establish the existence and extent of structural convergence for five-year interval data (1970-1995 in six periods) as a baseline for the estimations. The estimates obtained compared to the annual data estimates show that the amplitude of the coefficient on INCDIFF is slightly higher for all specifications. Therefore, Wacziarg concluded that his latest robustness check indicates that structural convergence was not an artifact from the use of annual data.

Following the same logic as Wacziarg (2001), Barrios, Barry, and Strobl (2002) highlight the phenomenon of structural convergence in the EU periphery. By the EU periphery, they mean four countries, namely Greece, Spain, Portugal, and Ireland. To highlight the structural similarity Barrios, Barry, and Strobl (2002) used the Krugman Specialisation Index (KSI) instead of the Wacziarg bilateral correlations. The KSI is the standard index among the sector specialization measures index. This index calculates the share of employment that would have to be relocated to obtain an industrial structure equivalent to the average structure of the reference group. The benchmark value can either be from another single country, as in Krugman (1991a), or it can refer to the average of all other countries in the reference groupe, as in Midelfart-Knarvik et al. (2000) or Longhi et al. (2004) or Palan and Schmiedeberg (2010). The KSI takes a value of zero if the reference country has an industrial structure identical to the reference group, and a maximum value of 2 if it has no industrial structure in common with the rest of the countries of the group. So the higher the index is, the more the economic structure of a country deviates from the benchmark group, and the more a country is considered to be specialized. The KSI index has the advantage of not changing the degree of specialization when dividing an industry into sub-industries if the country is relatively more specialized than the benchmark group in all sub-industries. If, on the other hand, the country under study is relatively more specialized in some sub-industries while being relatively less specialized in others when compared to the benchmark group, then industry mergers would reduce the level of specialization because the models of over-and under-specialization cancel each other out. The inclusion of industries with zero or very low employment shares has no effect on the degree of specialization. After computing the KSI

for each country, and bilaterally between countries (the four countries plus the other EU countries), Barrios, Barry, and Strobl (2002) uses the Wacziarg (2001) model to regress this index on the absolute value of the difference in GDP per capita, and add two other control variables, namely the absolute value of the difference in populations and a yearly specific effect variable. They estimate the previous equation with a standard fixed-effects estimator to see if income convergence and market size are related to industrial structure. The results of Barrios, Barry, and Strobl (2002) are very close to those of Wacziarg (2001). The positive and significant sign of the proxy variable of income convergence proves that the real convergence is related to the industrial structure, i.e. as the incomes of the EU countries converge, their industrial structure becomes more similar. However, the differences in the total size of the market have a negative and significant impact on the divergence in the industrial structure. Nevertheless, Barrios, Barry, and Strobl (2002) nuance their results by pointing out that the meaning of the causality between real convergence and convergence of the sectoral structure may not be clearly defined from the first results they obtained. The nature of industrial specialization in a country can be both a result and also a determining factor of per capita income. If the specialisation is in modern high value-added sectors, such as high technology, it is likely to favour higher incomes than specialisation in traditional industries. Furthermore, Barrios, Barry, and Strobl (2002) point out that there may be other factors not taken into account, such as the implementation of new industrial policies, which could affect both industrial structure and income, which could bias the coefficients of the results. To address previous concerns about the validity of their results, Barrios, Barry, and Strobl (2002) use an instrumental variables approach. They instrumented the convergence of income, under a panel estimator with fixed effects. In particular, they use the differences between country pairs in per capita savings as an appropriate instrument, because while the incidence of savings is likely to affect a country's wealth, it will not affect, at least in the short term, the structure of the manufacturing sector. After performing the Davidson-MacKinnon test of instrument validity, they support the specification taking into account endogeneity. The results of the fixed-effects panel estimator of instrumental variables show that the impact of income convergence on industrial similarity between countries increases by several times compared to the previous results, under this specification. Thus structural convergence caused by real convergence is indeed a reality according to this specification.

Longhi & Musolesi (2007) study the structural convergence between forty European cities. Based on the method of Wacziarg (2001), they use sectoral employment and sectoral value-added data to test the relationship between structural similarity and real convergence. They calculate not only a KSI like index but also bilateral correlations between sectoral employment shares between pairs of cities, which they regress on the log of the income ratio of the richest to the poorest city. The results they obtain are similar to those of Wacziarg (2001) and confirm the existence of a phenomenon of structural convergence between these European cities since 1975 (a process of 'metropolitisation' of cities).

Palan & Schmiedeberg (2010) investigated the structural convergence of 14 European EU countries over the period 1970 to 2005. Their analysis is based on employment data from the national accounts of these countries. They investigated inter-sectoral and inter-industry convergence, focusing on changes between the agricultural, manufacturing, and service sectors. Drawing on the two common convergence tests (σ-convergence and β-convergence), Palan & Schmiedeberg implement an index of structural heterogeneity, the SHE, which is constructed analogously to Krugman's KSI, but specified in two types to separately capture inter-sectoral heterogeneity (sSHEN) and inter-industry heterogeneity (iSHEN). They also test for unconditional convergence, which implies that all countries converge until all have the same employment shares in all respective industries. Palan & Schmiedeberg find as results a significant and rapid inter-sectoral convergence, accompanied by a mixed picture with regard to inter-industry convergence. The results also show a general shift towards technologically advanced industries, while employment shares in traditional low-tech industries are decreasing. However, European countries are not becoming more similar in terms of sectoral composition within the industry and service sectors; some industries are converging over time, while others are diverging or remaining unchanged. Given the rapid development of European countries in detail, there is no uniform pattern of catching up of lagging countries, as there are both leading countries like Ireland and Finland and stagnant countries like Portugal. The countries can be roughly classified into three groups according to Palan & Schmiedeberg's results: first, the leaders, countries like Germany, the UK, and France, which are leaders in technology and in industrial innovation and

knowledge from the beginning to the end of the observation period. Secondly, there are good followers, which in some industries seem to outperform even the best, for example, Finland in the field of telecommunications. Finally, the southern European countries are at the bottom of the scale with less dynamic development. As far as the latter is concerned, the level of lagging behind other countries seems to have even increased over time. It seems that the Southern European countries, which specialize in low-tech industries compared to other parts of Western Europe, have lost their comparative advantages. They face fierce competition from low-cost countries in Asia and Eastern Europe, while they have failed to develop successful high-tech industries. This situation, according to Palan & Schmiedeberg casts a negative perspective on European cohesion policy, although their results focus only on employment structures without taking into account changes in income levels unlike Wacziarg (2001) and Barrios, Barry, and Strobl (2002).

Based on sectoral employment shares, Albu (2012) studies the structural convergence between European countries (EU-27), Eastern European countries (EU-10) and Western European countries (EU-15) during the period 2000-2011. To assess changes in the economic structure, Albu expresses the employment shares in the three sectors of the economy as a function of the GDP per capita. In his model, the share of employment in agriculture in total employment, na, and respectively the share of employment in services in total employment, ns, as a function of GDP per capita, y, are expressed by the relationships below:

$$na(y) = (k1 * y + k2) / (k3 * y + k4)$$

$$ns(y) = k5 * y / (k6 + y)$$

where k1, ..., k6 are parameters.

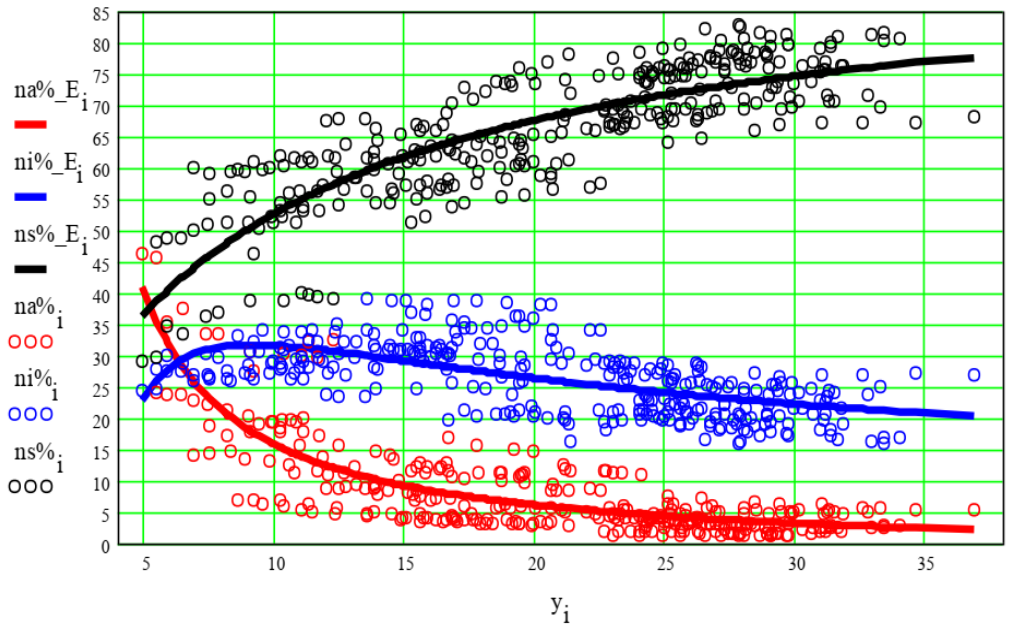
Thus, the resulting equation for the share of industry employment in total employment, ni, is:

$$ni(y) = 1 - \{[(k1 * y + k2) / (k3 * y + k4)] + [k5 * y / (k6 + y)]\}$$

The model as indicated in figure 9 demonstrates a process of structural convergence in the EU over the period analyzed, as per capita GDP increases. Differences between

countries can therefore be interpreted as differences between levels of income per capita, but also as structural differences (structural gap).

Figure 15: The share of the three sectors in total employment (in percentage) as a function of GDP per capita (in thousand PPS[18])



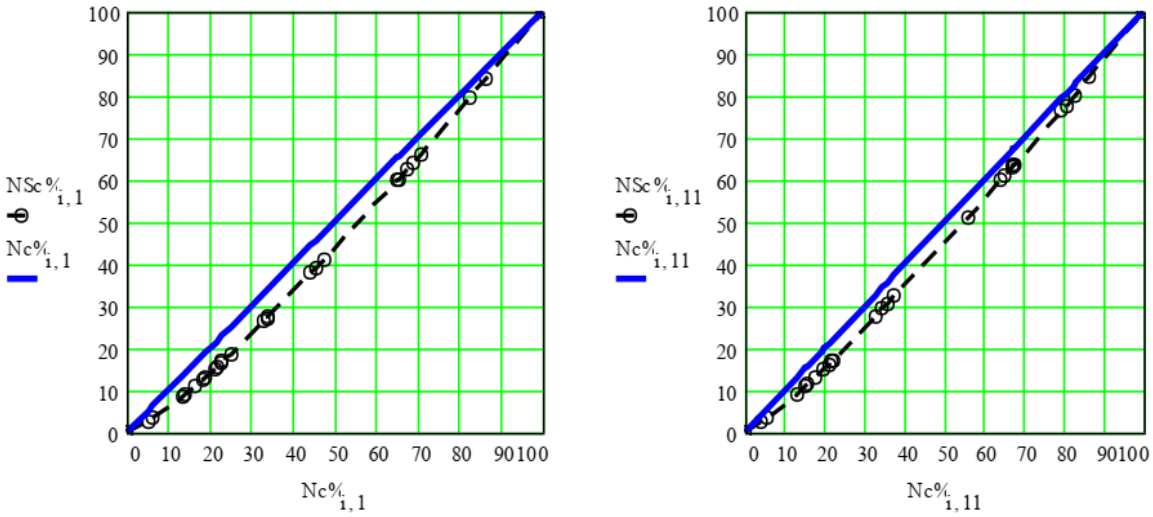
Source: Albu (2012)

Albu also uses the Lorenz curve (Lorenz, 1905) as a tool to analyze structural differences. the Lorenz curve makes it possible to study the distribution of a variable in a given population (in this case, it is the concentration of the share of jobs in the service sector in the EU countries that Albu proposes to 'to study). Changes in concentration over time are an indicator of convergence. The Lorenz curve expresses the distribution of a certain indicator of interest, such as service employment, NS, for example, within a certain population of jobs. Thus, on the x-axis is shown the cumulative share of countries in total EU employment, Nc%, from the lowest to highest share of services in total employment, and on the y-axis the corresponding cumulative share of countries in total EU employment in services, NSc%. The line passing through all the points (Nc%, NSc%) in the plane is

[18] The purchasing power standard, denoted as PPS, is an artificial currency unit (PPS is the technical term used by Eurostat for the common currency in which national accounts aggregates are expressed when adjusted for price level differences using PPPs; PPP being Purchasing power parity).

the Lorenz curve. The diagonal of the unit square thus formed signifies the average share of services in employment, while the area delimited by the Lorenz curve and this diagonal, denoted by A, represents an aggregate measure of disparities or of the degree of concentration. The diagonal corresponds to what is called the line of perfect equality (all levels of service sharing are equal; on the other hand, the line of perfect inequality is represented by the horizontal line, NSc% = 0 for all Nc % less than 100%, continuing with the vertical line NSc = 100% when Nc% = 10%). By way of illustration, in figure 10 Albu presents the Lorenz curve for the EU in 2000 and 2011 (where the cumulative weights of employment in services, NSc%, on the y-axis and those in the total employment, Nc%, on the abscissa are expressed as a percentage). The EU countries are noted i = 1, ..., 27 and the years of the period considered from 2000 = 0 to 2011 = 11. There is a decrease in the area delimited by the Lorenz curve and the diagonal in 2011 compared to 2000, which signifies a process of convergence over this period.

Figure 16: Lorenz curve for the EU in 2000 and 2011



Source: Albu (2012)

Marelli E. (2004) studies structural convergence in 145 EU regions over the period 1983-1997. He focuses his analysis on the distribution of employment between the main productive sectors. His main results show that convergence and persistence of employment structures can coexist; structural differences are more important within countries than between countries; and, finally, income convergence is enhanced by the

homogenisation of productive structures, although the industrial sector retains a key role in growth processes.

Marelli, E., & Signorelli, M. (2010) use a β-convergence test to test structural convergence in EU-27 countries from 1990 to 2007. In the regression model of β-convergence, they replaces GDP per capita with KSI, thus their model allows testing inter-sectoral convergence. The results show that convergence of sectoral structures is well established for the EU as a whole, for the old members (EU-15), and for the new CEEC members. For European Monetary Union (EMU) countries, a divergence in sectoral structures seems to emerge for the entire period; for even more precision, they run the regression over a shorter period (1999-2007), i.e. after the start of EMU: since the coefficient is not significant, they refrain from concluding within EMU, so the model of structural convergence is not clear at EMU level.

Imbs (2000) studies the role of sectoral similarity in determining the correlations of international business cycles for a sample of OECD countries. However, he treats the issue of structural similarity as an independent variable in his study. He implemented a methodology in which trade and economic structure measured by the sectoral composition of aggregate employment are assumed to affect the synchronization of the business cycle. As a result, he finds that the sector structure has a robust and economically significant impact on the synchronization of cycles; the variable is particularly important in EMU member countries, thus explaining why foreign countries like the UK or Scandinavian economies tend to display persistent idiosyncratic business cycles compared to members of the first stage.

Raiser, Schaffer, and Schuchhardt (2004) used the evolution of sectoral shares of employment as a function of GDP per capita to analyze the dynamics of structural change in 22 transition economies - 10 accession countries and 12 CIS (Commonwealth of Independent States) countries - from 1989 to 2000. They examine changes in the structure of employment in four sectors (industry, agriculture, market services, and non-market services) for the two groups of countries, they construct an employment distortion index that measures the distance between each country and the sectoral structure that would be found in a typical market economy with the same GDP per capita. The evolution

of the value of this index during the transition indicates whether a country has moved (converged) towards a market economy structure or whether it is moving (diverged) from the market economy structure. For industry the results show that the transition countries (12 CIS countries) started the transition with very large shares of employment in the industrial sectors. For most of these countries, employment in the industry sector was about 15 percentage points higher than in market economies with the same per capita income. The few exceptions are the poorest transition countries, which started their transitions with levels of industry fairly close to the benchmark. The results also show that all 22 transition countries experienced sharp declines in the share of employment in industry, but the observed adjustment takes one of two forms: the richest transition countries find themselves in 2000 with levels of industrial employment that are still well above the market economy benchmark. In contrast, poorer transition economies have industrial employment shares in 2000 that are equal to or even lower than the market economy benchmark. The results for the accession candidates (10 countries) show a "lateral U" trajectory of structural change in industry. The shape observed for most of these countries reflects the J-curve of output during the transition period, with an initial sharp decline in GDP followed by a recovery. All accession countries are moving towards the market economy benchmark, so a decline in the share of employment in the industrial sector is to be expected. However, in 2000, not only did, the 10 accession countries still employ more in industry than the market economy countries that served as a reference, but in most of these countries, the adjustment has slowed down or even stopped altogether. Indeed, most have shares of industrial employment that are stabilizing at levels that are not only above the benchmark for market economies of the same GDP per capita, but are also well above the peak of the market economy benchmark that is observed at a much higher level of income. The pattern observed in the CIS countries is quite different. The European CIS countries - Russia, Ukraine, Belarus - show declines in the share of industry in employment that leaves these countries well above the market economy benchmark, although in the case of Russia and Ukraine (but not Belarus) the data suggest that the adjustment is continuing. The other CIS countries are different: they were also likely not to start the transition with smaller shares of employment in the industrial sector that were quite close to the market economy benchmark, and in 2000 they have shares of employment in industry that are either comparable to or lower than those found in market

economies at the same income level. In agriculture, the results show a difference between the richer accession countries and the poorer transition countries. Richer accession countries started the transition with a much smaller agricultural employment share than would be found in market economies of comparable income. These countries continued to face a fall in the share of employment in agriculture so that by 2000 their employment share in agriculture was even lower than that in the market economy at the start of the transition. The share of employment in agriculture observed today in many of these countries is now comparable to the range observed in the less wealthy members of the European Union. The CIS countries present a different picture; the European CIS countries started with, and still have, a share of employment in agriculture that is lower than would be expected in a comparable market economy, and the poorer CIS countries have increased their share of employment in agriculture to the point where they are now all close to the market economy benchmark. The results for the market services sector (trade, finance, transport, communications, etc.) are interesting for almost all accession candidates. The share of employment in this sector has increased significantly during the transition and is in the 2000s in most cases at or above the level of market economies. In contrast, the evolution of the share of employment in the non-market services sector (health, education, administration) is less interesting. Many candidate countries, and almost all CIS countries, have employment shares in non-market services well above those that would be found in market economies of comparable income.

Based on an analysis of 275 Portuguese counties over the period 1985-2003, Crespo, N., & Fontoura, M. P. (2010) studied the determinants of structural similarity at the Portuguese level. They use employment data from these counts to estimate their structural similarity using the KSI which they then regress on several other variables namely: the common border between regions, the distance between regions, the difference between regions in terms of population, the difference between regions in terms of per capita income, the difference between regions in terms of human capital endowment and difference between regions in terms of their physical capital endowment. The results show on the one hand that there is an evolution towards more sectoral similarity over time between these regions, and on the other hand that the structural similarity between the Portuguese counties increases with geographical proximity, the

existence of a common border, the similarity of factor endowments in terms of physical and human capital and the similarity in terms of centrality and market size.

Structural convergence through sectoral shares of employment in relation to real convergence or not has been empirically highlighted by various authors and at several levels (global, continental, regional, sub-regional and local). Thus, the simultaneous movement of labor from the primary to the secondary sector and then to the tertiary sector seems to be globally confirmed as predicted by the 3-sector hypothesis. We then turn to empirical studies on structural convergence through sectoral productivity and its determinants.

2.2.3.2 Structural convergence through sectoral productivity or sectoral value-added

Structural convergence through sectoral productivity shares refers to the fact that the sectoral structures of several countries tend towards similarity or homogeneity in terms of sectoral productivity or sectoral value added as per capita income in these countries converges. However, as will be mentioned, some authors limit themselves to inter-sectoral similarity without addressing the issue of income per capita convergence.

Dowrick (1989) investigates the determinants of productivity in OECD countries from 1950 to 1985. He uses sectoral shares of employment to represent output shares. He arrives at several results, including the fact that the shift of labor out of agriculture increases GDP growth because marginal productivity is much higher in industry and services. Thus, the movement of labor from the agricultural sector to the other two will continue in the lagging countries until they converge with the advanced countries, but the technological gap between countries should also be taken into account for them to experience converge. Countries with the same sectoral employment share, but with a significant technological gap, are unlikely to converge in terms of productivity or value-added per sector, as technology is much more important than labor in determining productivity.

Doyle, E. & E. O'Leary, (1999) uses a constructed dataset of GDP and employment at the aggregate and sectoral levels for the EU11 from 1970 to 1990 to study

the convergence of aggregate and sectoral labour productivity. They finds that there was a greater degree of aggregate than sectoral convergence among EU countries between 1970 and 1990. The overall convergence of 0.9% per year coincided with the divergence of the manufacturing and agricultural sectors, with only the service sectors converging. The results also show that structural change, as measured by changes in sectoral employment shares, accounted for between 50 and 66% of the overall rate of aggregate productivity convergence among EU countries over the period. Countries with relatively low levels of aggregate productivity have benefited most from structural changes that contribute positively to the degree of overall labour productivity convergence in the EU11.

Cuadrado-Roura & al (1999) analyzed the evolution of regional differences in 17 Spanish regions over the period 1955-1995. They use data on GDP per capita and sectoral employment shares with the approach of σ-convergence, β-convergence and an index that measures sectoral homogeneity to highlight structural convergence through productivity and sectoral similarity through employment shares. As a result, they observe a convergence of productivity at the aggregate regional level but not at the sectoral level. The aggregate convergence is because of the progressive homogenization of regional productive structures. Therefore, they conclude that productivity differences between regions will tend to stabilize. This shows the existence of mechanisms such as synergies or agglomeration economies that act in favor of maintaining differences and against real convergence.

