Endogenous Structural Change

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Résumé
We present a model of endogenous structural change in line with the endogenous growth literature of Romer [1987, 1990] and the mechanism of structural change of Matsuyama [1992]. The model generates in an endogenous way a fall in agricultural employment and growth of industrial employment drawn by Research and Development activity (R&D) as determinant of economic growth. The main mechanism behind this process is endogenous technical progress and overall externality effects generated by the increase of innovation used in the production of intermediate and industrial goods sectors. The more the economy produces in an innovative way, the more the number of goods produced by the industrial sector increases and the more we see productivity increase in the agricultural sector. This mechanism of productivity aid to release labor of the two sectors towards the R&D sector which in turn increases innovation (Rodrik [2013b]). It is a virtuous cycle of sustainable and endogenous structural change. An exploitation of new datasets makes it possible to better determine the