Landesmann, (2000) analyses the process of economic catching up between groups of industrialized, newly industrialized, and less industrialized Central and Eastern European Countries (CEEC) over the period 1989-1999. He distinguishes two groups of reference countries with which the CEE countries are compared: a group of northern EU countries (Belgium, France, Germany, UK) and a group of southern EU countries (Greece, Portugal, Spain). He uses the shares of industries in total production with the formula of the structural deviation indicator[19]. This indicator provides synthetic

[19] The formula is: $S = \sqrt{(sh_k^x - sh_k^y)^2 . \left(sh_k^y/100\right)}$

x = individual CEEC compared

information on the similarity (or distance) between the industrial structures of different countries or groups of countries. As results he found that:

- There is a clear difference between the CEECs in their respective similarities or differences with the northern and southern groups of the EU. The countries closest in manufacturing structure to the northern EU group are Slovenia and the Czech Republic, followed by the Slovak Republic. The countries closest to the southern EU reference group are Poland, Bulgaria, and Romania. The distance to the southern EU reference group is quite large for the other CEE countries.

- Over time, there is a general convergence of structures between the CEEC-5 and the northern EU reference group over the period 1992-1998 (with the exception of Hungary over the last two years, which is mainly the result of a strong decrease in the share of food products and a strong increase in the share of electrical and optical equipment). Bulgaria and Romania seem stationary in their distance from the EU's northern reference group.

Using a panel of 39 countries and 24 industries over the period 1973-1990, Fagerberg, J. (2000) studied the impact of specialization and structural change on productivity growth in manufacturing. He uses value added and employment data to see how structural change affects productivity. His results show that while structural change was not on average conducive to productivity growth, countries that managed to increase their presence in the most technologically advanced industry of the period (electronics) experienced higher productivity growth than other countries.

Gács, J. (2003) uses sectoral shares of GDP and sectoral shares of employment over the period 1988-1999 to show a trend of structural convergence between the CEEC-10 and the EU-15 countries. Gács uses also the structural deviation indicator to study the evolution of sectoral reorganizations over time and also to compare the economic

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y = individual West-European country or region compared
k =individual industry
sh_k^y = share of industry k in total output at constante prices of country y in %
sh_k^x = share of industry k in total output at constante prices of country x in %
Gács, J. (2003) uses this same index to study the evolution of sectoral reorganizations over time and also to compare the economic structures of different countries.

structures of different countries. The results show a sharp rise in this index, synonymous with important changes in the sectoral structures of the CEEC-10 countries.

Gugler & Pfaffermayr, (2004) use data on nominal value added and employment for manufacturing industries at the 3-digit level for European Union (EU) member countries covering the period 1985-98. They use the β-convergence approach to measure the speed of structural convergence. As a result, they find a very rapid convergence in productivity for 99 European three-digit industries over the period 1985-98. The speed of convergence is much higher than previously obtained in the literature. However, the convergence in productivity is not accompanied by a convergence in industrial structure (measured by nominal value added and employment shares) which is much slower or even non-existent in most industries. The type of industry, i.e. whether it is skill and/or capital intensive, is much more important for structural convergence than for productivity convergence.

Using sectoral shares of value added from 1980 to 2001, Sassi, M. (2007) analysed the evolution of structural change and structural convergence for 80 Western European regions. She uses the KSI to assess the sectoral similarity of the regions, and then the β-convergence to highlight structural convergence. As a result, Sassi highlights not only a trend towards the reduction of sectoral heterogeneities through the KSI, but also a process of structural convergence between these 80 Western European regions through the β-convergence approch.

Abegaz, B. (2002) applies logistic regressions to cross-country [Industrial Market Economies (IMEs), Newly Industrialised Economies (NIEs) and Least Industrialised Economies (LIEs)][20] to production data [per capita income (domestic demand), industry in GDP (scale or agglomeration), population (endowment), trade turnover (openness)] for three-digit manufacturing sector to test for convergence in

[20] IMEs group consists of 15 industrialised countries: Australia, Austria, Belgium, Canada, Iceland, Denmark, Finland, France, Italy, Japan, Netherlands, New Zealand, Norway, Sweden and USA. NLIEs group consists of developing countries Argentina, Brazil, Chile, China, Colombia, Spain, Greece, India, Indonesia, Jamaica, Korea, Mauritius, Mexico, Philippines, Portugal, Singapore, South Africa, Thailand, Turkey and Venezuela. LIEs group consists of the following countries: Bangladesh, Bolivia, Ecuador, Egypt, El Salvador, Ghana, Honduras, Iran, Kenya, Morocco, Malawi, Nicaragua, Pakistan, Panama, Senegal, Tunisia, Tanzania, Zambia and Zimbabwe.

manufacturing sectors. He found evidence of increasing structural homogeneity in manufacturing between leaders and late comers. Applying a two-stage sequential estimation procedure to three-digit manufacturing data for 45 mostly middle-income countries, Abegaz, B. (2007) estimates the speed of structural convergence in the manufacturing industries of newly industrializing economies. He found empirical support for the hypothesis that production efficiency is a major determinant of inter-sectoral output share adjustment, i.e. the speed of share gain or loss for many industries is driven by differences in inter-sectoral production efficiency.

O'Leary E (2003) uses sectoral labor productivity data to apply the σ-convergence approach and other supplementary calculus to highlight sectoral or overall aggregate convergence among the Irish regions in the period 1960-1996. He also uses sectoral labor productivity, defined as regional Gross Value Added (GVA) per worker and sectoral employment share in each region to analyze if the structural change has a convergent effect. The results showed that aggregate productivity converged significantly between 1960 and 1979, principally because of the converging effect of structural change and the convergence of the service sectors. Between 1979 and 1996, aggregate productivity diverged modestly, principally because of a strong divergence between the manufacturing and service sectors. The aggregate divergence would have been stronger had it been the continued convergent effect of structural change.

Applying first and second generation panel unit root tests to determine whether agriculture in Central and Eastern European countries is converging or diverging, Fertő, I. (2016) uses as dependent variables agricultural value added as a percent of GDP (Share of agricultural GDP) and employment in agriculture as a percent of total employment (Share of agricultural employment), and then uses the share of food expenditure in total expenditure (Food share of expenditure) as a structural indicator over the period 1990-2011. The results of the panel unit root tests do not confirm the hypothesis of convergence in the agricultural structural transformation of the region. The structural transformation does not follow the common path in these countries. The estimates reinforce the fact that the convergence analysis requires careful application of various panel unit root tests.

Using several variables, indicating real convergence (GDP/capita), structural convergence (GDP/capita produced in agriculture) and FDI stocks (FDI/capita), Strat, VA & Popovici OC (2015) analyse the evolution of disparities between EU Member States. Applying a time series methodology of Gini coefficients, at the level of the whole Union and also at the level of new and old EU Member States, they find decreasing disparities in stocks of FDI/capita, GDP/capita and GDP/capita produced in agriculture for the new Member States, but oscillating developments for the old ones. They also found evidence suggesting a positive relationship (simple correlation) between these three phenomena. Therefore, FDI can be seen as a factor (enhancer) for both real and structural convergence in the EU and the new EU Member States, but not confirmed for the old Member States.

Using OECD data such as labor productivity, regional values added, and employment shares in branches (agriculture, industry, construction, trade services, financial intermediation, and other services) for the period 1995-2007, Di Berardinopaci & al (2017) analyze the relationship between structural change and the process of convergence among Italian regions. They adopted the shift-and-share methodology of Fua` (1993) to divide the average annual aggregate growth rate of productivity into its infra-sectoral and structural components. They use the β-convergence approach to see whether relatively poorer countries experience faster productivity growth than richer ones. The results show that structural changes have played an important role in explaining the growth and catching-up process of the lagging Italian regions[21]. Although slow, their results confirm the existence of convergence, but also that only structural change has played a statistically significant supporting role.

Using sectoral shares (agriculture, mining, manufacturing, construction, and services) of per capita income between 1970 and 2012, Chong et al. (2017) investigate the process of structural convergence among ASEAN (Association of Southeast Asian Nations) member states by applying the KSI. The objective for them was to investigate whether the new ASEAN members, namely Cambodia, Laos, Myanmar, and Vietnam

[21] Paci R and Pigliaru F (1997) had earlier also found quite similar results on the convergence of Italian regions.

(i.e. CLMV) were in a process of catching up with the more advanced members in terms of their sectoral structures. The results revealed increasing structural convergence within ASEAN. The new ASEAN members, namely the CLMV, had almost caught up with the more advanced members in their structural development.

We can observe that some above-mentioned papers on structural convergence through sectoral productivity or sectoral value added are methodologically less rigorous than others. Thus, their results will be less robust than those using more rigorous methodologies. Chong et al. (2017) for example, just use the KSI to conclude on structural convergence. The single KSI measure, which tells us which share of employment or output would have to be reallocated to achieve an industrial structure equivalent to the average structure of the reference group, does not rigorously allow us to conclude whether or not there is structural convergence. Indeed, structural convergence as we have defined it, is achieved when there is a tendency towards structural homogeneity at the same time that there is a tendency towards real homogeneity (real convergence). The KSI is limited to comparing structures without looking at real convergence. Although Strat, VA & Popovici OC (2015) used GDP/capita, GDP/capita produced in agriculture and FDI/capita data to show a positive relationship between these three variables and then conclude that there is structural convergence, we can see that they use simple correlations which of course say nothing about possible causality. Landesmann, (2000) and Gács, J. (2003) limit themselves to the use of the structural deviation indicator which provides summary information on the similarity (or distance) between the industrial structures of different countries or groups of countries. This method also, of course, does not give information on the existence of a real convergence or not. Di Berardinopaci & al (2017), O'Leary E (2003), Sassi, M. (2007), Gugler & Pfaffermayr, (2004), and Cuadrado-Roura & al (1999) for some of them, in addition to the sectoral heterogeneity indices, use the σ-convergence and/or β-convergence approaches to highlight structural convergence. Subject to the criticisms and limitations of these methods already mentioned in the first chapter, this approach seems more rigorous than the simple use of the KSI or the structural deviation indicator.

Thus, despite the diversity of methods and types of data used (in addition to productivity or value-added data), despite the diversity of the sectors studied, despite the different periods studied, and despite also the diversity of the areas studied (EU, CEEC, ASEAN, European regions, region-specific to countries, regions grouping several continents), an at least partial tendency towards structural convergence has been highlighted everywhere, except for Fertő, I. (2016), his results of the unit root tests of the panel do not confirm the hypothesis of convergence in the agricultural structural transformation of the region of the Central and Eastern Europe.

2.2.3.3 Structural convergence through trade integration or business cycle synchronization

Lazarev V & Gregory P (2007) examine the structural transformations in Russia's transition process between 1990-2002. They use as data sectoral shares of employment, sectoral value-added, and the structure of GDP by end-use (shares of consumption, investment, government expenditure, and net exports) to calculate a series of indexes to determine the extent to which the Russian economy is converging to market economies in the process of its transformation. To determine the reference group of so-called market economies, Lazarev V & Gregory P extract from the high-income countries a group of "lower of the high" income countries - those often cited as possible targets for Russian development in the foreseeable future (Cyprus, Greece, Israel, New Zealand, Portugal, Singapore, South Korea, and Spain). To compare Russia's economic structure with this reference group, they use an index that allows them to estimate the "distance" between a particular economy (Russia) and the reference group of countries. The index of the reference group is an average of the indices of the countries that make up the group. The difference between the latter and the index of Russia gives the distance between the structure of the Russian economy and that of the reference group at a given date. The estimation of the same distance at one or more later dates allows us to see if there is a convergence of structure between Russia and the reference group. The results show that Russia has become structurally more similar to the benchmark market economies countries in the upper-middle income group and the lower tier of high-income countries. Also, the extent of labor reallocation remains inadequate and Russia’s pattern of

consumption remains distorted because of the incomplete price liberalization. The structure of the manufacturing industry still bears the strong imprint of the initial conditions of planned socialism.

Examining structural convergence from the trade integration perspective, Crespo, N. & Fontoura, M.P. (2007) analyse the transformation of the export structures of CEEC countries to see whether this transformation has led to structural convergence with other EU members. They use the Lawrence index and the KSI which they apply to export data from CEEC countries to the EU-15 over the extreme dates 1995 and 2003 so that they can see how the export structures of these countries have evolved and also whether they converge toward the structures of EU-15 countries. The results show that, in general, the CEECs have not only experienced a transformation of their export structures but have also converged both inter- and intra-sectorally towards the pre-existing members of the European Union (EU-15).

Examining structural convergence from the perspective of business cycle synchronization, Beck, K. (2013) analyzes the impact of structural similarities on business cycle synchronization. He estimates bilateral correlations and other indexes (KSI, intensity of bilateral trade, correlation of budget deficits, correlation of public debts, correlation coefficient of inflation rates) with variables such as GDP, sectoral value added, sectoral employment shares, imports, exports, budget deficits as a percentage of GDP, public debt as a percentage of GDP, and inflation rates of EU countries over the period 1990-2007. He uses the Baxter-King band pass filter to capture the high and low frequencies of the GDP series and then estimates bilateral correlations between countries, so he regresses this business cycle indicator variable on the group of other variables to identify the extent to which structural similarities determine the synchronization of business cycles in the European Union through extreme bounds analysis (EBA). His results are robust at different levels (but not all) of disaggregation, but also for value added and sectoral employment shares. The degree of convergence is a robust determinant of business cycle synchronization, with a negative point estimate. The results of Beck, K. (2013) are thus close to those of Imbs J. (2004) who concludes that specialization models have a significant effect on business cycles for a group of countries

(Australia, Austria, Belgium, Canada, Chile, Finland, France, Germany, Israel, Italy, Japan, Korea, Mexico, the Netherlands, Norway, Peru, the Philippines, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom, and the United States) over the period 1980-1990.

Thus, as presented below, in addition to structural convergence from a sectoral similarity perspective, empirical studies have also highlighted structural convergence from a trade integration and also from a business cycle synchronization perspective. We now turn to understand the impacts and/or implications of structural convergence on the trade and economic growth of the countries that are in this process.

2.2.4 Structural convergence and it implication for trade and growth: theoretical and empirical literature

According to Doyle, E. & E. O'Leary, (1999), structural transformation or structural change would largely explain structural convergence processes and also productivity convergence. In section 3.1.2, we have already empirically highlighted a sectoral structural convergence of African countries over the period 1994-2019. Thus, the structural transformation underway in Africa over this period can be assimilated to structural convergence. From a structural change perspective, it is relevant to ask how imports and exports affect the sectoral structures of countries (how do they change the allocation of factors between sectors?). An increase in imports creates competition for domestic producers of similar goods, but benefits firms that use these imports as inputs in their production process. The net effect of these imports on the allocation of factors between sectors may be difficult to discern ex ante. On the export side, their increases naturally lead to additional factors in the production of exportable goods and/or firms involved in exporting. This reallocation is likely to increase overall productivity, as various theories suggest that exporting industries or firms are more productive than those not engaged in trade (Alessandria, George, Robert Johnson, and Kei-Mu Yi; 2021). Teignier, Marc, (2018) shows that trade has played an important role in the structural transformations of several countries such as the United Kingdom and the United States

Structural changes are driven in general by changes in the composition of supply and demand (Fisher 1939, 1952; Fourastié 1949/1969; Pasinetti 1981) On the demand side, a higher per capita income as predicted in Engel's law leads to a change in the structure of demand, the "demand hypothesis". This suggests that income growth leads to structural change due to adjustments in the production process caused by changes in the demand side. So more economic growth accelerates the process of structural change. On the supply side, the term "productivity hypothesis" is often used, which emphasises the importance of technological progress in different sectors for structural change. Sectors with below-average productivity growth must use more labor, while sectors with above-average productivity growth must reduce labor. Thus, productivity growth and its consequences cause structural change (Baumol 1967; Ngai and Pissarides 2007; Krüger

2008b). The determinant role of structural change in economic growth and productivity increase has been demonstrated by Lewis (1954), Clark (1940), Kaldor (1966), Kuznets (1966), Kuznets (1979), Denison (1967), Syrquin (1988), Lin and Monga (2010) and Lin (2009), Lin (2011), Lin (2012). The continuous shift of factors of production from low productivity sectors to high productivity sectors increases aggregate productivity. Lewis (1954) uses a dualistic economics framework to show this dynamic: the shift of surplus labor from subsistence agriculture to the capitalist sector increases worker's productivity, the country's aggregate productivity, and output per capita. Structural changes in an economy drive overall economic growth due to productivity gains caused by the shift of factors of production from low to high productive sectors. In addition, the change in the composition of demand caused by the change in consumption behaviour of consumers due to higher per capita incomes also leads to a process of adjustment of supply to meet the new demand. This will involve a readjustment of the aggregate economic growth rate according to the sectoral productivity gains or losses that accompany these changes. If demand grows faster in sectors with low productivity growth, changes in sectoral structure have a negative impact on aggregate economic growth (Dietrich, A. 2011). According to Baumol (1967), these negative effects on economic growth occur in the tertiarisation process and are often referred to as Baumol's cost disease. More recent work confirms this view (Baumol, Blackman, and Wolff 1985; Nordhaus 2008).

The effect of structural change on growth has been empirically proven in numerous studies. Denison (1967: 319-322) shows, using growth decomposition methods, that the reallocation of productive inputs from agriculture to other sectors was an important factor explaining why the US outperformed the UK but lagged behind Germany in terms of GDP growth between 1950 and 1962. Using general equilibrium methods and simulation techniques, Echevarria (1997) confirms a positive relationship between changes in sectoral composition and growth. By studying OECD countries using causal methods, Kaniovski and Peneder (2002) and Dietrich (2012) prove that structural change plays an important role in economic growth. Van Ark and Timmer (2003) show that for Asian countries, the reallocation of resources from agriculture to other sectors is a powerful source of growth, while for more advanced economies, the shift of labor to service sectors such as finance has a significant effect. According to Fan et al. (2003), the

shift in the sectoral composition is critical to China's economic growth. Caselli and Coleman (2001) show that structural change is a major factor in regional convergence in the US by examining the growth dynamics of US states. Vu KM (2017) introduces a new measure of structural change, the index of effective structural change (ESC), and uses it in a dynamic model to study the effects of structural change on economic growth, using a sample of 19 Asian economies for the period 1970 to 2012. His results suggest the importance of reforms in fostering productivity-enhancing structural change and the need for strategies to overcome their short-term costs.

However, structural change does not always prove conducive to growth. For example, McMillan et al. (2014) show that, unlike Asia, the contribution of structural change to productivity growth was negative for Latin America over the period 1990-2005 and for Africa over the period 1990-2000. Authors such as De Vries, Timmer, and De Vries (2015) found a structural change process with a pattern of static gains but dynamic reallocation losses since 1990. According to Baumol (1967), labor can shift from a high-productivity, fast-growing sector to a low-productivity, stagnant sector, leading to a decline in the productivity growth rate of the overall economy. The rapid expansion of employment in low-productivity services in the US can be used as evidence by Baumol, Blackman, and Wolff (1985). Furthermore, Ngai and Pissarides (2007) introduce a model that suggests that the effect of structural change may not be reflected in aggregate growth; Meckl (2002) argues that the change in the sectoral composition may be a by-product of economic growth and may have no feedback effect on the growth process, although their approach is purely theoretical with restrictive assumptions. Adegboye and Ighodaro (2020) highlight the precarious and informal nature of service sector jobs following the movement of African labor from the agricultural sector. Fagerberg (2000) concludes that structural change does not contribute to productivity growth after studying the manufacturing industries of 39 countries from 1973 to 1990. Timmer and Szirmai (2000) reach the same conclusion for the Asian manufacturing sector.

2.3 SUMMARY

The objective of this chapter was to deal specifically with structural convergence and its implications for trade and economic growth. For this reason, the chapter is divided into two parts. The first part deals with structural transformation, which is a prerequisite

for structural convergence. We define and characterize the process of structural transformation through its theoretical underpinnings as an ongoing changes by which low-income countries, in which the primary sector (agriculture) employs most of the workforce and generates most of the value-added, become high-income countries distinguished by a relatively smaller primary sector in terms of the workforce but more efficient in terms of production and value-added. The empirical literature for developed and developing countries is then discussed with a particular focus on stylized facts from the recent literature on Africa. The theoretical survey shows that Engel's law on the declining share of food in consumption, Lewis' hypothesis on the elastic supply of labor in most developing countries, and the stages of comparative advantage help to explain the process of structural transformation, among other things. From the survey of the empirical literature, it appears that developed countries have undergone a process of structural transformation that has materialized in the shift of labor from the agricultural sector to the industrial sector and then from the industrial sector to the service sector. This process seems to be the same but less pronounced for developing countries, especially with regard to the shift of labor from the industrial to the service sector. The process of structural transformation on the African continent seems to show two different stages. The first stage, which extends from independence to the 1990s, shows a shift in labor similarly to that in developed countries, i.e. from the agricultural sector to the industrial sector. Then a second stage from the 1990s where the shift in labor was done directly from the agricultural sector to the service sector. The second part of this chapter deals with structural convergence and its implications for trade and growth. Thus, this part is divided into two subsections. The first subsection deals with the theoretical and empirical literature on structural convergence, and the second deals with the theoretical and empirical literature on the implications of structural convergence for trade and growth. In the first subsection of the second part of this chapter, we define structural convergence, which is a simultaneous process of structural transformation in several countries that results in a rapprochement or similarity between the sectoral structures of these countries as they are experiencing the phenomenon of real convergence. Then we discuss its theoretical and empirical literature. The survey of the theoretical literature shows that the three-sector hypothesis, the Chenery convergence hypothesis followed by some theoretical extensions to these hypotheses such as market forces on demand and supply,

contribute among others to explain structural convergence. The survey of the empirical literature shows that a significant part of its works concerns European countries, with some works on Asian and American countries. Depending on the variables used to highlight structural convergence, the empirical literature has pointed out structural convergence through sectoral employment, structural convergence through sectoral productivity or sectoral value-added, and structural convergence through trade integration or business cycle synchronization. In the second subsection of the second part of this chapter, which addresses the implications of structural convergence on trade and growth, we survey the theoretical and empirical literature on this issue. The survey of the theoretical literature shows that through the "demand hypothesis" and the "productivity hypothesis" there can be a two-way causality between trade (imports and exports) and structural transformation, and also between economic growth and structural transformation. The survey of the empirical literature shows that several studies have highlighted the positive impacts of structural transformation on growth. However, a number of studies, notably on Africa, nuance this result.

CHAPTER 3: STRUCTURAL CONVERGENCE, TRADE AND GROWTH IN AFRICAN COUNTRIES: ECONOMETRIC ANALYSIS

In this chapter, we use an econometric approach to examine the structural convergence of African economies through sectoral similarity and real convergence, then we analyze the implications of this structural convergence on trade and economic growth. As mentioned above, the literature on econometric studies on structural convergence of African economies is poor, so we rely on the literature on structural convergence of European and Asian economies to address the case of the African continent. Thus, the first part of this chapter deals with the structural convergence of the economies of African countries, and the second part deals with the implications of this convergence on trade and economic growth.

3.1 STRUCTURAL CONVERGENCE OF AFRICAN ECONOMIES

In absolute terms, structural convergence refers to sectoral similarity, business cycle synchronization, and foreign trade integration (Alexoaei, Robu, 2018), in this work we focus on sectoral similarity, and we also outline the issue of foreign trade integration. Thus, as we defined it in the previous chapter, structural convergence is a simultaneous process of structural transformation in several countries which results in a rapprochement or similarity between the sectoral structures of these countries as they are experiencing the phenomenon of real convergence. By sectoral similarity, we mean the similarity or rapprochement between the three main sectors of the economy between several countries through their sectoral value added and/or their sectoral employment. By real convergence, we mean the reduction of gaps between the GDP per capita of several countries[22]. Thus our conception of structural convergence is inspired by Wacziarg (2001) and Barrios, Barry, and Strobl (2002). In this section, we firstly investigate the structural transformation processes underway in African countries i.e., the shift of employment between sectors and changes in value-added by sectors, and then secondly, we investigate

[22] which is quite close to the σ-convergence or convergence defined as the reduction in the dispersion of the distribution of GDP per capita that we dealt with in the first chapter.

the structural convergence of African economies namely sectoral similarity while countries experience real convergence.

3.1.1 Structural transformation processes underway in african countries

In this section, we investigate the processes of shifts of labor and the evolution of value-added between the three main sectors of the economy. We first present the data we use and their sources, then we describe the empirical model and the method we use, and finally, we present the results we got.

3.1.1.1 Data issues

To investigate empirically the processes of shifts of labor and the evolution of value-added between the three main sectors of the economy in Africa, we use two distinct databases. The first one is extracted from the World Bank's World Development Indicators (WDI)[23] database and the second one is extracted from the Groningen Growth and Development Center (GGDC) 10-Sector Database[24], which provides employment and value-added statistics for 42 countries broken down into 10 sectors[25], including 13 African countries. The database covers a broad period from 1960 to around 2012. We also use the GGDC PWT version 9.1 database[26], which provides information on relative income, output, and productivity levels, covering 182 countries between 1950 and 2017. The first database, which is extracted from the WDI, includes 48 African countries over the period 1994-2019, while the second, which is extracted from the GGDC 10-Sector, includes 13 African countries over the period 1960-2012. Each of our databases includes data on value added by sector, employment by sector, population, GDP, Gross National Incom (GNI), and gross savings.

[23] https://databank.worldbank.org/reports.aspx?source=world-development-indicators
[24] https://www.rug.nl/ggdc/productivity/10-sector/
[25] Agriculture, hunting, forestry and fishing ; Mining and quarrying; Manufacturing ; Electricity, gas and water supply; Construction; Wholesale and retail trade, hotels and restaurants; Transport, storage, and communication; Finance, insurance, real estate and business services; Government services; Community, social and personal services
[26] https://www.rug.nl/ggdc/productivity/pwt/

3.1.1.2 Empirical models descriptions

Inspired by Duarte and Restuccia (2010), Albu (2012) and Herrendorf, Rogerson, and Valentinyi (2014) we construct a simple model to show the evolution of sectoral shares of employment and value-added as a function of the evolution of GDP per capita. This model will give us an idea of the trends and magnitude of the structural transformations taking place within African countries. As mentioned earlier, a simultaneous structural transformation between countries is an indication of possible structural convergence.

This models are presented as follows:

$$shareVA\ AG_{it} = \alpha_0 + \alpha_1 GDPCAP_{it} + \varepsilon_{it} \quad (3\text{-}1)$$

$$shareVA\ IND_{it} = \alpha_0 + \alpha_0 GDPCAP_{it} + \varepsilon_{it} \quad (3\text{-}2)$$

$$shareVA\ SERV_{it} = \alpha_0 + \alpha_1 GDPCAP_{it} + \varepsilon_{it} \quad (3\text{-}3)$$

$$shareEMP\ AG_{it} = \alpha_0 + \alpha_1 GDPCAP_{it} + \varepsilon_{it} \quad (3\text{-}4)$$

$$shareEMP\ IND_{it} = \alpha_0 + \alpha_1 GDPCAP_{it} + \varepsilon_{it} \quad (3\text{-}5)$$

$$shareEMP\ SERV_{it} = \alpha_0 + \alpha_1 GDPCAP_{it} + \varepsilon_{it} \quad (3\text{-}6)$$

Where VA stands for value-added, EMP stands for employment, AG refers to the agricultural sector, IND refers to the industrial sector and SERV refers to the service sector. So $shareVA\ AG_{it}$ refers to the share of value-added in the agricultural sector in the country i at the year t, $shareVA\ IND_{it}$ is the share of value-added in the industrial sector in the country i at year t, $shareVA\ SERV_{it}$ is the share of value-added in the service sector in the country i at year t, $shareEMP\ AG_{it}$ is the share of employment in the agricultural sector in the country i at the year t, $shareEMP\ IND_{it}$ is the share of employment in the industrial sector in the country i at the year t, $shareEMP\ SERV_{it}$ is the share of employment in the in the service sector in the country i at the year t, $GDPCAP_{it}$ is the log of GDP per capita in the country I at the year t and ε_{it} is the usual error term.

Equations (3-1) to (3-6) allow us to see trends and magnitude of the structural transformations taking place within African countries in terms of sectoral value-added and in terms of sectoral employment as a function of GDP per capita. Previous empirical studies on Africa and on other regions Duarte and Restuccia (2010), Albu (2012) and Herrendorf, Rogerson, and Valentinyi (2014) tell us that the agricultural sector is in perpetual decline, while the service sector is in perpetual rise. The industrial sector has an inverted U-shape, i.e. it grows to a certain level of GDP per capita and then declines. Given the low level of industrialization and GDP per capita in Africa, the inverted U-shape for the industrial sector has not yet been observed by previous studies Duarte and Restuccia (2010). Thus, the expected signs of the coefficients of the independent variable GDPCAP in equations (3-1) and (3-4) will be negative while they will be positive in equations (3-2), (3-3), (3-5) and (3-6).

The agricultural, industrial, and service sectors we use are based on the International Standard Industrial Classification (ISIC) developed by the United Nations Statistics Division (UNSD). Thus the agricultural sector includes the activities of agriculture, forestry, and fishing, the industrial sector includes the activities of mining, manufacturing, utilities, and construction, the service sector includes the activities of trade, restaurants and hotels, transportation, storage and communication, finance, insurance, real estate and business, government services, community services, and social and personal services.

3.1.1.3 Results and analysis on the structural transformation processes

In this section, we first present the descriptive statistics and then present, discuss and comment on the results of our estimations of the shares of employment and value-added as a function of GDP per capita and over time.

- ***Descriptive statistics***

In this section we address equations (3-1) to (3-6) to investigate the trends and magnitude of structural transformations taking place within African countries. Tables 2 and 3 summarize the basic statistics for the annual frequency data used in this section to

see trends and magnitudes of structural transformations (inter-sectoral labor movement and sectoral value-added distribution) taking place in African countries. It can be noted that the WDI database sample has a larger number of available observations (1,248), while the GGDC database sample has only about half (689). This is due to the fact that the WDI database sample includes almost all African countries 48 while the GGDC database sample has only 13 countries, the gap between these observations is only doubled because the GGDC sample covers the period 1960-2012 while the WDI database sample covers the period 1994-2019.

Table 2: Descriptive statistics WDI DATABASE

Variable	Obs	Mean	Std. Dev.	Min	Max
sharvaag	1197	27.685	17.674	0	91.791
sharvaind	1193	33.155	20.29	0	96.208
sharvaserv	993	47.339	12.264	11.198	100
sharEmplag	1248	49.683	21.752	4.6	92.37
sharEmplind	1248	13.77	7.844	1.86	39.83
sharEmplserv	1248	36.549	15.383	5.36	72.41
lngdpcap	1235	6.862	1.053	4.631	10.041

Source: Author's calculations

Table 3: Descriptive statistics GGDC data base

Variable	Obs	Mean	Std. Dev.	Min	Max
sharAgricVA	689	25.785	17.006	0	81.052
sharIndustVA	689	28.082	13.126	0	68.248
sharServVA	689	42.65	14.145	0	67.205
sharEmpag	630	57.986	22.876	7.018	96.189
sharEmpind	630	13.884	9.993	1.405	43.198
sharEmpserv	630	28.13	14.227	2.335	63.124
lngdpcap	689	7.858	.873	6.059	9.827

Source: Author's calculations

Tables 4 and 5 and figures 17 and 18 show, respectively, the correlation matrices and the correlation matrix graphs of the 7 variables of our equations. Thus, we observe in both our samples (WDI database and GGDC database) negative and statistically significant correlations between (sharEmpag and lngdpcap), (sharAgricVA and lngdpcap) and positive and statistically significant correlations between lngdpcap and other variables. This suggests that the agricultural sectoral shares of employment and value-added are in continuous decline, while the industrial and services sectoral shares are in continuous growth in both our samples.

Table 4: Matrix pairwise correlations WDI DATABASE

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) sharEmplag	1.000						
(2) sharEmplind	-0.873***	1.000					
(3) sharEmplserv	-0.969***	0.725***	1.000				
(4) sharvaag	0.555***	-0.473***	-0.544***	1.000			
(5) sharvaind	-0.452***	0.438***	0.416***	-0.401***	1.000		
(6) sharvaserv	-0.379***	0.273***	0.396***	-0.572***	-0.235***	1.000	
(7) lngdpcap	-0.795***	0.667***	0.784***	-0.648***	0.564***	0.333***	1.000

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations

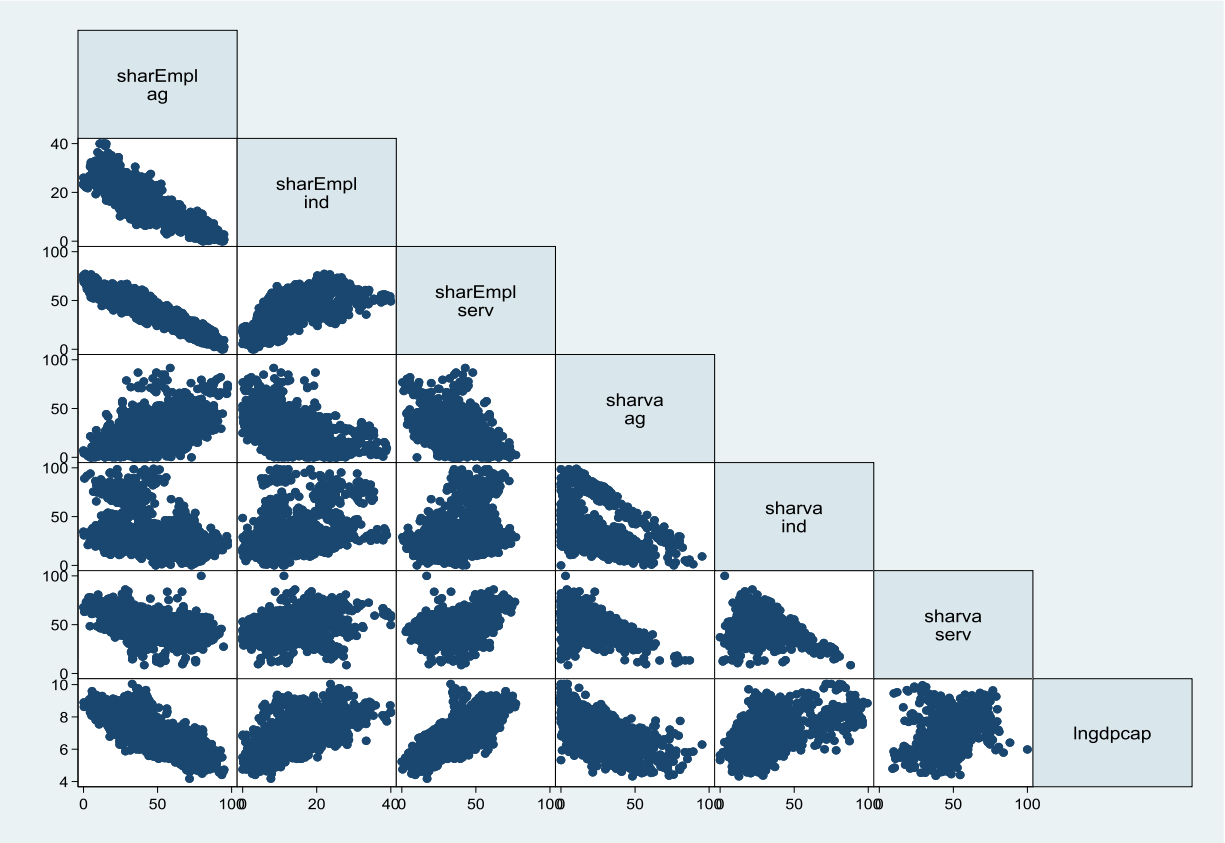
Table 5: Matrix pairwise correlations GGDC data base

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) sharEmpag	1.000						
(2) sharEmpind	-0.920***	1.000					
(3) sharEmpserv	-0.962***	0.778***	1.000				
(4) sharAgricVA	0.643***	-0.594***	-0.616***	1.000			
(5) sharIndustVA	-0.477***	0.347***	0.523***	-0.498***	1.000		
(6) sharServVA	-0.393***	0.422***	0.336***	-0.366***	0.198***	1.000	
(7) lngdpcap	-0.837***	0.794***	0.788***	-0.676***	0.457***	0.363***	1.000

*** p<0.01, ** p<0.05, * p<0.1

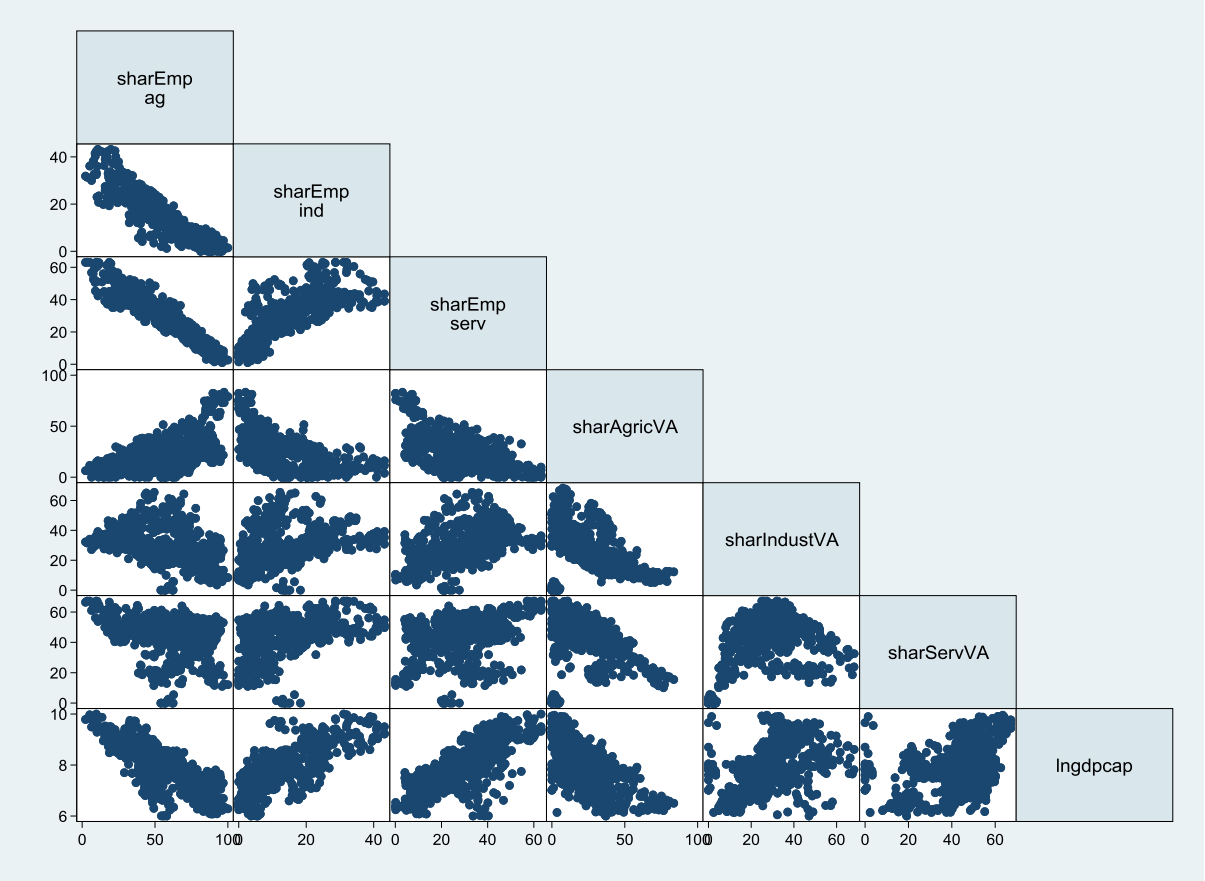
Source: Author's calculations

Figure 17: Graphe matrix WDI DATABASE



Source: Author's elaboration

Figure 18: Graphe matrix GGDC data base



Source: Author's elaboration

- ***Employment and value-added shares as a function of GDP per capita and over time: regressions and graphs***

In this section we present the results of the regressions of the employment and value added shares on the log of GDP per capita from the equations (3-1) to (3-6). Table 6 presents these results for the WDI database, while Table 7 presents those for the GGDC database. Firstly, we present the results and analyses relating to employment data, secondly, those relating to value-added, and thirdly we analise the share of value-added and employment over time.

- ✓ ***Results and analyses relating to employment data***

For the GGDC database, we observed that the employment shares in the agricultural sector are negatively and significantly associated with GDP per capita. Thus, a 1% increase in the log of GDP per capita is associated with a decrease of more than 21 points in the share of employment in the agricultural sector, while the same 1% increase in the log of GDP per capita is significantly associated with more than 9 points increase in the share of employment in the industrial sector and also significantly associated with more than 12 points increase in the share of employment in the services sector (table 7 columns 1, 2 and 3). The trend in the WDI database is the same as in the GGDC database but less pronounced. In WDI database (table 6) a 1% increase in the log of GDP per capita is associated with a decrease of more than 16 points in the share of employment in the agricultural sector, while the same 1% increase in the log of GDP per capita is significantly associated with almost 5 points increase in the share of employment in the industrial sector and also significantly associated with more than 11 points increase in the share of employment in the services sector (table 6 columns 1, 2 and 3).

Table 6: linear regession estimates WDI database, equation (3-1) to (3-6).

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	sharEmplag	sharEmplind	sharEmplserv	sharvaag	sharvaind	sharvaserv
lngdpcap	-16.48***	4.986***	11.50***	-10.79***	10.78***	3.938***
	(0.358)	(0.159)	(0.259)	(0.367)	(0.457)	(0.354)
Constant	162.9***	-20.46***	-42.39***	101.7***	-40.80***	20.69***
	(2.486)	(1.102)	(1.799)	(2.549)	(3.173)	(2.425)
Observations	1,235	1,235	1,235	1,197	1,193	993
R-squared	0.632	0.445	0.615	0.419	0.318	0.111

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's estimations.

Table 7:linear regession estimates GGDC database, equation (3-1) to (3-6).

VARIABLES	(1) sharEmpag	(2) sharEmpind	(3) sharEmpserv	(4) sharAgricVA	(5) sharIndustVA	(6) sharServVA
lngdpcap	-21.82***	9.041***	12.78***	-13.18***	6.874***	5.880***
	(0.569)	(0.276)	(0.398)	(0.548)	(0.510)	(0.576)
Constant	229.5***	-57.19***	-72.34***	129.3***	-25.94***	-3.556
	(4.505)	(2.186)	(3.150)	(4.329)	(4.035)	(4.555)
Observations	630	630	630	689	689	689
R-squared	0.700	0.630	0.621	0.457	0.209	0.132

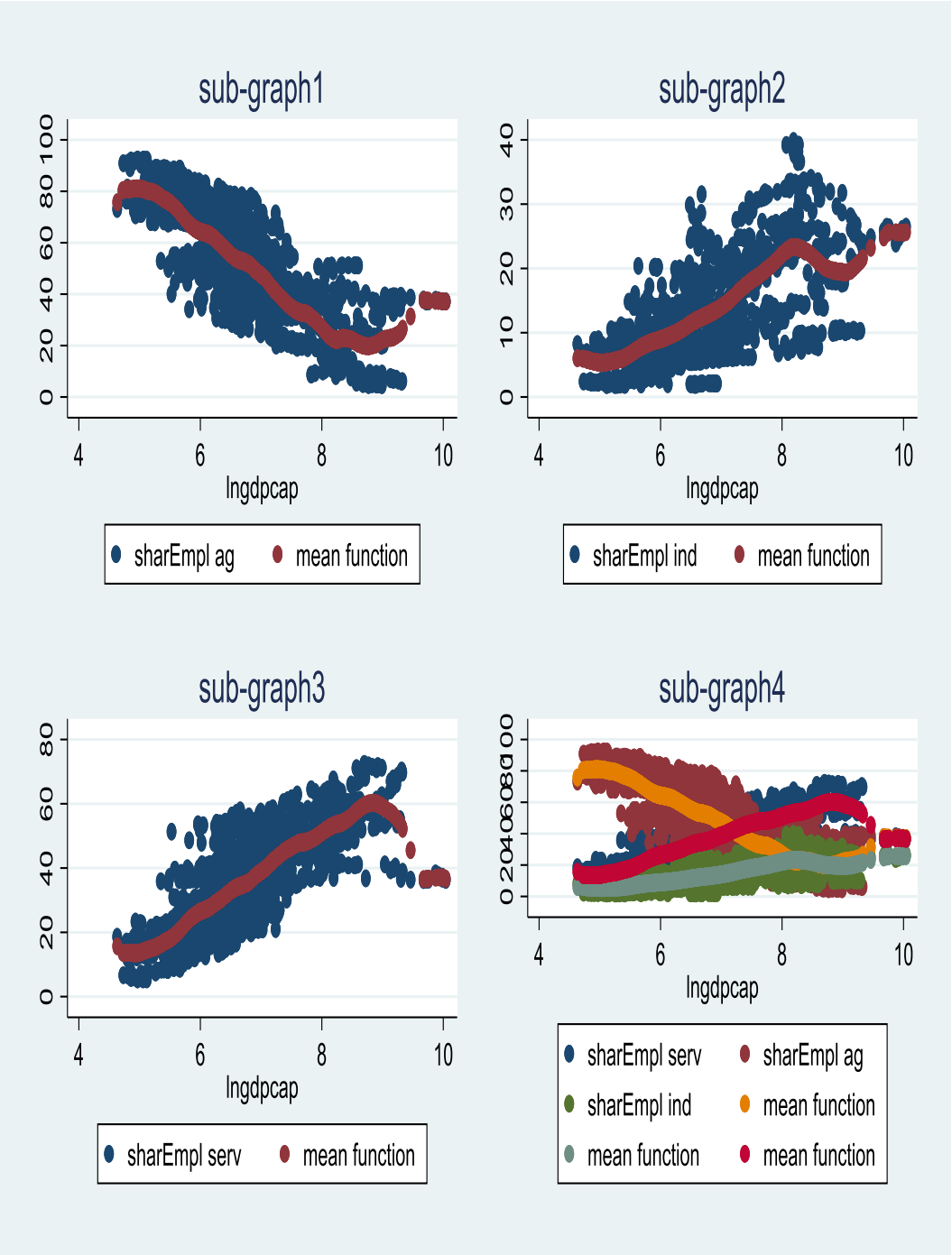
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations

This trend shows a shift in labor from the agricultural sector to the other two sectors of the economy. This finding is typically characteristic of a structural transformation process, and that result is almost identical to those of previous authors Duarte and Restuccia (2010), Albu (2012), Herrendorf, Rogerson, and Valentinyi (2014) and McMillan, & Kenneth Harttgen (2014). According to Albu (2012) this simulation model, which we represent schematically in figures 19 and 20, seems to show a general process of structural convergence in Africa, because while the GDP per capita of African countries is increasing, the sectoral shares of employment in the three sectors on the continent and in the two databases follow a similar trend. For the WDI database figure 19 (sub-graph4) we can see the trend of employment shares in the three sectors, i.e. an important and continuous decrease of employment shares in the agricultural sector, an almost similar increase of employment shares in the service sector and a less pronounced increase of employment shares in the industrial sector. For figure 20 of the GGDC database (sub-graph4) we can also see the evolution of the employment shares in the three sectors, we notice the same trends as in the WDI database except that the gap between the employment shares of the services sector and the employment shares of the industrial sector is smaller, according to tables 6 and 7, this gap is almost 7 points for the WDI

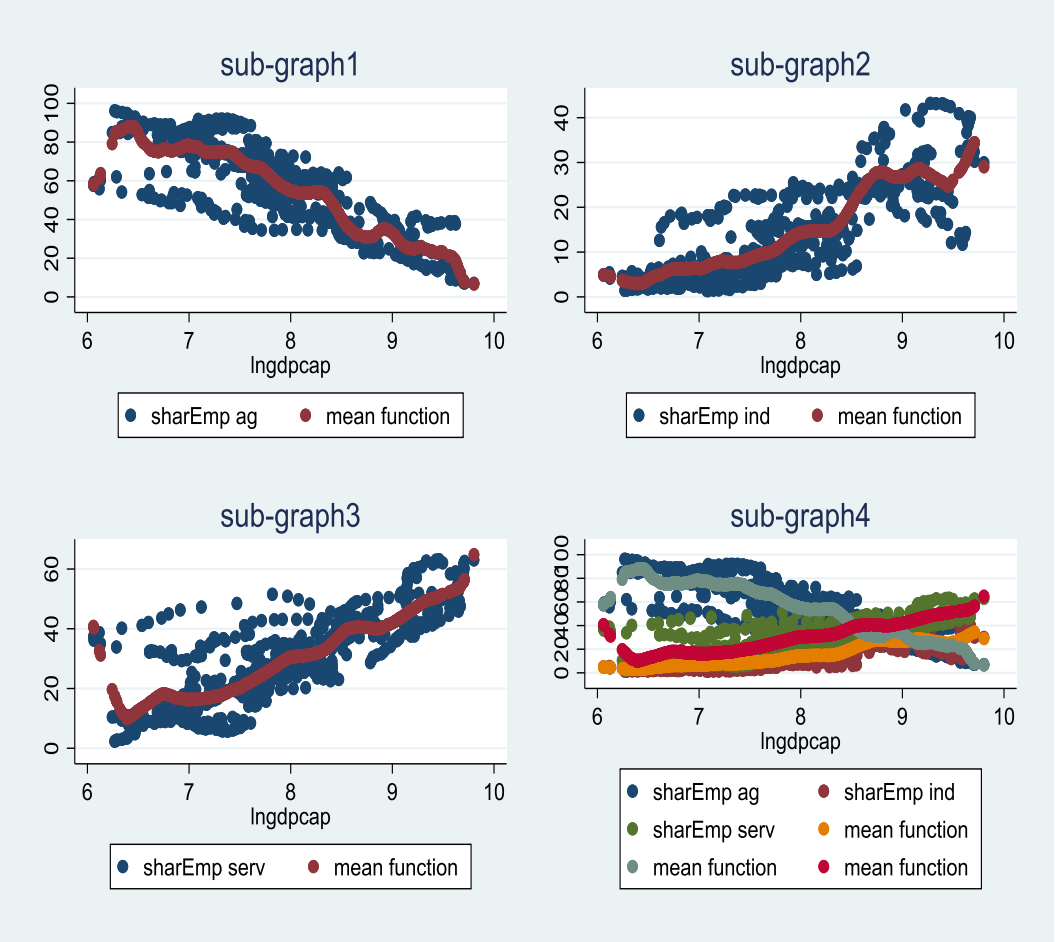
database while it is only a little more than 3 points for the GGDC database. This could be explained by the time periods over which the two databases cover. Indeed, the GGDC database starts in 1960, at that time a large part of the African countries acceded to their independence and tried to create industries to allow the development of their countries, thus the movements of employment on this period was from the agricultural sector towards the two other sectors, But from the years 1994, date of the beginning of the WDI database, the movements of employment is mainly from the agricultural sector towards the service sector because the industrial sector only developed slightly. Another fact that we can note is that unlike the results of authors such as Duarte and Restuccia (2010), Albu (2012) and Herrendorf, Rogerson, and Valentinyi (2014) for non-African countries, our results on figure 19 and 20 do not show the inverted "U" shape for the industrial sector that is synonymous with deindustrialization or the shift of employment from the industrial to the service sector. This is due to the fact that the GDP per capita of each of these African countries is still below the threshold at which the rate of change of the share of industry employment goes from positive to negative (Or we can say, they are under-industrialized, so they cannot experience deindustrialization).

Figure 19: share of the 3 sectors in total employement in % and log of GDP/cap WDI data base



Source: Author's elaboration

Figure 20: share of the 3 sectors in total employement in % and log of GDP/cap GGDC data base



Source: Author's elaboration

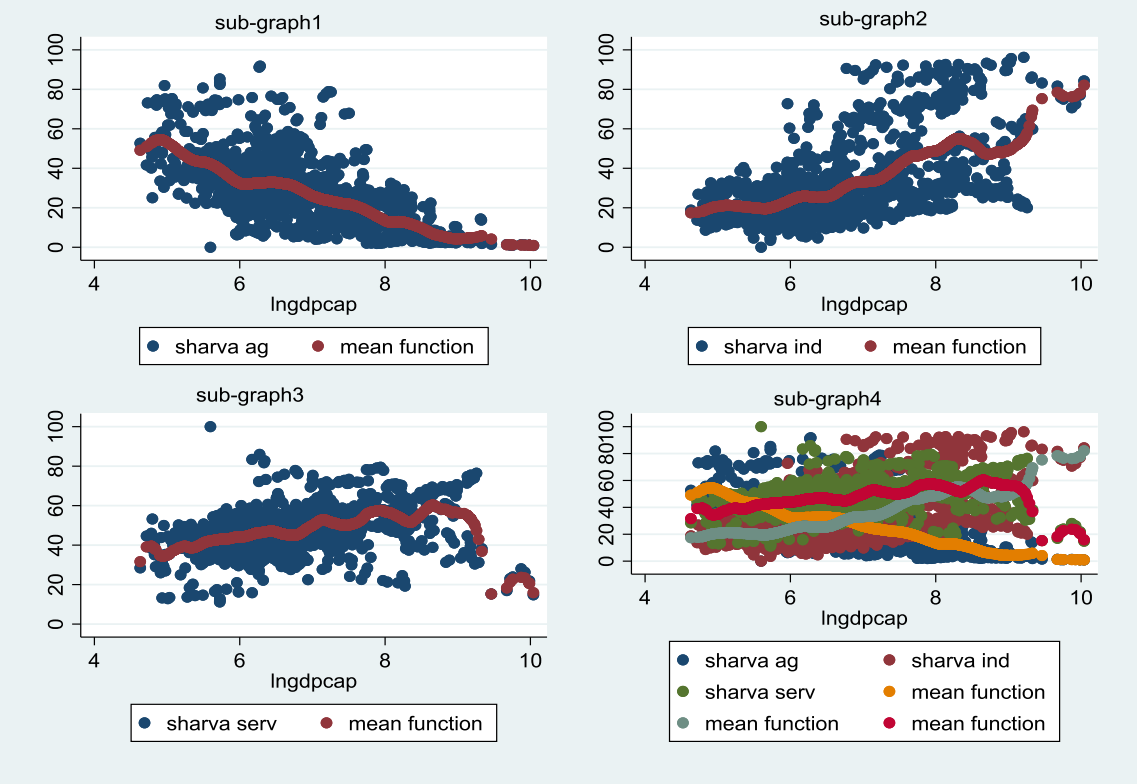
✓ **Results and analyses relating to value-added data**

For the GGDC database (table 7), we observed that the value-added shares in the agricultural sector are negatively and significantly associated with the log of GDP per capita. Thus, a 1% increase in the log of GDP per capita is associated with a decrease of more than 13 points in the share of value-added in the agricultural sector, while the same 1% increase in the log of GDP per capita is significantly associated with more than 6 points increase in the share of value-added in the industrial sector and also significantly associated with more than 5 points increase in the share of value-added in the services

sector (table 7 columns 4, 5 and 6). The trend in the WDI database is the same as in the GGDC database but less pronounced, except for the industrial sector which is more pronounced. In WDI database (table 6) a 1% increase in the log of GDP per capita is associated with a decrease of more than 10 points in the share of value-added in the agricultural sector, while the same 1% increase in the log of GDP per capita is significantly associated with also more than 10 points increase in the share of value-added in the industrial sector and also significantly associated with more than 3 points increase in the share of value-added in the services sector (table 6 columns 4, 5 and 6). These trends show significant variations in the shares of sectoral value-added. Thus, the sharp decline in the value-added shares of the agricultural sector is mainly explained by the decline in employment in this sector, other factors such as climate change, the reduction of arable land due to heavy urbanization, or the use of new techniques can explain the variations in the value-added of this sector in Africa, but the trend is clearly downwards. This result is typically characteristic of a structural transformation process, where sectoral productivity shares evolve in proportion to sectoral employment shares and other factors of production. It is noteworthy for the WDI database that although the employment shares of the service sector are increasingly above the employment shares of the industrial sector (see figure 19), the value-added share of the industrial sector is catching up with and exceeding that of the service sector (see figure 21), which proves that a large part of the labor force leaving the agricultural sector is joining the traditional service sector which does not require a high level of education and which has a very low value-added (security services, cleaning, parcel deliveries, dry cleaning...). For the GGDC database, while the employment shares of the service sector are gradually moving up away from those of the industrial sector (see Figure 20), the gap between the value-added shares of the service sector and those of the industrial sector is narrowing (see Figure 22). As explained earlier, the service sector in Africa is very low value-added, whereas the industrial sector is mostly integrated by a slightly more qualified workforce. Unlike the results of authors such as Duarte and Restuccia (2010), Albu (2012), and Herrendorf, Rogerson, and Valentinyi (2014) for non-African countries and as with the employment data, the value-added data for the industrial sector in both databases does not show the inverted "U" shape for the industrial sector that is synonymous with deindustrialization or shift of employment from the industrial to the service sector. This is because the GDP per capita

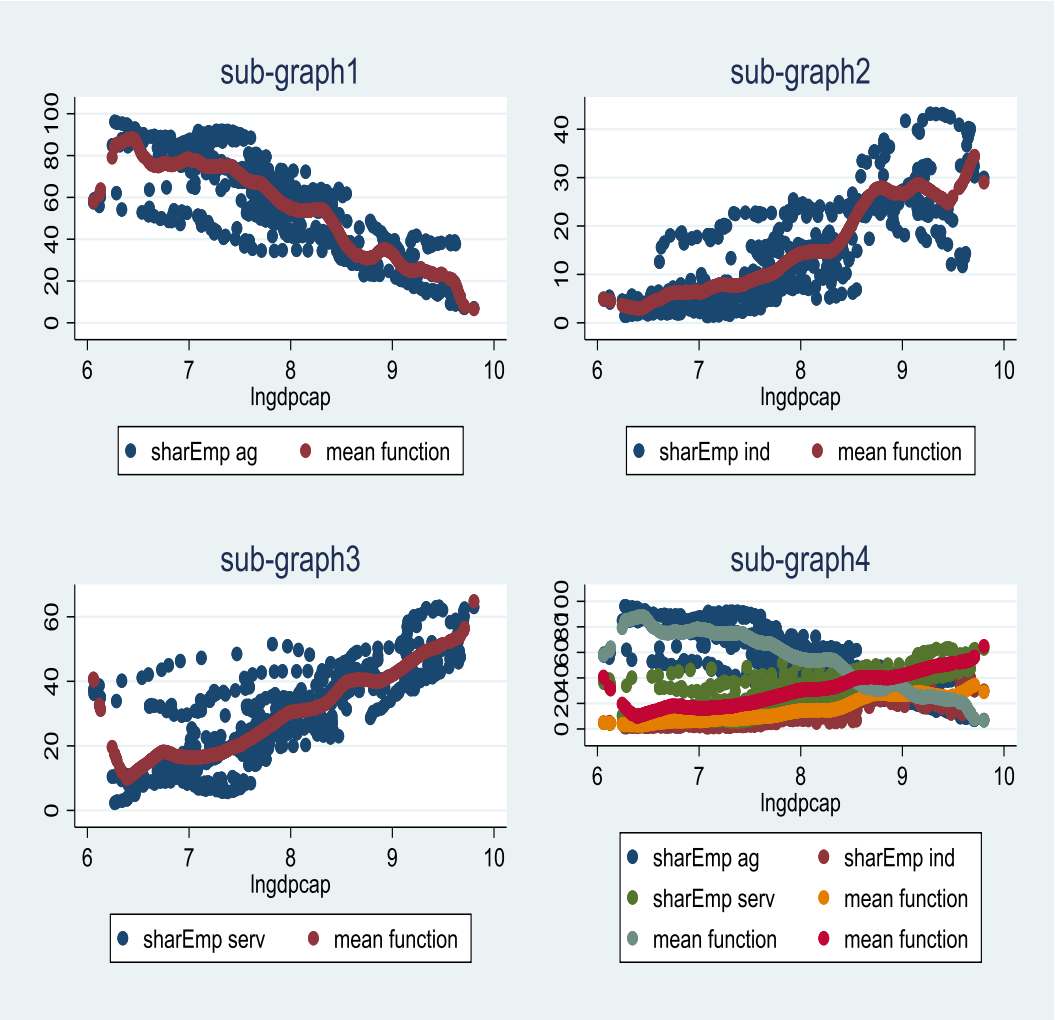
of each of these African countries is still below the threshold at which the rate of change in the share of industrial employment goes from positive to negative (or we can say that they are under-industrialized, and therefore cannot experience deindustrialization).

Figure 21: share of the 3 sectors in total value-added in % and log of GDP/cap WDI database



Source: Author's elaboration

Figure 22: share of the 3 sectors in total value-added in % and log of GDP/cap GGDC database



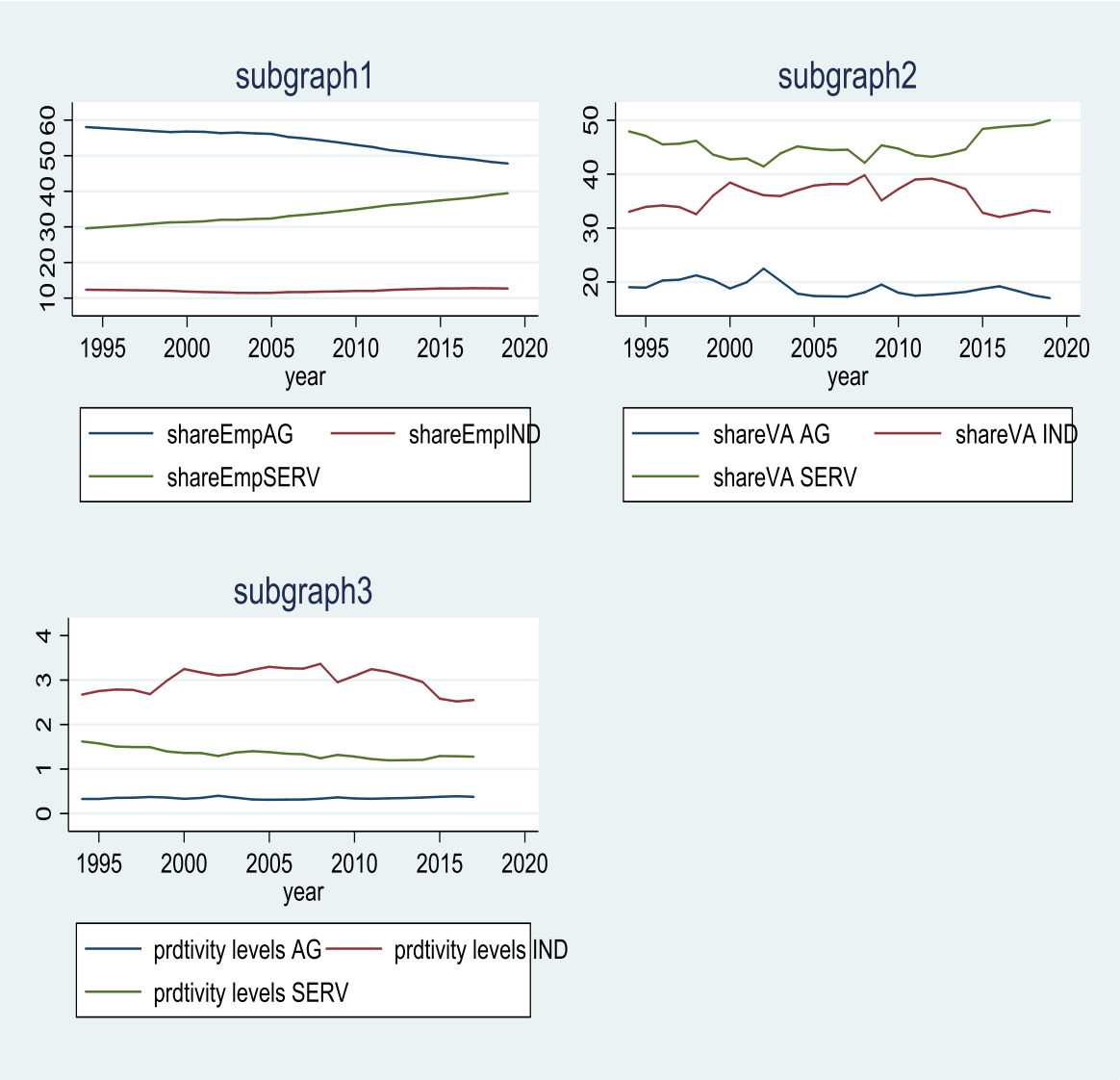
Source: Author's elaboration

✓ **Sectoral shares of value-added and employment over time**

Inspired by De Vries, Timmer, and De Vries (2015) we analyze the time variation of sectoral shares of value-added, employment, and relative productivity levels using the WDI database. To estimate the relative productivity level, we first calculate the sectoral productivity level, i.e. the value-added of the sector divided by the population engaged in that sector, then we calculate the productivity of the whole economy, i.e. the value-added of the whole economy divided by the total population engaged in the whole

economy, the relative productivity level is calculated as the ratio of the productivity level of the sector to the productivity level of the whole economy. This index allows us to see what the productivity level of each sector represents in relation to that of the entire economy. Thus, according to Table 8, in 1994 the average productivity level in agriculture was 0.32 times that of the total economy, while in the industry it was 2.6 times that of the total economy, and in the services sector, it was 1.6 times that of the total economy. Thus, the average productivity in the industrial sector in Africa over the entire period of our study is higher than that of the service sector and itself far higher than that of the agricultural sector. This is due to the fact that agricultural production is still done in the traditional way in many African countries and is also subject to climatic uncertainties, which makes its relative productivity very low. The relative productivity of the services sector is higher than that of agriculture over the whole period (see figure 23 sub-graph 3), the diversity of activities in this sector and their permanent nature (unlike agriculture which is only carried out over three months, particularly in the Sahelian countries) means that the relative productivity is far better than that of agriculture. The industrial sector has the best relative productivity of all three sectors (see Figure 23 sub-graph 3), as the labor force is better qualified and has access to better physical capital. As mentioned earlier, most of the labor entering the service sector comes from the agricultural sector, which is generally uneducated and usually engages in traditional service sector activities (security services, cleaning, parcel deliveries, dry cleaning, etc.). This observation between the relative productivity of the three sectors is also visible through table 8, at the beginning of the period 1994, the share of value-added of the industrial sector is 33.02% while its share of employment is only 12.36%. For the same date, the share of value-added of the agricultural sector is only 19.04% despite an employment share of 58.06%, while the service sector produces 47.94% of the value-added with an employment share of 29.59%. At the end of the period, i.e. 2019, the agricultural sector produces 17% of the total value-added with 47.82% of the employment share, and the industrial and service sectors produce 33 and 50% of the value-added with 12.71 and 39.47% of the employment share, respectively.

Figure 23: Sectoral value-added, sectoral employment, and relative productivity levels



Source: Author's elaboration

Figure 23 subgraph 1 shows that over the whole period the employment shares of the industrial sector are the lowest and have remained constant at around 12%, whereas the movements are from the agricultural sector, which is always in the lead, to the services sector, hence a kind of symmetry between the two curves. In terms of value-added in Figure 23 subgraph 2, we see almost the same symmetry between the service and industrial sectors, while the agricultural sector shows a slight decrease due to the movement of jobs to the service sector.

In terms of relative productivity in Figure 23 subgraph 3, we see a spike for the industrial sector around 2005 followed by a continuous downward trend until the end of the period. This downward trend appears to be structural, given the length of time it spans (almost 20 years). This decline can be explained on the one hand by the multiple crises that Africa has been facing for more than two decades (political crises, wars, rebellions, terrorism, etc.) and also by the effects of exogenous shocks due to economic liberalization, which became stronger in 2000 and which put Africa's weak industries in competition with those of European or Asian countries that have more human and physical capital. These two facts mainly explain the decline in the value-added and relative productivity of the industrial sector since 2005 (Figure 23 subgraphs 2 and 3). Despite this decline, according to McMillan and Zeufack (2021) the African industrial sector is becoming more capital-intensive, labor productivity growth appears to be healthy in large manufacturing firms, but employment growth in these firms has been disappointing.

Table 8: Sectoral value-added, sectoral employment, and relative productivity levels

	Value-added			Employment			Relative productivity level		
	1994	2007	2019	1994	2007	2019	1994	2007	2017
Agriculture	19,04	17,3	17	58,06	54,85	47,82	0,328	0,315	0,376
Industriy	33,02	38,2	33	12,36	11,71	12,71	2,672	3,257	2,553
service	47,94	44,5	50	29,59	33,43	39,47	1,62	1,332	1,278
Total economy	100	100	100	100	100	100	1	1	1

Source: Author's elaboration

3.1.2 Structural convergence of african economies

In this section, we investigate the processes of structural convergence in Africa. We first present the data we use and their sources, then we describe the empirical models

and the method we use, and finally, we present and analyze the results we got from our estimations.

3.1.2.1 Data issues

To investigate empirically the processes of structural convergece in Africa, we use two distinct databases. The first and the main one is extracted from the World Bank's World Development Indicators (WDI)[27] database. The second one, which allows us to control and/or confirm the results is extracted from the Groningen Growth and Development Center (GGDC) 10-Sector Database[28], which provides employment and value-added statistics for 42 countries broken down into 10 sectors[29], including 13 African countries. The database covers a broad period from 1960 to around 2012. We also use the GGDC PWT version 9.1 database[30], which provides information on relative income, output, and productivity levels, covering 182 countries between 1950 and 2017. The first database, which is extracted from the WDI, includes 48 African countries over the period 1994-2019, while the second, which is extracted from the GGDC 10-Sector, includes 13 African countries over the period 1960-2012. Each of our databases includes data on value added by sector, employment by sector, population, GDP, Gross National Incom (GNI), and gross savings. It should be noted that for the WDI database we have N=48 countries and T=26 years so N>T and for the GGDC database N=13 countries and T= 52 years so N<T.

3.1.2.2 Empirical models descritions

Inspired by Wacziarg, R. (2001) and Barrios, Barry, and Strobl (2002) we build an elaborate model that relates the sectoral structure to the income gap to investigate whether the reduction in the income gap is associated with greater sectoral similarity.

[27] https://databank.worldbank.org/reports.aspx?source=world-development-indicators
[28] https://www.rug.nl/ggdc/productivity/10-sector/
[29] Agriculture, hunting, forestry and fishing ; Mining and quarrying; Manufacturing ; Electricity, gas and water supply; Construction; Wholesale and retail trade, hotels and restaurants; Transport, storage, and communication; Finance, insurance, real estate and business services; Government services; Community, social and personal services
[30] https://www.rug.nl/ggdc/productivity/pwt/

This model is presented as follows:

$$\text{ksiVA AG}_{ij}(t) = \alpha_0 + \alpha_1 \text{INCOMDIFF}_{ij}(t) + \alpha_2 \text{POPDIFF}_{ij}(t) + \alpha(t) + \varepsilon_{ij}(t) \quad (3\text{-}7)$$

$$\text{ksiVA IND}_{ij}(t) = \alpha_0 + \alpha_1 \text{INCOMDIFF}_{ij}(t) + \alpha_2 \text{POPDIFF}_{ij}(t) + \alpha(t) + \varepsilon_{ij}(t) \quad (3\text{-}8)$$

$$\text{ksiVA SERV}_{ij}(t) = \alpha_0 + \alpha_1 \text{INCOMDIFF}_{ij}(t) + \alpha_2 \text{POPDIFF}_{ij}(t) + \alpha(t) + \varepsilon_{ij}(t) \quad (3\text{-}9)$$

$$\text{ksiEMP AG}_{ij}(t) = \alpha_0 + \alpha_1 \text{INCOMDIFF}_{ij}(t) + \alpha_2 \text{POPDIFF}_{ij}(t) + \alpha(t) + \varepsilon_{ij}(t) \quad (3\text{-}10)$$

$$\text{ksiEMP IND}_{ij}(t) = \alpha_0 + \alpha_1 \text{INCOMDIFF}_{ij}(t) + \alpha_2 \text{POPDIFF}_{ij}(t) + \alpha(t) + \varepsilon_{ij}(t) \quad (3\text{-}11)$$

$$\text{ksiEMP SERV}_{ij}(t) = \alpha_0 + \alpha_1 \text{INCOMDIFF}_{ij}(t) + \alpha_2 \text{POPDIFF}_{ij}(t) + \alpha(t) + \varepsilon_{ij}(t) \quad (3\text{-}12)$$

Were $\text{ksiVA AG}_{ij}(t)$ refers to the Krugman Specialization Index Krugman (1991a) computed with value-added data from the agricultural sector between countries i and j at year t, $\text{ksiVA IND}_{ij}(t)$ is the Krugman Specialization Index computed with value-added data from the industrial sector between countries i and j at year t, $\text{ksiVA SERV}_{ij}(t)$ is the Krugman Specialization Index computed with value-added data from the service sector between countries i and j at year t, $\text{ksiEMP AG}_{ij}(t)$ is the Krugman Specialization Index computed with employment data from the agricultural sector between countries i and j at year t, $\text{ksiEMP IND}_{ij}(t)$ is the Krugman Specialization Index computed with employment data from the industrial sector between countries i and j at year t and $\text{ksiEMP SERV}_{ij}(t)$ is the Krugman Specialization Index computed with employment data from the service sector between countries i and j at year t. To compute the $\text{ksiVA AG}_{ij}(t)$, between countries i and j at date t, we first evaluate the share of the value-added in the agricultural sector in the total value-added produced in the country i at date t which we note $shareVA\ AG_i(t)$. We then evaluate the share of the agricultural sector value-added in the African region (country j), i.e. all the other African countries in our database except country i at year t. We note this value as $shareVA\ AG_j(t)$. The $\text{ksiVA AG}_{ij}(t)$ will be equal to the absolute value of the difference between $shareVA\ AG_i(t)$ and $shareVA\ AG_j(t)$.

$$\text{ksiVA AG}_{ij}(t)=\left|shareVA\ AG_i(t) - shareVA\ AG_j(t)\right|$$

$\text{ksiVA IND}_{ij}(t)$ and $\text{ksiVA SERV}_{ij}(t)$ are computed in the same way as $\text{ksiVA AG}_{ij}(t)$ with respectively value-added data from industrial sector and service sector. The ksi in equations (3-10), (3-11), and (3-12) are also computed in the same way as the previous ksi but with sectoral employment data. The ksi takes a value of zero if country i has a perfectly identical sectoral structure to the rest of Africa, and a maximum value of 2 if it has no sectoral similarity with the rest of Africa.

$\text{INCOMDIFF}_{ij}(t)$ is the absolute value of the difference in GDP per capita between countries i and j at date t.

$$\text{INCOMDIFF}_{ij}(t) = \left|\text{GDPpercapita}_i(t) - \text{GDPpercapita}_j(t)\right|$$

$\text{POPDIFF}_{ij}(t)$ is the absolute value of the difference in market size measured by population between countries i and j at date t.

$$\text{POPDIFF}_{ij}(t) = \left|POP_i(t) - POP_j(t)\right|$$

$\alpha(t)$ is a year-specific effect materialized by a set of time dummies, and $\varepsilon_{ij}(t)$ is the usual error term. Since our dependent variable ksi is bound between 0 and 2, we estimate our equations in logarithmic form, the index i represents a particular African country in our database, and the index j represents the group of other African countries that includes all other countries in our database except country i as in Midelfart-Knarvik et al. (2000) or Longhi et al. (2004) or Palan and Schmiedeberg (2010) for compuiting KSI.

The agricultural, industrial, and service sectors we use are based on the International Standard Industrial Classification (ISIC) developed by the United Nations Statistics Division (UNSD). Thus the agricultural sector includes the activities of agriculture, forestry, and fishing, the industrial sector includes the activities of mining, manufacturing, utilities, and construction, the service sector includes the activities of trade, restaurants and hotels, transportation, storage and communication, finance,

insurance, real estate and business, government services, community services, and social and personal services.

Equations (3-7) to (3-12) allow us to relate income convergence to sectoral similarity, if income convergence or reduction in income gaps is associated with a reduction in gaps between sectoral structures then we are in a situation of structural convergence so the coefficient α_1 associated to the independent variable INCOMDIFF will then have a positive and significant sign. If the coefficient α_1 is negative, then we are in a situation of structural divergence where the reduction in income gaps is associated with greater sectoral heterogeneity. The second independent variable POPDIFF is a kind of control variable that allows us to see the effects of the reduction in domestic market size gaps, thus a positive sign of the coefficient α_2 of this variable implies that the reduction in domestic market size gaps is associated with more sectoral similarity and a negative sign of this coefficient implies that the reduction in domestic market size gaps is associated with more sectoral heterogeneity. Thus, our model will be applied to the three sectors of the economy (agricultural, industrial and service) with data on value added and employment.

As mentioned above, "*two countries are said to structurally converge if convergence in their per capita incomes is accompanied by convergence in their sectoral structure*" (Wacziarg, R. 2001). Convergence of per capita income occurs if the difference or ratio of per capita income between the richest to the poorest country in each pair decreases. In our case, each pair consists of one of the 48 African countries in our database (represented by index i), and another country that represents all other African countries (represented by index j) except country i. For example, figure 24 presents the ratio of GDP per capita between two pairs of countries, the Rwanda-Africa pair and the South Africa-Africa pair (the richest country divided by the poorest country). Rwanda at the beginning of our 1994 study period had the lowest level of GDP per capita while South Africa had one of the highest GDP per capita, figure 24 shows that the Africa/Rwanda and South Africa/Africa ratios are continuously declining. This decline implies that Rwanda, which was poorer than Africa, is converging toward Africa and Africa, which was poorer than South Africa, is converging toward South Africa.

Figure 24: ratio of GDPper capita between the richest to the poorest country (Africa/Rwand, Southafrica/Africa)



Source: Author's elaboration

Thus, we note that at the beginning of the period, Africa's GDP per capita was almost five times higher than Rwanda's, whereas at the end of the period this ratio is only a little over two, showing that Rwanda has continuously and significantly reduced its GDP per capita gap with Africa. We also notice the same trend between Africa and South Africa, at the beginning of the period, South Africa's GDP per capita was over seven times higher than Africa's, at the end of the period this ratio is only about 3.5, showing that Africa has continuously and significantly reduced its GDP per capita gap with South Africa.

3.1.2.3 Econometrics estimations, results and analysis on structural convergence of african economies

In this section, we first present the descriptive statistics for all the variables and for the two databases we use (WDI and GGDC). We then, run preliminary unit root tests. Finally, we present, discuss and analyze the results of our estimations according to Panel-corrected standard errors, Feasible General least-squares (FGLS), Tobit and instrumental variable methods.

- ***Descriptive statistics***

In this section we address equations (3-7) to (3-12) to investigate structural convergence of African countries. Tables 9 and 10 summarize the basic statistics for the annual frequency data used in this section. It can be noted that the WDI database sample has a larger number of available observations (1,248), while the GGDC database sample has only about half (689). This is due to the fact that the WDI database sample includes almost all African countries 48 while the GGDC database sample has only 13 countries, the gap between these observations is only doubled because the GGDC sample covers the period 1960-2012 while the WDI database sample covers the period 1994-2019.It can also be noted that the minimum and maximum values of all ksi fluctuating between 0 and 0.5 indicate at first sight a low degree of sectoral heterogeneity, as a ksi close to 0 is synonymous with sectoral homogeneity.

Table 9: Descriptive statistics WDI database

Variable	Obs	Mean	Std. Dev.	Min	Max
ksiEmpAG	1248	.191	.115	.001	.514
ksiEmpIND	1248	.064	.05	0	.276
ksiEmpserv	1248	.132	.082	0	.375
ksivaAG	1197	.15	.116	0	.638
ksivaIND	1197	.164	.116	0	.572
ksivaSERV	1102	.137	.134	0	.531
lnincomdiff	1248	6.576	1.226	-1.907	9.963
lnpopdiff	1248	20.597	.199	19.958	20.958
lnsavingcapdiff	1248	9.72	.632	8.123	10.647

Source: Author's calculations

Table 10: Descriptive statistics GGDC database

Variable	Obs	Mean	Std. Dev.	Min	Max
ksiEmpag	630	.205	.126	0	.503
ksiEmpind	630	.089	.065	0	.326
KSIempser	630	.123	.08	0	.338
ksiVaag	665	.134	.104	0	.515
ksiVAind	665	.109	.086	0	.515
ksiVAserv	665	.11	.098	0	.424
lnincomdif	689	7.365	1.071	2.986	9.476
lnpopdif	689	19.371	.446	18.131	20.2
lnsavingcapdiff	689	7.233	1.214	2.254	9.007

Source: Author's calculation

Tables 11 and 12 and figures 25 and 26 show, respectively, the pairwise correlation matrices and the correlation matrix graphs of the 9 variables of our equations. Thus, we observe in both our samples (WDI database and GGDC database) a positive and statistically significant correlations between lnincomdiff and all the ksi, excepte for the ksiVAser and ksiVAind in the GGDC database. This result suggests that narrower income gaps are accompanied by greater sectoral similarities. The variables lnpopdiff and lnsavingcapdiff show mixed correlations with the different ksi. The variable lnsavingcapdiff shows a positive and significant correlation in both databases with the variable lnincomdiff, which bodes well for its use as an instrument.

Table 11: Pairwise correlations WDI database

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ksiEmpAG	1.000								
(2) ksiEmpIND	0.737***	1.000							
(3) ksiEmpserv	0.891***	0.376***	1.000						
(4) ksivaAG	0.056*	-0.021	0.093***	1.000					
(5) ksivaIND	0.054*	0.181***	0.012	0.203***	1.000				
(6) ksivaSERV	0.383***	0.407***	0.302***	0.155***	0.511***	1.000			
(7) lnincomdiff	0.421***	0.379***	0.358***	0.153***	0.163***	0.181***	1.000		
(8) lnpopdiff	0.010	0.028	-0.010	0.047*	0.065**	0.053*	0.386***	1.000	
(9) lnsavingcapdiff	-0.027	-0.047*	-0.018	-0.017	0.080***	0.037	0.324***	0.701***	1.000

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations

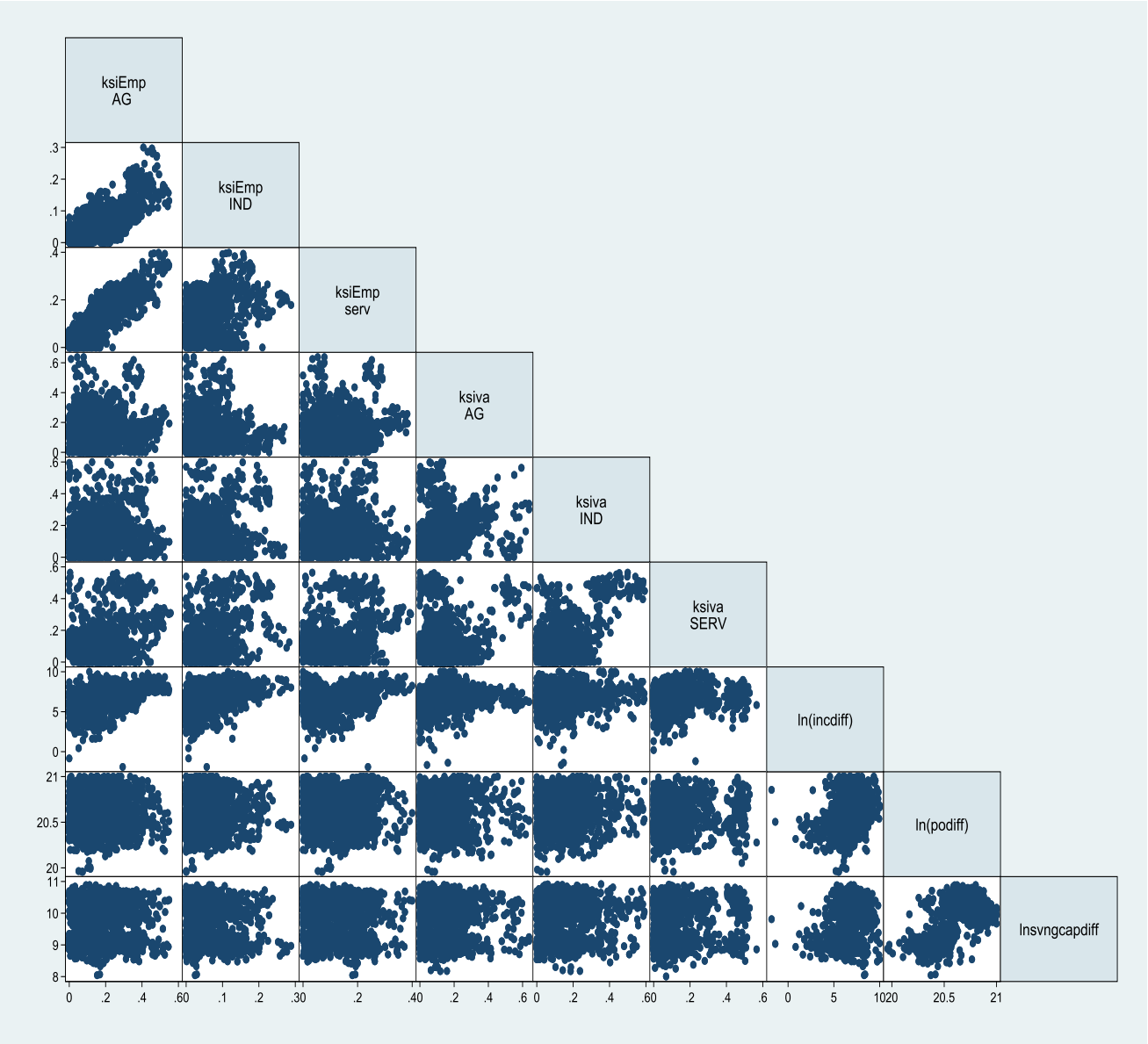
Table 12: Pairwise correlations GGDC database

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ksiEmpag	1.000								
(2) ksiEmpind	0.794***	1.000							
(3) KSIempser	0.840***	0.385***	1.000						
(4) ksiVaag	0.339***	0.157***	0.380***	1.000					
(5) ksiVAind	-0.133***	-0.118***	-0.039	0.258***	1.000				
(6) ksiVAserv	-0.071*	-0.106***	0.110***	0.516***	0.179***	1.000			
(7) lnincomdif	0.639***	0.538***	0.544***	0.303***	0.074*	0.008	1.000		
(8) lnpopdif	0.127***	0.033	0.075*	-0.102***	-0.157***	-0.304***	0.226***	1.000	
(9) lnsavingcapdiff	-0.005	-0.106***	0.077*	-0.106***	-0.168***	-0.064*	0.071*	0.788***	1.000

*** p<0.01, ** p<0.05, * p<0.1

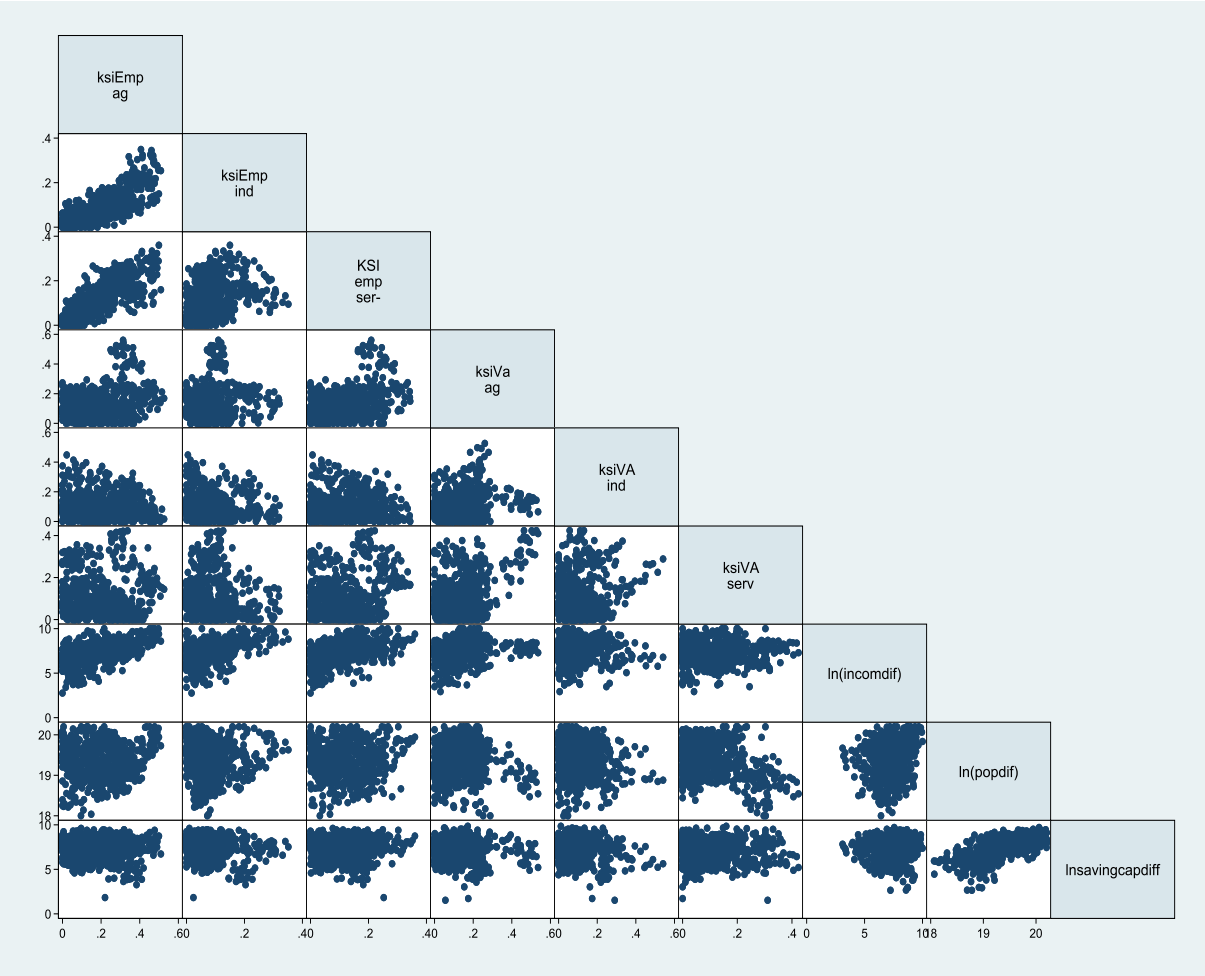
Source: Author's calculations

Figure 25: Graphe matrix WDI database



Source: Author's elaboration

Figure 26: Graphe matrix GGDC database



Source: Author's elaboration

- ***Unit-root test***

Tables 13 show the unit root test results for WDI data. The null hypothesis of unit root is rejected for all variables by the Levin-Lin-Chu unit-root test and Fisher-type unit-root test based on augmented Dickey-Fuller (ADF) tests, implying that all are stationary. This means that the mean and variance of those variables do not change systematically over time and these time series variables can be used for regression analyses.

Table 13:Levin-Lin-Chu and Fisher-Type (ADF) unit-root test results

Variables / Statistics	ksiEmp AG	ksiEmpIND	ksiEmpServ	incomdiff	popdiff	saving/capdiff
Inverse chi-squared(96) Fisher-type (ADF) test	226.7809***	215.7137***	216.0152***	352.3742***	814.7762***	258.2050***
Adjusted t* Statistic Levin-Lin-Chu test	-2.923***	-4.276***	-1.970**	-3.172***	-1.3e+02***	-3.1875***

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

- ***Panel-Corrected Standard Errors (PCSE) methodes***

To investigate the existence of structural convergence between African economies, we run fixed-effect[31] regressions of the indixes that measure sectoral similarity (ksi) on the values of real convergence and domestic market size (incomdiff and popdiff), after which we perform tests of autocorrelation, heteroscedasticity and crossectionale depandance, and our model suffers from autocorrelation and heteroscedasticity. We circumvent these problems by using Feasible General least-squares (FGLS) and panel-corrected standard errors (PCSE) methods. As Beck and Katz (1995), and Beck and Katz (2011) have pointed out, these methods correct for both cross-sectional heteroskedasticity and general correlation of observations between cross-sectional individuals. The PCSE method is appropriate for the WDI database, because for this database we have N>T[32] and the GLS method is appropriate for the GGDC database because for that database we have T>N[33].

Tables 14, 15, 16 and 17 display the results of the estimation of equations (3-7) to (3-12) with the WDI and the GGDC databases. These results show that a shrinking

[31] The Hausman test which rejects the null hypothesis for all sectors motivates this choice.
[32] N=48 and T=26.
[33] N=13 and T=42.

income gap ceteris paribus is significantly linked to greater similarity in the three sectoral economic structures. Indeed, the positive and significant coefficients of incomdiff indicate the structural convergence of African economies using both sectoral employment data and sectoral value-added data[34]. Market size differences, on the other hand, once controlling for incomdiff, appear to act against the similarity of sectoral structures. Indeed, the negative and significant signs of the popdiff coefficients in the majority of the results indicate this. These results of structural convergence are very similar to those of Wacziarg (2001), Barrios, Barry, and Strobl (2002) and C. Longhi and Musolesi (2007). The tendency of popdiff to act against structural convergence is a result close to that of Barrios, Barry, and Strobl (2002).

Table 14: PCSE estimates with employment and WDI data [equations (3-10), (3-11) and (3-12)]

VARIABLES	(1) ksiEmpAG	(2) ksiEmpIND	(3) ksiEmpserv
lnincomdiff	0.0491***	0.0192***	0.0303***
	(0.00373)	(0.00131)	(0.00253)
lnpopdiff	-0.0673***	0.0235**	-0.0930***
	(0.0231)	(0.00977)	(0.0171)
Time FE	yes	yes	yes
Constant	1.440**	2.467***	-0.845*
	(0.657)	(0.282)	(0.488)
Observations	1,248	1,248	1,248
R-squared	0.221	0.177	0.168
Number of countrinum	48	48	48

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

[34] Except for ksiVAserv in Table 16 which shows a coefficient with a negative sign but not significant.

Table 15: PCSE estimates value-added and WDI data [equations (3-7), (3-8) and (3-9)]

VARIABLES	(1) ksivaAG	(2) ksivaIND	(3) ksivaSERV
lnincomdiff	0.0189***	0.0146***	0.0218***
	(0.00197)	(0.00216)	(0.00332)
lnpopdiff	0.148***	-0.101**	-0.116***
	(0.0406)	(0.0469)	(0.0272)
Time FE	yes	yes	yes
Constant	2.292*	-7.874***	-5.540***
	(1.246)	(1.996)	(1.556)
Observations	1,197	1,197	1,102
R-squared	0.064	0.069	0.041
Number of countrinum	48	48	48

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 16: FGLS estimates with employment and GGDC data [equations (3-10), (3-11) and (3-12)]

VARIABLES	(1) ksiEmpag	(2) ksiEmpind	(3) KSIempser
lnincomdif	0.0802***	0.0368***	0.0423***
	(0.00359)	(0.00203)	(0.00252)
lnpopdif	0.0345**	0.00595	-0.0457***
	(0.0175)	(0.00991)	(0.0123)
Constant	-1.264***	-0.397**	0.631**
	(0.357)	(0.202)	(0.251)
Observations	630	630	630
Number of countrinum	13	13	13

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 17:FGLS estimates with value-added and GGDC data [equations (3-7), (3-8) and (3-9)]

VARIABLES	(1) ksiVaag	(2) ksiVAind	(3) ksiVAserv
lnincomdif	0.0320***	0.00892***	-0.00141
	(0.00372)	(0.00320)	(0.00319)
lnpopdif	-0.0623***	-0.0733***	-0.228***
	(0.0178)	(0.0153)	(0.0153)
Constant	1.171***	1.503***	4.701***
	(0.362)	(0.311)	(0.310)
Observations	665	665	665
Number of countrinum	13	13	13

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

- ***African sub regional features of structural convergence with Feasible General Least-Squares (FGLS) methode***

In this section, we investigate whether the evidence of structural convergence found in the previous section is only driven by specific subsets of the sample, or whether it is a reality across all the African continent? For this purpose, we consider 5 Regional Economic Communities (RECs) on the African continent for which we estimate the equations from (3-7) to (3-12) with the Feasible Generalized Least Squares (FGLS) estimation method because for the different RECs T>N. These 5 RECs[35] are: Arab Maghreb Union (AMU), Economic Community of Central African States (ECCAS), Economic Community of West African States (ECOWAS), Intergovernmental Authority on Development (IGAD) and the East African Community (EAC), Southern African Development Community (SADC). Estimates are made only with data from the WDI database.

For the AMU community, the estimation results reported in tables 18 and 19 are mixed. Indeed, the results for sectoral value-added data (Table 19) are very similar to those of the previous section, namely a positive and significant coefficient of incomdiff

[35] List of countries by RECs in appendix.

for all three sectors, showing structural convergence, and a negative and significant coefficient of popdiff for all three sectors, showing that market size difference act against the similarity of the sectoral structures. The results of the sectoral employment data (Table 18) show a partial structural divergence. Indeed, a negative and significant coefficient of incomdiff for the agricultural and services sector show that a reduction in income gap, ceteris paribus, is significantly related to greater heterogeneity of these sectoral structures. For the industrial sector, the coefficient remains positive and significant, indicating the structural convergence in this sector. A positive and significant coefficient of popdiff for all three sectors shows that the difference in market size favors the similarity of sectoral structures.

Table 18: FGLS estimates (AMU) employement data [equations (3-10), (3-11) and (3-12)]

VARIABLES	(1) ksiEmpAG	(2) ksiEmpind	(3) ksiEmpserv
lnincomdiff	-0.0117***	0.00797***	-0.0190***
	(0.00317)	(0.00154)	(0.00350)
lnpopdiff	0.0208***	0.00993***	0.00716***
	(0.00190)	(0.000919)	(0.00209)
Time FE	yes	yes	yes
Constant	19.12	-11.66	31.45
	(48.13)	(23.30)	(53.04)
Observations	130	130	130
Number of countrinum	5	5	5

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 19: FGLS estimates (AMU) value-added data [equations (3-7), (3-8) and (3-9)]

VARIABLES	(1) ksiVAAG	(2) ksiVAind	(3) ksiVAserv
lnincomdiff	0.00919***	0.0391***	0.0406***
	(0.00258)	(0.0132)	(0.0136)
lnpopdiff	-0.00935***	-0.0326***	-0.0465***
	(0.00154)	(0.00788)	(0.00795)
Time FE	yes	yes	yes
Constant	-9.663	-64.06	0
	(39.08)	(199.6)	(0)
Observations	125	125	115
Number of countrinum	5	5	5

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

The partial structural divergence observed in the AMU can be explained by the small size of the database, but also by the important differences in factor endowment and in developmental options of the countries of that union. Algeria is endowed with oil and gas resources and has opted since its independence for industrial development, Egypt still has an agricultural sector that employs more than 20% of the workforce while Morocco and Tunisia are more tourism-oriented. The global structural convergence highlighted by Wacziarg (2001) no longer exists when considering only OECD[36] countries, this seems to be the case for our results with AMU as this community is relatively richer on the continent when compared to others. This result is in line with findings from Imbs and Wacziarg (2001), who showed that rich countries appear to be in a stage of sectoral specialization, while others are in a stage of sectoral diversification.

For the ECCAS community (tables 20 and 21), despite a positive sign in almost all the incomdiff coefficients, their non-significance means no conclusion can be drawn, except for the data on value-added of the industrial sector, which shows a positive and significant coefficient indicating structural convergence.

[36] Organization for Economic Co-operation and Development.

Table 20: FGLS estimates (ECCAS) employement data [equations (3-10), (3-11) and (3-12)]

VARIABLES	(1) ksiEmpAG	(2) ksiEmpind	(3) ksiEmpserv
lnincomdiff	0.00328	0.00322	0.00104
	(0.00421)	(0.00221)	(0.00416)
lnpopdiff	0.0765***	0.0362***	0.0325***
	(0.00852)	(0.00447)	(0.00842)
Time FE	yes	yes	yes
Constant	5.057	3.217	-0.256
	(77.84)	(40.84)	(76.94)
Observations	260	260	260
Number of countrinum	10	10	10

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 21: FGLS estimates (ECCAS) value-added data [equations (3-7), (3-8) and (3-9)]

VARIABLES	(1) ksivaAG	(2) ksivaIND	(3) ksivaSERV
lnincomdiff	0.00237	0.0314***	-0.00173
	(0.00742)	(0.00582)	(0.00760)
lnpopdiff	0.0450***	0.0600***	0.0388**
	(0.0146)	(0.0115)	(0.0152)
Time FE	yes	yes	yes
Constant	5.407	1.872	0
	(131.9)	(103.5)	(0)
Observations	240	240	220
Number of countrinum	10	10	10

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

For the remaining communities, namely ECOWAS, IGAD+EAC, SADC, structural convergence is a widely shared reality for all data (employment and value-added, tables from 22 to 27). The difference between market sizes is sometimes in favor and sometimes against sectoral similarity. The coefficient implying a structural

divergence in table 27 for SADC with value added data is certainly due to significant industrial gaps in this community, as countries such as South Africa, Botswana, and Mauritius show significant differences in industrial value added with other countries in the community.

Table 22: FGLS estimates (ECOWAS) employement data [equations (3-10), (3-11) and (3-12)

VARIABLES	(1) KsiEmpAG	(2) ksiEmpind	(3) ksiEmpServ
lnincomdiff	0.0483***	0.00533**	0.0393***
	(0.00574)	(0.00211)	(0.00430)
lnpopdiff	0.00364	0.0103***	-0.00916**
	(0.00584)	(0.00214)	(0.00437)
Time FE	yes	yes	yes
Constant	5.963	0.614	4.860
	(62.93)	(23.11)	(47.13)
Observations	390	390	390
Number of countrinum	15	15	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 23: FGLS estimates (ECOWAS) value-added data [equations (3-7), (3-8) and (3-9)]

VARIABLES	(1) ksivaAG	(2) ksivaIND	(3) ksivaSERV
lnincomdiff	0.0353***	0.0281***	0.0237***
	(0.00828)	(0.00514)	(0.00501)
lnpopdiff	0.0322***	0.0111**	0.00543
	(0.00830)	(0.00516)	(0.00519)
Time FE	yes	yes	yes
Constant	20.61	18.65	0
	(89.41)	(55.58)	(0)
Observations	384	384	354
Number of countrinum	15	15	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 24:FGLS estimates (IGAD+EAC) employement data [equations (3-10), (3-11) and (3-12)

VARIABLES	(1) ksiEmpAG	(2) ksiEmpind	(3) ksiEmpserv
lnincomdiff	0.0659***	0.0104***	0.0566***
	(0.00408)	(0.00128)	(0.00315)
lnpopdiff	0.148***	0.0360***	0.101***
	(0.0133)	(0.00420)	(0.0103)
Time FE	yes	yes	yes
Constant	13.86	3.538	9.496
	(63.65)	(20.02)	(49.10)
Observations	208	208	208
Number of countrinum	8	8	8

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 25: FGLS estimates (IGAD+EAC) value-added data [equations (3-7), (3-8) and (3-9)]

VARIABLES	(1) ksivaAG	(2) ksivaIND	(3) ksivaSERV
lnincomdiff	0.0483***	0.0103***	0.0595***
	(0.00941)	(0.00378)	(0.00874)
lnpopdiff	0.0645**	-0.0760***	0.231***
	(0.0296)	(0.0119)	(0.0276)
Time FE	yes	yes	yes
Constant	25.58	13.19	0
	(131.4)	(52.80)	(0)
Observations	189	189	173
Number of countrinum	8	8	8

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 26: FGLS estimates (SADEC) employement data [equations (3-10), (3-11) and (3-12)

VARIABLES	(1) ksiEmpAG	(2) ksiEmpind	(3) ksiEmpserv
lnincomdiff	0.169***	0.0580***	0.104***
	(0.00744)	(0.00347)	(0.00513)
lnpopdiff	0.0102	0.0577***	-0.0442**
	(0.0296)	(0.0138)	(0.0204)
Time FE	yes	yes	yes
Constant	-27.47	-4.815	-21.52
	(77.62)	(36.17)	(53.47)
Observations	390	390	390
Number of countrinum	15	15	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 27: FGLS estimates (SADEC) value-added data [equations (3-7), (3-8) and (3-9)]

VARIABLES	(1) ksivaAG	(2) ksivaIND	(3) ksivaSERV
lnincomdiff	0.00774	-0.0374***	0.0270***
	(0.00545)	(0.00805)	(0.00848)
lnpopdiff	-0.00534	-0.00709	-0.0228
	(0.0217)	(0.0320)	(0.0335)
Time FE	yes	yes	yes
Constant	-31.39	-28.87	0
	(57.80)	(85.32)	(0)
Observations	388	388	359
Number of countrinum	15	15	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

After addressing the five regional sub-sets that cover the entire African continent, we find that structural convergence is a reality across the continent. For the robustness check in the next section we use estimation methods such as the tobit model and instrumental variables.

- ***Robustness check***

For the robustness check we use the tobit model and instrumental variables estimation methods.

- ***Tobit model***

The dependent variable KSI is bounded below by 0 as shown in Tables 9 and 10, this may firstly create problems for out-of-sample predictions, secondly, it may also lead to inconsistent parameter estimates if a linear model is fitted to a bounded dependent variable (Wacziarg 2001). To correct this possible problem, we apply a tobit model with left-censoring limit with random effects. The results presented for WDI and GGDC database in Tables 28, 29 and 30 show that this method also confirms the structural convergence of African economies for both sectoral employment and sectoral value-added data. Except for the services sector for which the incomdiff coefficient is negative but insignificant for the sectoral employment data, and not estimated for the sectoral value-added data due to some missing data. Since the GGDC database is not strongly balanced, estimates with sectoral value added data were not possible.

Table 28: Tobit model estimates employement WDI data [equations (3-10), (3-11) and (3-12)]

VARIABLES	(1) ksiEmpAG	(2) ksiEmpIND	(3) ksiEmpserv
lnincomdiff	0.00337**	0.00393***	-0.000485
	(0.00149)	(0.000834)	(0.00127)
lnpopdiff	0.357*	0.125	0.0907
	(0.202)	(0.0890)	(0.147)
Time FE	yes	yes	yes
	(0.00848)	(0.00441)	(0.00685)
Constant	9.205	5.179	0.000264
	(14.97)	(8.108)	(12.43)
Observations	1,248	1,248	1,248
Number of countrinum	48	48	48

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 29: Tobit model estimates value-added WDI data [equations (3-7) and (3-8)]

VARIABLES	(1) ksivaAG	(2) ksivaIND
lnincomdiff	0.00952***	0.0107***
	(0.00269)	(0.00321)
lnpopdiff	0.381*	-0.0771
	(0.209)	(0.196)
Time FE	yes	yes
Constant	12.46	-3.695
	(23.24)	(27.58)
Observations	1,197	1,197
Number of countrinum	48	48

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 30: Tobit model estimates employement GGDC data [equations (3-10), (3-11) and (3-12)]

VARIABLES	(1) ksiEmpag	(2) ksiEmpind	(3) KSIempser
lnincomdif	0.0215***	0.0138***	0.0100***
	(0.00253)	(0.00141)	(0.00265)
lnpopdif	1.273***	0.335***	0.768***
	(0.144)	(0.0806)	(0.170)
Constant	-25.67***	-6.857***	-15.43***
	(2.893)	(1.617)	(3.406)
Observations	630	630	630
Number of countrinum	13	13	13

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

- ***Instruimental variable (IV) approche***

The meaning of the causality between the reduction in income gaps and the homogeneity of sectoral structures may not be clearly accepted despite the positive link we have highlighted through our estimates. It is easy to accept that the industrial specialization of a country can be both an outcome and a determinant of per capita income. Specialization in high value-added sectors is likely to generate higher incomes than specialization in traditional sectors. Beyond this, there may well be other factors changing over time, such as changes in economic, social and industrial policies, which affect both industrial structure and incomes that we have not taken into account, but which could bias our estimated coefficients. In order to investigate how these factors may affect our results, and inspired by Barrios, Barry, and Strobl (2002) we use an IV approach. We instrument our independent variable that materializes income convergence incomdiff, with an instrument that materializes the difference in savings per capita between countries (savingcapdiff)[37]. It is easy to see that savings may affect the wealth of a country, but it is unlikely to affect, at least in the short term, the structure of that country's sectors.

To verify the above statements and the validity of the instrument, we perform post-estimation endogeneity tests on the independent variable incomdiff, over and under-identification tests on the instrument savingcapdiff, and heteroscedasticity tests to see the disturbance in the models. Table 31 shows the Durbin and Wu-Hausman statistics for the endogeneity tests of the incomdiff variable. The null hypothesis that the incomdiff variable is exogenous is rejected with significant probabilities (less than 1% significance level[38]) in all equations except (3-4) dealing with value-added data on service sector. Thus, the incomdiff variable is endogenous, which supports the option of relying on a valid instrument. For equation (3-4) the incomdiff variable can be treated as exogenous, thus the results of our PCSE estimations remain valid. The over and under-identification tests show that the model is well specified and that the savingcapdiff is a valid instrument.

[37] This variable is computed in the same way as incomdiff but with per capita saving data
[38] except (3-6) with less than 10% significance level.

Table 31: Durbin and Wu-Hausman statistics for endogeneity tests of the incomdiff variable

Equations / statistics	(3-5)	(3-6)	(3-7)	(3-2)	(3-3)	(3-4)
Durbin (score) chi2 (1)	12.3787***	2.85652*	23.3375***	27.3399***	30.3722***	1.06111
Wu-Hausman F(1 ,1219)	12.2122***	2.79654*	23.2296***	27.3011***	30.4079***	1.03611

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

The results of IV approach, presented in Table 32, 33, 34 and 35 confirm the structural convergence of the African economies, all the coefficients of incomdiff are positive and significant, except value-added data for the agricultural sector with WDI data (in table 34) and the service sector with GGDC data (in table 35), which show structural divergence because their coefficients are negative and significant.. The differences in market size maintain the same pattern as with the PCSE estimates. Post-estimation tests such as the Anderson Canon under identification test, the Cragg-Donald Wald F statistic for weak identification test, the Sargan statistic for over identification test, and the IV heteroscedasticity test show that the instrument is valid and the models does not suffer from heteroscedasticity for all data and sectors.

Table 32: Instruimental variable estimates employment WDI database

VARIABLES	(1) ksiEmpAG	(2) ksiEmpIND	(3) ksiEmpserv
lnincomdiff	0.0302***	0.0233***	0.0112**
	(0.00611)	(0.00273)	(0.00458)
lnpopdiff	-0.0426	0.0181	-0.0680**
	(0.0452)	(0.0202)	(0.0339)
Time FE	yes	yes	yes
Constant	-2.405	2.202	-4.598
	(42.53)	(18.97)	(31.83)
Observations	1,248	1,248	1,248
R-squared	0.188	0.169	0.102

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 33: Instruimental variable estimates employment GGDC database

VARIABLES	(1) ksiEmpag	(2) sharEmpind	(3) sharEmpserv
lnincomdif	0.0892***	10.45***	14.85***
	(0.00925)	(1.199)	(1.786)
lnpopdif	0.0352**	9.082***	-7.205**
	(0.0176)	(2.282)	(3.398)
Time FE	yes	yes	yes
Constant	-1.347***	-236.1***	80.43
	(0.367)	(47.64)	(70.95)
Observations	630	630	630
R-squared	0.456	-0.450	-0.587

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 34: Instruimental variable estimates value added WDI database

VARIABLES	(1) ksivaAG	(2) ksivaIND	(3) ksivaSERV
lnincomdiff	-0.0131*	0.0481***	0.0294***
	(0.00713)	(0.00714)	(0.00825)
lnpopdiff	0.197***	-0.152***	-0.126**
	(0.0522)	(0.0522)	(0.0607)
Time FE	yes	yes	yes
Constant	2.015	-6.435	-79.70
	(48.56)	(48.62)	(54.17)
Observations	1,197	1,197	1,102
R-squared	-0.022	-0.027	0.037

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

Table 35: Instruimental variable estimates value added GGDC database

VARIABLES	(1) ksiVaag	(2) ksiVAind	(3) ksiVAserv
lnincomdif	0.0318***	0.0652***	-0.0153*
	(0.00981)	(0.0102)	(0.00853)
lnpopdif	-0.0624***	-0.0661***	-0.230***
	(0.0179)	(0.0186)	(0.0155)
Time FE	yes	yes	yes
Constant	1.174***	0.890**	4.852***
	(0.375)	(0.391)	(0.326)
Observations	665	665	665
R-squared	0.137	-0.359	0.268

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's estimations

3.2 THE IMPLICATIONS OF STRUCTURAL CONVERGENCE ON TRAIDE AND GROWTH

In this section, we examine the implications of structural convergence in Africa on economic growth and trade. The question is whether structural change causes or predicts economic and trade growth. As mentioned earlier, structural convergence is a simultaneous process of structural transformation for a group of countries experiencing the phenomenon of real convergence. According to Doyle, E. & E. O'Leary, (1999), structural transformation or structural change would largely explain structural convergence processes and also productivity convergence. In the previous section, we have already empirically highlighted a sectoral structural convergence of African countries over the period 1994-2019. Thus, the structural transformation underway in Africa over this period can be assimilated to structural convergence. We first present the data we use and their sources, then we describe the empirical models and the method we use, and finally, we present and analyze the results we got from our estimations.

3.2.1 Data issues

We use the same database as in the previous section on structural convergence to investigate empirically whether structural change causes or predicts African economic and trade growth. This previous database contains GDP and sectoral employment data. We supplement these figures with import and export figures for the African countries studied during the same time period (1994-2019). These trade figures come from the International Monetary Fund's (IMF) database[39]. GDP data allow us to capture economic growth. Data on imports and exports allow us to capture trade growth. Data on sectoral employment allows us to capture structural change.

3.2.2 Methodology

To highlight the casualties between structural transformation and growth and inspired by Dumitrescu and Hurlin (2012) and Dietrich, A. (2011), we use Granger non-

[39] https://data.imf.org/regular.aspx?key=61013712

causality test in a dynamic panel data between the variables which captures structural transformation and growth variables (economic growth and trade growth).

3.2.2.1 Measurement of structural change

The economic literature is particularly interested in the composition of an economy's sectoral structure in order to statistically describe it and study ongoing structural changes. As a result, various Structural Change Indexes (SCI) have been developed to capture changes in an economy's sectoral composition between two points in time. In addition to the KSI that we used in the previous section which captures the convergence of sectoral structures, we use two other SCI:

- The first one is the Norm Absolute Value (NAV), sometimes also called the Michaely index (1962) or Stoikov index (1966).

$$NAV_{s,t} = 0{,}5 * \sum_{i=1}^{n} \left| X_{i,t} - X_{i,s} \right| \qquad (3-13)$$

t = 2, . . . , T, s = 1, . . . , T - 1.

Where n is the number of sectors in the economy; $X_{i,t}$ and $X_{i,s}$ represent the share of sector i in time t and s, respectively. The 0.5 factor is used to correct the double counting of changes in employment share. Because the NAV index is calculated using sectoral shares of the economy, its value ranges between zero and one. The interpretation is straightforward: the amount of structural change is exactly equal to the share of sectoral movements in the total economy. The index is zero if the structure remains unchanged, and unity if the change in all sectors is at its maximum, i.e. the entire economy undergoes a total change.

- The second is the Lilien Index (Lilien ,1982) and its modification, the Modified Lilien Index (MLI). This index measures the structural change in an economy by estimating the standard deviation of sectoral employment growth rates between periods s and t.

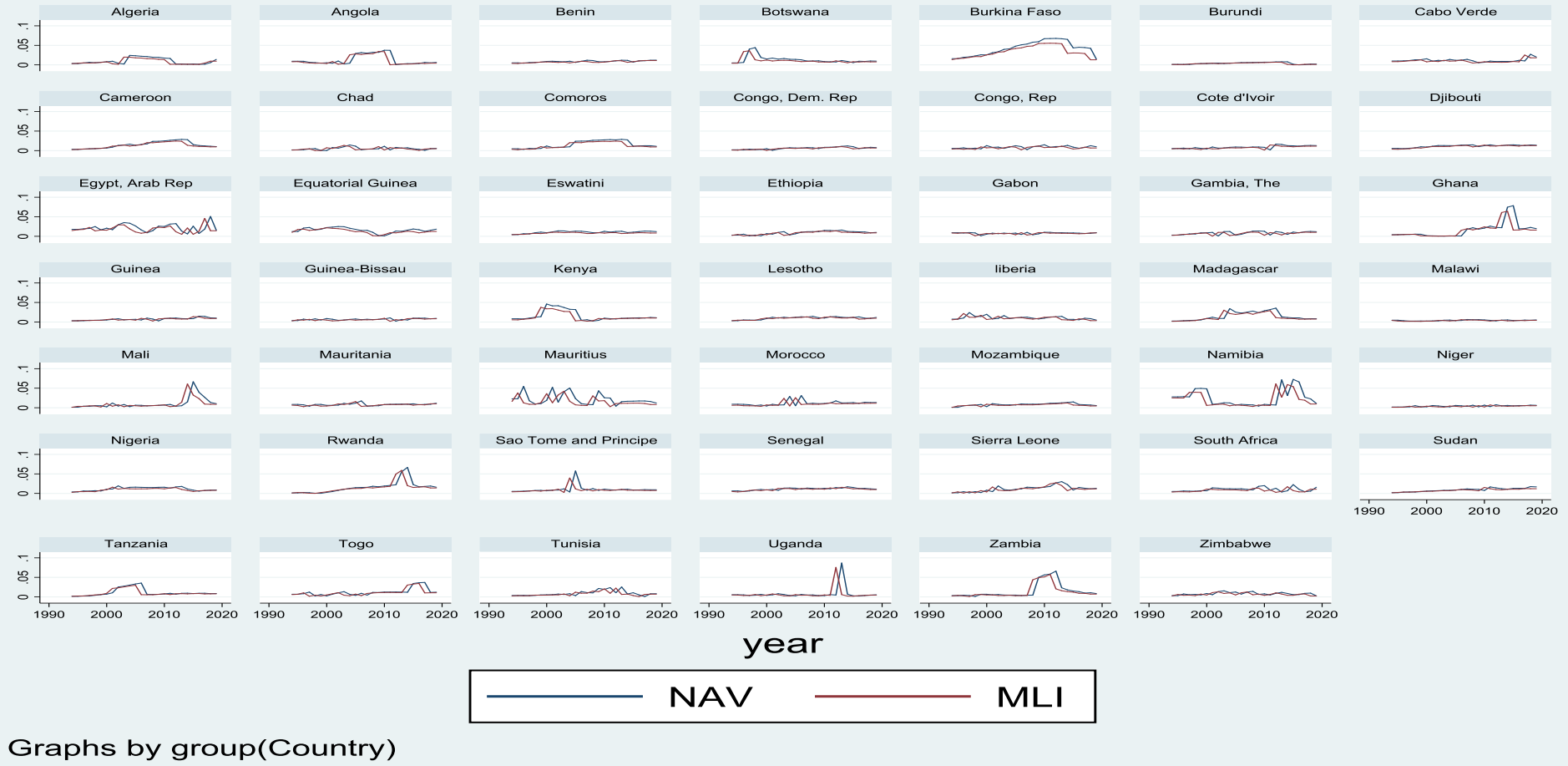
$$MLI_{s,t} = \sqrt{\sum_{i=1}^{n} X_{i,s} * X_{i,t} * \left(ln \frac{X_{i,t}}{X_{i,s}} \right)^2} \qquad (3-14)$$

$X_{i,s}>0$; $X_{i,t}>0$; t = 2, . . . , T, s = 1, . . . , T - 1.

Where n is the number of sectors in the economy, $X_{i,t}$ is the share of sector i at time t and time s.

Figure 27 shows the graphs of the NAV and MLI of each of the understudy countries. The graphs show high similarity between these two different ways of capturing the structural transformation. However, for all countries, in terms of value, there is a small superiority of the NAV over the MLI, and in terms of time, a small lag of the MLI over the NAV. These small differences are due to the methodological difference in estimating these two indexes.

Figure 27: MLI and NAV index plots for each country understudy



Source: Author's elaboration

3.2.2.2 Measurement of economic growth and trade growth

Economic growth is captured by the annual growth rate of GDP ($\frac{GDP_{i,t}-GDP_{i,s}}{GDP_{i,s}}$), while trade growth is captured by the annual growth rate of total exports ($\frac{EXP_{i,t}-EXP_{i,s}}{EXP_{i,s}}$) and total imports ($\frac{IMP_{i,t}-IMP_{i,s}}{IMP_{i,s}}$).

t = 2, . . . , T, s = 1, . . . , T - 1.

3.2.2.3 Granger causality test in a panel framework

Granger causality, Granger (1969) is quite used to study the causal effects between two-time series. The basic principle is that a cause always precedes its own effects and never vice versa. This means that the past can only predict the future and not vice versa. In this sense, a process X_t is said to Granger-cause another process Y_t if the future values of Y_t can be better predicted using the past values of X_t and Y_t than using only the past of Y_t. This concept is of course not without criticism. Indeed, Granger's causality does not imply true causality in an absolute sense because it is only a necessary, but not sufficient, condition of causality, making then, the post hoc ergo propter hoc fallacy possible. Granger's causality is thus only a concept that refers merely to predictability, not to causality in the strict sense. Despite criticism, the Granger causality test is still used to determine the causality of relationships between two variables. As a result, several authors have extended its use to panel data (Dumitrescu and Hurlin ,2012). According to Hurlin and Venet (2001), the addition of a panel data dimension enables the use of both cross-sectional and time-series data to test causal relationships between two variables. The larger number of observations in this framework has a significant advantage in terms of increasing degrees of freedom and reducing collinearity between the explanatory variables. As a result, the efficiency of Granger causality tests is greatly improved. Furthermore, panel data provide far more flexibility in modeling the behavior of cross-sectional units than traditional time series analyses (Greene 2008).

Inspired by Dumitrescu and Hurlin (2012) we then construct the bivariate models below to test for Granger causality between economic growth, trade, and structural transformation, all of them stationary variables observed for N countries on T periods.

$$GDPgrowth_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} GDPgrowth_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} SCI_{i,t-k} + \varepsilon_{i,t} \qquad (3-15)$$

$$SCI_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} SCI_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} GDPgrowth_{i,t-k} + \varepsilon_{i,t} \qquad (3-16)$$

$$EXPgrowth_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} EXPgrowth_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} SCI_{i,t-k} + \varepsilon_{i,t} \qquad (3-17)$$

$$SCI_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} SCI_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} EXPgrowth_{i,t-k} + \varepsilon_{i,t} \qquad (3-18)$$

$$IMPgrowth_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} IMPgrowth_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} SCI_{i,t-k} + \varepsilon_{i,t} \qquad (3-19)$$

$$SCI_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} SCI_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} IMPgrowth_{i,t-k} + \varepsilon_{i,t} \qquad (3-20)$$

i = 1,....., N; at time t = 1,...., T

Where GDPgrowth is annual GDP growth, EXPgrowth is annual total export growth, IMPgrowth is annual total import growth, SCI is structural change index (NAV or MLI), α_i is unobserved heterogeneity and $\varepsilon_{i,t}$ is an idiosyncratic error term. $\gamma_i^{(k)}$ the autoregressive parameters , and $\beta_i^{(k)}$ the regression coefficients slopes. If one of the slope parameters attached to SCI $\beta_i^{(k)}$ in equations is different from zero, there is then one-way Granger causality running from SCI to growth. Similarly, there is one-way Granger

causality running from growth to SCI if one of the slope parameters attached to growth $\beta_i^{(k)}$ is different from zero in equations.

Causality tests between growth (economic and trade) and structural change are carried out with one, two, and three lags, respectively, to account for potential lag effects after two and three years.

3.2.3 Results and discussion

In this section, we first present the descriptive statistics for all the variables . We then run preliminary unit root tests, Cross- Sectional Dependence (CD) and Slope Homogeneity tests. Finally, we present, discuss and analyze the results of our estimations according to Granger Non-casuality test method.

3.2.3.1 Descriptive statistics

Table 36 presents the descriptive statistics of the set of variables used in this section. The number of observations is, 1248 for all variables, which shows that the panel is strongly balanced. The two indexes that capture the annual structural transformation, namely the NAV and the MLI, show maximum values of 8.7 and 7.6% respectively. The minimum values of these indexes tend to zero which shows that structural change is quite low for some African countries in some years of the study period. The economic growth captured by gdpgrowth shows a maximum annual value of 3.05%, and a minimum value quite close to zero. The growth of import impgrowth and export expgrowth show maximum values of 6.6 and 22.6% respectively, with also minimum values quite close to zero. Given the positive character of both SCI, we considered the absolute values of economic growth and trade growth.

Table 36: Descriptive statistics for all the variables used in this section

Variable	Obs	Mean	Std. Dev.	Min	Max
NAV	1248	.012	.011	.00015	.087
MLI	1248	.01	.009	.00014	.076
gdpgrowth	1248	.132	.157	.000007	3.052
impgrowth	1248	.194	.33	.000031	6.659
expgrowth	1248	.263	.784	.001	22.685

Source: Author's calculations

3.2.3.2 Unit-root test

Table 37 reports the Levin-Lin-Chu, Harris-Tzavalis and Fisher type(P-Perron) tests for all variables. All these tests reject the null hypothesis at 1% level that they contain panel unit-roots. This means that these time series variables are stationary and can be used for regression analyses and in particular in a Granger non-causality test. The Levin-Lin-Chu test is performed with the time trend option. The Harris-Tzavalis test is performed with "suppress panel-specific means" and "subtract cross-sectional means" options. The Fisher type (P-Perron) test is conducted with a time trend and "subtract cross-sectional means" options to help control for contemporaneous correlation.

Table 37: Result for panel unit-root test

Variable	Levin-Lin-Chu unit-root test Adjusted t* statistic	Harris-Tzavalis unit-root test Z statistic	Fisher type(P-Perron) unit-root test P statistic
NAV	-4.1090***	-38.0177***	293.4899***
MLI	-5.0514***	-38.9823***	305.5255***
gdpgrowth	-11.9340***	-95.0785***	657.1304***
impgrowth	-12.6278***	-1.2e+02***	873.1094***
expgrowth	-9.9248***	-1.2e+02 ***	819.4343***

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

3.2.3.3 Cross- sectional Dependence (CD) and slope homogeneity tests

The Granger Non-causality test in heterogeneous panels requires, no cross-sectional dependence, and also individual-specific heterogeneity. So we apply different tests to check whether these conditions are satisfied. For Cross-sectional Dependence (CD) tests we use Pesaran's (2021), Frees (1995) and Friedman (1937) tests, and for individual heterogeneity (slope homogeneity test) we use Pesaran and Yamagata (2008)

test. The CD test is a post estimation of fixed effect and random effect regressions. To perform this test, we first run fixed effect regression of growth (gdpgrowth, impgrowth and expgrowth) on structural change (NAV and MLI), then we test for CD.

- ***Fixed effect regression GDPgrowth on NAV***

Table 38 reports the results of CD and slope homogeneity tests.The Pesaran's and Friedman's CD test strongly rejects the null hypothesis of no cross-sectional dependence. Frees' CD test also rejects the null hypothesis of no cross-sectional dependence because the Frees' CD test statistic (3.088) is greater than the critical values of the Q distribution for α = 0.10, α = 0.05, and α = 0.01. The results of the Slope homogeneity test also strongly reject the null hypothesis of slope homogeneity, i.e. This means that the slope coefficients are not all the same across cross-sectional units.

Table 38: Result for CD and Slope homogeneity test

		Statistics	Critical values from Frees' Q distribution
Pesaran's test of CD		32.191***	
Frees' test of CD	$\alpha = 0.10$	3.088	0.0996
	$\alpha = 0.05$		0.1297
	$\alpha = 0.01$		0.1870
Friedman's test of CD		274.633***	
Slope homogeneity test	Δ	3.457***	
	$\Delta\ adj$	3.676***	

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

- ***Fixed effect regression GDPgrowth on MLI***

Table 39 reports the results of CD and slope homogeneity tests.The Pesaran's and Friedman's CD test strongly rejects the null hypothesis of no cross-sectional dependence. Frees' CD test also rejects the null hypothesis of no cross-sectional dependence because the Frees' CD test statistic (3.109) is greater than the critical values of the Q distribution for α = 0.10, α = 0.05, and α = 0.01. The results of the Slope homogeneity test also strongly reject the null hypothesis of slope homogeneity, i.e. This means that the slope coefficients are not all the same across cross-sectional units.

Table 39: Result for CD and Slope homogeneity test

		Statistics	Critical values from Frees' Q distribution
Pesaran's test of CD		32.241***	
Frees' test of CD	$\alpha = 0.10$	3.109	0.0996
	$\alpha = 0.05$		0.1297
	$\alpha = 0.01$		0.1870
Friedman's test of CD		276.023***	
Slope homogeneity test	Δ	3.686***	
	$\Delta\ adj$	3.919***	

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

- ***Fixed effect regression impgrowth on NAV***

Table 40 reports the results of CD and slope homogeneity tests.The Pesaran's and Friedman's CD test strongly rejects the null hypothesis of no cross-sectional dependence. Frees' CD test also rejects the null hypothesis of no cross-sectional dependence because the Frees' CD test statistic (2.083) is greater than the critical values of the Q distribution for α = 0.10, α = 0.05, and α = 0.01. The results of the Slope

homogeneity test does not reject the null hypothesis of slope homogeneity, because the level of significance is slightly lower than 90% (respectively a probability of 82 and 85% for the statistics Δ and Δ adj).

Table 40:Result for CD and Slope homogeneity test

		Statistics	Critical values from Frees' Q distribution
Pesaran's test of CD		27.473***	
Frees' test of CD	$\alpha = 0.10$	2.083	0.0996
	$\alpha = 0.05$		0.1297
	$\alpha = 0.01$		0.1870
Friedman's test of CD		233.268***	
Slope homogeneity test	Δ	-1.326	
	$\Delta\ adj$	-1.410	

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

- ***Fixed effect regression impgrowth on MLI***

Table 41 reports the results of CD and slope homogeneity tests.The Pesaran's and Friedman's CD test strongly rejects the null hypothesis of no cross-sectional dependence. Frees' CD test also rejects the null hypothesis of no cross-sectional dependence because the Frees' CD test statistic (2.034) is greater than the critical values of the Q distribution for α = 0.10, α = 0.05, and α = 0.01. The results of the Slope homogeneity test does not reject the null hypothesis of slope homogeneity.

Table 41: Result for CD and Slope homogeneity test

		Statistics	Critical values from Frees' Q distribution
Pesaran's test of CD		27.500***	
Frees' test of CD	$\alpha = 0.10$	2.034	0.0996
	$\alpha = 0.05$		0.1297
	$\alpha = 0.01$		0.1870
Friedman's test of CD		229.769***	
Slope homogeneity test	Δ	-0.216	
	$\Delta\ adj$	-0.229	

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

- ***Fixed effect regression expgrowth on NAV***

Table 42 reports the results of CD and slope homogeneity tests.The Pesaran's and Friedman's CD test strongly rejects the null hypothesis of no cross-sectional dependence. Frees' CD test also rejects the null hypothesis of no cross-sectional dependence because the Frees' CD test statistic (1.403) is greater than the critical values of the Q distribution for α = 0.10, α = 0.05, and α = 0.01. The results of the Slope homogeneity test also reject the null hypothesis of slope homogeneity, i.e. This means that the slope coefficients are not all the same across cross-sectional units.

Table 42: Result for CD and Slope homogeneity test

		Statistics	Critical values from Frees' Q distribution
Pesaran's test of CD		20.869***	
Frees' test of CD	$\alpha = 0.10$	1.403	0.0996
	$\alpha = 0.05$		0.1297
	$\alpha = 0.01$		0.1870
Friedman's test of CD		178.080***	
Slope homogeneity test	Δ	1.555	
	$\Delta\ adj$	1.653*	

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

- ***Fixed effect regression expgrowth on MLI***

Table 43 reports the results of CD and slope homogeneity tests.The Pesaran's and Friedman's CD test strongly rejects the null hypothesis of no cross-sectional dependence. Frees' CD test also rejects the null hypothesis of no cross-sectional dependence because the Frees' CD test statistic (1.465) is greater than the critical values of the Q distribution for α = 0.10, α = 0.05, and α = 0.01. The results of the Slope homogeneity test also strongly reject the null hypothesis of slope homogeneity, i.e. This means that the slope coefficients are not all the same across cross-sectional units.

Table 43: Result for CD and Slope homogeneity test

		Statistics	Critical values from Frees' Q distribution
Pesaran's test of CD		21.597***	
Frees' test of CD	$\alpha = 0.10$	1.465	0.0996
	$\alpha = 0.05$		0.1297
	$\alpha = 0.01$		0.1870
Friedman's test of CD		183.066***	
Slope homogeneity test	Δ	2.394**	
	$\Delta\ adj$	2.546**	

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

Overall, the results of the various CD and slope homogeneity tests reject the null hypotheses of no cross-sectional depandance and slope homogeneity. Thus we can apply the Granger non-causality test on the different variables as they globally fulfil the conditions of stationarity, CD and slope homogeneity.

3.2.3.4 Granger non-causality tests results and analyses

In this section, we address equations (3-15) to (3-20) in order to test the Granger non-causality between economic growth (gdpgrowth) and structural change (NAV and MLI), import growth (impgrowth) and structural change (NAV and MLI) and finally export growth and structural change (NAV and MLI). The objective is to analyse to what extent structural change implies economic and trade growth and vice versa.

Table 44 displays the results of the Granger Non-causality test between economic growth (Gdpg)[40] and structural change (NAV and MLI). The left-hand side of the table displays the results between Gdpg and NAV. The null hypothesis that economic growth does not cause structural change captured by NAV index cannot be rejected,

[40] For the sake of simplicity, Gdpgrowth will be referred to as Gdpg in the following results.

regardless of the 3 lags included. The same is true in the other way around, the null hypothesis that the structural change captured by NAV index does not cause economic growth cannot be rejected, regardless of the 3 lags included. Thus, by capturing structural change through NAV index, economic growth does not Granger-cause structural change and structural change also does not Granger-cause economic growth for African countries. The right-hand side of the table displays the results between Gdpg and MLI. The null hypothesis that economic growth does not cause the structural change captured by MLI cannot be rejected, for the first and second lags. For the third lag, the null hypothesis can be rejected at the 5% significance level. On the other way around, in contrast, the null hypothesis that the structural change captured by MLI does not cause economic growth can be strongly rejected (1% significance level for the first two lags and 5% significance level for the third lag). Thus, by capturing structural change through the MLI, we can broadly say that economic growth does not Granger-cause structural change while structural change Granger-cause economic growth for African countries.

Table 44: Granger Non-causality tests results: Gdpgrowth ⇔SCI

lags	NAV		MLI	
	Gdpg⇏SCI	SCI⇏Gdpg	Gdpg⇏SCI	SCI⇏Gdpg
1	1.0843	-1.2251	-0.0889	3.9248***
2	0.5318	0.1267	0.7731	2.5530**
3	0.0319	0.0193	2.3653**	2.2421**

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

Table 45 displays the results of the Granger Non-causality test between import growth (Impg) and structural change (NAV and MLI). The left-hand side of the table displays the results between Impg and NAV. The null hypothesis that import growth does not cause structural change captured by NAV index cannot be rejected for the first and second lags. For the third lag, the null hypothesis can be rejected at the 10% significance level. The other way around situation is a little bit different, the null hypothesis that the structural change captured by NAV index does not cause import growth cannot be rejected, for the first lag only. For the second and third lags, the null hypothesis can be rejected at the 5% significance level and 10% significance level. Thus, by capturing

structural change through NAV index, we can broadly says import growth does not Granger-cause structural change but structural change Granger-cause import growth for African countries. The right-hand side of the table displays the results between Impg and MLI. The null hypothesis that import growth does not cause structural change captured by MLI cannot be rejected for the first lags only. For the second and third lags, the null hypothesis can be rejected at 10% and 1% significance levels, respectively. On the other way around, in contrast, the null hypothesis that the structural change captured by MLI does not cause import growth cannot be rejected for the second lags only. For the first and the third lags, the null hypothesis can be rejected at 10% and 1% significance levels, respectively. Thus, by capturing structural change through MLI, we can broadly say that the trend seems to be that structural change Granger-cause import growth much more than import growth Granger-cause structural transformation.

Table 45: Granger Non-causality tests results: Impgrowth ⇔SCI

lags	NAV		MLI	
	Impg⇏SCI	SCI⇏Impg	Impg⇏SCI	SCI⇏Impg
1	0.1635	-0.4383	0.5661	-1.8890*
2	1.2285	2.0400**	1.9468*	0.4858
3	1.7585*	1.6586*	3.2040***	2.5866***

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

Table 46 displays the results of the Granger Non-causality test between export growth (Expg) and structural change (NAV and MLI). The left-hand side of the table displays the results between Expg and NAV. The null hypothesis that import growth does not cause structural change captured by NAV index cannot be rejected for the first lag only. For the second and third lags, the null hypothesis can be rejected at 10% and 1% significance levels. The other way around situation is different, the null hypothesis that the structural change captured by NAV index does not cause export growth can be rejected regardless of the 3 lags included. Thus, by capturing structural change through NAV index, we can broadly say that export growth Granger-cause structural change, but structural change does not Granger-cause export growth for African countries. The right-

hand side of the table displays the results between Expg and MLI. The null hypothesis that export growth does not cause structural change captured by MLI can be rejected regardless of the 3 lags included. On the other way around, the null hypothesis that the structural change captured by MLI does not cause export growth cannot be rejected for the first and second lags. For the third lag, the null hypothesis can be rejected. Thus, by capturing structural change through MLI, we can broadly say that the trend seems to be that export growth Granger-cause structural change much more than structural change Granger-cause export growth.

Table 46: Granger Non-causality tests results: Expgrowth⇔ SCI

lags	NAV		MLI	
	Expg⇏SCI	SCI⇏Expg	Expg⇏SCI	SCI⇏Expg
1	1.3269	-0.7368	1.7502*	2.0347**
2	1.8897*	-1.1290	8.8787***	2.9981***
3	6.0039***	-1.1866	10.6737***	1.1368

Source: Author's estimations, *** p<0.01, ** p<0.05, * p<0.1

In light of these results, we find that structural change Granger-causes economic growth, but not the other way around. This result is in contrast to Dietrich (2011) who finds for 7 OECD countries that economic growth has a deeper Granger-causality impact on structural change than the other way around. As noted earlier, the shift of labor in African countries since the 1990s has been mainly from the agricultural sector to the service sector. The agricultural sector, as highlighted earlier, has a much lower level of productivity than the service sector in Africa. But jobs in the service sector in Africa are also often very precarious (Adegboye and Ighodaro 2020). Thus, the structural change that has been materialized by a shift in labor from agriculture to services led to an increase in productivity, which naturally had an impact on economic growth. As highlighted by Lin and Monga (2010) and Lin (2009), Lin (2011), Lin (2012), the continuous shift of factors of production (especially labor) from low productivity sectors to high productivity sectors increases overall productivity. For this reason, several reports and papers pointed out the upside of the structural change process in Africa. The African Center for

Transformation report (ACET 2014), the 2013 United Nations Economic Commission for Africa report (UNECA 2013), the 2012 UNCTAD report on structural transformation (UNCTAD 2012), the IMF papers (IMF 2013), and the McKinsey Global Institute report (McKinsey 2010) highlight the fact that Africa's recent progress is not exclusively due to natural resources. The World Bank report (World Bank 2014) concludes that African economies are growing unexpectedly fast. Nevertheless, the fact that the NAV index does not show causality of structural change on economic growth seems to show that the impact of this causality is rather weak, although it is clear from the MLI. Also, employment in the service sector in Africa is mostly precarious (Adegboye and Ighodaro 2020). Unskilled labor that leaves the agricultural sector joins jobs in areas such as security services, cleaning, parcel deliveries, dry cleaning, buying and selling of small products, etc. which are globally very low value-added.

On commercial aspect, the results show that structural change causes imports growth much more than the other way around. This causality of structural change on imports is probably due to the change in the composition of demand. According to Engel's law An increase in per capita income in developing countries is associated with a decrease in spending on food and therefore an increase in the spending on other goods and services. As the production of goods and services is very low in Africa, any additional demand leads to imports. According to reports by the AfDB, the African Union and several structures, intra-African trade does not exceed 16% by 2020[41]. The results also show that export growth causes structural change much more than the other way around. As mentioned earlier, labor reallocations are mainly from agriculture to low value-added branches of the service sector. Thus, this reallocation will hardly impact on exports, which in many African countries are mainly from natural resources[42].

3.3 SUMMARY

The aim of this chapter was to use econometric approaches to, first, study the ongoing structural transformation process in Africa. Second, to study the eventual

[41] https://www.tralac.org/resources/infographic/15294-intra-africa-trade-update-2020.html
[42] https://au.int/sites/default/files/documents/39607-doc-af-trade_yearbook2020_v4_comp-compresse_1.pdf

convergence of the sectoral structures of African economies through the Krugman Specialization Index (KSI), income differences (Incomdiff) and differences in domestic market sizes (popdiff). Third, to investigate the predictability or causality of structural transformation on trade and economic growth. Through simple linear regression methods, we have highlighted the shift of labor and value added between the three main economic sectors in Africa (agricultural, industrial, service). Indeed, for labor, the shift is mainly from the agricultural sector to the service sector. For the value-added, the shift is mainly from agriculture to industry. Through regression methods such as PCSE, FGLS, Tobit model and Instrumental variables approach, we have highlighted the existence of the phenomenon of sectoral structural convergence in Africa, i.e. a greater similarity of sectoral structures while income gaps are narrowing. Finally, using the Granger non-causality test, we investigates the impacts of structural change on trade and economic growth in Africa. The results show that structural transformation appears to Granger-cause economic growth, but not the other around. These results also show a reverse Granger-causality between structural transformation and import growth, but with a deeper impact of structural transformation on import growth than the other way around. In contrast to import growth, the results show a reverse Granger-causality between structural transformation and export growth, but with a deeper impact of export growth on structural transformation than the other way around.

CONCLUSION AND POLICY IMPLICATIONS

Economic convergence between several countries, whether real, nominal, or structural, is an important issue, as evidenced by economists' special interest in it from the 18th century to the present. This is why there is a plethora of theoretical and empirical literature on the subject. Real and nominal convergence has received more attention in the literature, but structural convergence, which is the result of simultaneous structural transformation and focuses on sectoral structural similarity or business cycles synchronization between countries, appears to have emerged and has received increasing attention in the literature since the beginning of the 2000s. Despite this emergence, it is clear that African countries have received very little attention on this topic. In addition, Africa faces a major problem of unemployment and underemployment, which pushes a large proportion of young people to opt for immigration. There is about 12 million young people who join its labor force every year (African Development Bank. (2018). According to African Development Bank. (2019) the current labor market situation suggests that Africa will face a huge employment challenge between 2016 and 2063. Assuming constant employment rates, African countries will have to collectively create 1.7 million jobs per month over the period to maintain constant unemployment rates. To meet this challenge, African countries must structurally transform their economies to be able to absorb this unemployment and create economic growth. For these reasons, this thesis attempts to fill this gap (little attention to structural convergence between African countries) with the general objective of investigating the phenomenon of structural convergence between African countries and to examine how structural convergence is affecting economic and trade growth.

To achieve this objective, this thesis is divided into three chapters.

Chapter 1 entitled "The concept of convergence in economics: Statistical aspects, Theoretical and Empirical Literature" is divided into three parts. The first part deals with the statistical aspects of convergence. We first define and distinguish converging series from those that have converged, the series converging towards a constant from those tending towards equality. Then second we present the statistical characterization of the convergent series. Thus, we distinguish convergence according to the average evolution

of their difference, or according to the evolution of their dispersion. The second part of this chapter makes a survey of the theoretical literature of convergence in economics. This survey shows that the hypothesis of convergence between lagging and leading countries is a controversial topic that goes back to the 18th century. Neoclassical growth models broadly support the convergence hypothesis (conditional or unconditional). Alternative endogenous growth models to some extent, the new literature on economic geography and dependency theory support non-convergence. The third part of this chapter first presents the main criteria commonly used to measure real convergence, namely the σ-convergence and β-convergence. Then we survey the empirical literature on real convergence. The analysis of this literature shows that conditional convergence or convergence clubs seem to be more credible..

Chapter 2 entitled "Structural convergence, trade, and growth: Theory and empirical evidence" is divided into two parts. The first part deals with structural transformation, which is a prerequisite for structural convergence. We define and characterize the process of structural transformation through its theoretical underpinnings as an ongoing changes by which low-income countries, in which the primary sector (agriculture) employs most of the workforce and generates most of the value-added, become high-income countries distinguished by a relatively smaller primary sector in terms of the workforce but more efficient in terms of production and value-added. The empirical literature for developed and developing countries is then discussed with a particular focus on stylized facts from the recent literature on Africa. The theoretical survey shows that Engel's law on the declining share of food in consumption, Lewis' hypothesis on the elastic supply of labor in most developing countries, and the stages of comparative advantage help to explain the process of structural transformation, among other things. From the survey of the empirical literature, it appears that developed countries have undergone a process of structural transformation that has materialized in the shift of labor from the agricultural sector to the industrial sector and then from the industrial sector to the service sector. This process seems to be the same but less pronounced for developing countries, especially with regard to the shift of labor from the industrial to the service sector. The process of structural transformation on the African continent seems to show two different stages. The first stage, which extends from

independence to the 1990s, shows a shift in labor similarly to that in developed countries, i.e. from the agricultural sector to the industrial sector. Then a second stage from the 1990s where the shift in labor was done directly from the agricultural sector to the service sector. The second part of this chapter deals with structural convergence and its implications for trade and growth. Thus, this part is divided into two subsections. The first subsection deals with the theoretical and empirical literature on structural convergence, and the second deals with the theoretical and empirical literature on the implications of structural convergence for trade and growth. In the first subsection of the second part of this chapter, we define structural convergence, which is a simultaneous process of structural transformation in several countries that results in a rapprochement or similarity between the sectoral structures of these countries as they are experiencing the phenomenon of real convergence. Then we discuss its theoretical and empirical literature. The survey of the theoretical literature shows that the three-sector hypothesis, the Chenery convergence hypothesis followed by some theoretical extensions to these hypotheses such as market forces on demand and supply, contribute among others to explain structural convergence. The survey of the empirical literature shows that a significant part of its works concerns European countries, with some works on Asian and American countries. Depending on the variables used to highlight structural convergence, the empirical literature has pointed out structural convergence through sectoral employment, structural convergence through sectoral productivity or sectoral value-added, and structural convergence through trade integration or business cycle synchronization. In the second subsection of the second part of this chapter, which addresses the implications of structural convergence on trade and growth, we survey the theoretical and empirical literature on this issue. The survey of the theoretical literature shows that through the "demand hypothesis" and the "productivity hypothesis" there can be a two-way causality between trade (imports and exports) and structural transformation, and also between economic growth and structural transformation. The survey of the empirical literature shows that several studies have highlighted the positive impacts of structural transformation on growth. However, a number of studies, notably on Africa, nuance this result.

Chapter 3 entitled "Structural convergence, trade and growth in African countries: Econometric analysis" is divided into two parts. In this chapter, we investigate, present and analyze our empirical findings on structural transformation, structural convergence and its implications on trade and growth in Africa. The first part of this chapter, which deals with structural convergence, is also divided into two subsections. The first subsection deals with the ongoing structural transformation process in Africa. In this subsection, we start by presenting the data and their sources used to make the necessary estimates. Then we present the empirical models that allow us to estimate the structural transformation in Africa. We regress the sectoral share of employment and value-added on GDP per capita to investigate how and to what extent labor and value-added shift as GDP per capita increases. The simulation results for both databases we use show that the labor shifts are mainly from the agricultural sector to the service sector. With the value-added data the shifts are mainly from the agricultural sector to the industrial sector. The time trend analysis (from 1994 to 2019) of the series of sectoral shares of employment and value added for all the African countries under study shows that the shifts in labor are also mainly from the agricultural sector to the service sector, while the sectoral shares of industry are constant over the whole period. With value-added data, the shifts are almost exclusively between the industrial and service sectors, while the sectoral share of agriculture is decreasing slightly. The estimation and analysis of relative sectoral productivity levels reveal that the agricultural sector has the lowest level and is almost constant over the entire period. The service sector is well above the agricultural sector, but with a slight downward trend. The industrial sector has by far the best level and shows a peak around the year 2005 followed by a continuous downward trend until the end of the period. These results seem to partially invalidate *hypothesis 1* of this thesis, in the sense that the labor shift and the value-added shift do not fully respect the steps of our hypothesis. Indeed, our results show that as GDP per capita increases, labor shifts directly from the agricultural sector to the service sector while value-added shifts mainly from the agricultural sector to the industrial sector. The second subsection of this first part of Chapter 3 deals with structural convergence between African countries. In this subsection, we start by presenting the data and their sources used to make the required estimates. Then we present the empirical models that allow us to estimate structural convergence among African countries. Using panel data for 48 African

countries and several estimation methods [PanelCorrected Standard Errors (PCSE), Feasible Generalized Least Squares (FGLS), tobit model, instrumental variable], which relate sectoral structure to the difference in per capita income, the results show the existence of the phenomenon of structural convergence in Africa, i.e. a greater similarity of sectoral structures while the income gaps are narrowing. Thus, these results confirm *Hypothesis 2* of this thesis, as the reduction in per capita income gaps that implies real convergence clearly seems to lead to greater sectoral similarity. The second part of this chapter deals with the implications of structural convergence for trade and growth in Africa. We begin by presenting the data and their sources used to make the required estimates. Then, we present empirical models that allow us to estimate the implications of structural convergence on trade and growth. Structural convergence is the outcome of a simultaneous process of structural transformation among several countries. Having already highlighted structural convergence among African countries in the previous section, the ongoing structural transformation process in Africa can therefore be considered as structural convergence. Using a Granger-non causality test, we investigate the reverse causality between structural transformation (captured by the NAV index and the MLI) and economic growth, and between structural transformation and trade growth (import growth and export growth). The results show that structural transformation appears to Granger-cause economic growth. These results also show a reverse Granger-causality between structural transformation and import growth, but with a deeper impact of structural transformation on import growth than the other way around. In contrast to import growth, the results show a reverse Granger-causality between structural transformation and export growth, but with a deeper impact of export growth on structural transformation than the other way around.

from this study, several policy implications can be drawn. The low relative productivity level of the service sector despite a significant shift in labor from the agricultural sector shows that this labor force is unskilled, and therefore engages in precarious service activities with very low value-added, as pointed out by Adegboye and Ighodaro. (2020). Thus, the development of human capital through education and technical and vocational training coupled with the improvement of the business environment, particularly in terms of low-cost access to financial resources and access to

markets, would contribute to increase the productivity of the services sector in Africa. The low attractiveness of the industrial sector in terms of labor despite its higher relative productivity level shows that this sector is losing momentum in Africa. Indeed, as noted by Page. (2012) deindustrialization (privatization and subsequent bankruptcy of several state-owned industries in Africa) after the 1990s was characterized not only by a decline in manufacturing output and employment but also by a decline in the diversity and sophistication of manufacturing sectors. This decline in sophistication coupled with strong competition from newly industrialized Asian countries partly explains the decline in the relative productivity level of the industrial sector in Africa. To address this situation, specific industrial policies are needed to develop and acquire human and physical capital in the industrial sectors that will enable African countries to achieve their latent comparative advantage in the long run. The occurrence of structural convergence among African countries implies that globally these countries follow similar stages of development characterized by the rise and fall of similar sectors, and those countries can converge towards a structural 'steady state'. Thus, African countries have the opportunity to develop common policies to achieve their latent comparative advantage. Indeed, the growth potential available in Africa should encourage countries to pool their efforts in order to achieve their latent comparative advantage by developing and acquiring the human and physical capital required to boost high-value-added activities in the industrial and service sectors. Because the persistence of low quality human and physical capital would explain the service sector's low productivity and the industrial sector's low labor attractiveness in Africa. The relatively minor impact of structural transformation on growth and exports and its rather favourable impact on imports implies also human capital development policies, physical capital acquisition, and the implementation of import substitution industrialization and export promotion policies.

This thesis could pave the way for further aspects of structural convergence in Africa. If data availability permits, attention can be given to intersectoral industry convergence, business cycle synchronization, and trade integration.

APPENDIX

Table 47: List of countries understudy for WDI data base

Algeria	Congo, Dem. Rep.	Ghana	Mauritius	South Africa
Angola	Congo, Rep.	Guinea	Morocco	Sudan
Benin	Cote d'Ivoire	Guinea-Bissau	Mozambique	Tanzania
Botswana	Djibouti	Kenya	Namibia	Togo
Burkina Faso	Egypt, Arab Rep.	Lesotho	Niger	Tunisia
Burundi	Equatorial Guinea	Liberia	Nigeria	Uganda
Cabo Verde	Eswatini	Madagascar	Rwanda	Zambia
Cameroon	Ethiopia	Malawi	Sao Tome and Principe	Zimbabwe
Chad	Gabon	Mali	Senegal	
Comoros	Gambia, The	Mauritania	Sierra Leone	

Table 48: List of countries understudy for GGDC data base

Botswana	Malawi	South Africa
Egypt, Arab Rep	Mauritius	Tanzania
Ethiopia	Morocco	Zambia
Ghana	Nigeria	
Kenya	Senegal	

REGIONAL ECONOMIC COMMUNITIES (RECS) ON THE AFRICAN CONTINENT

-**Arab Maghreb Union (AMU)** formed by Algeria, Libya, Morocco, and Tunisia, to which we add Egypt.

-**Economic Community of Central African States (ECCAS)** formed by Angola, Burundi, Cameroon, Chad, Congo Dem Rep, Congo Rep, Equatorial Guinea, Gabon, Rwanda, and Sao Tome and Principe.

-**Economic Community of West African States (ECOWAS)** formed by Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

-**Intergovernmental Authority on Development (IGAD)** and the **East African Community (EAC)** formed by Burundi, Djibouti, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda.

- **Southern African Development Community (SADC)** formed by Angola, Botswana, Comoros, Congo Dem. Rep, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Zambia, and Zimbabwe.

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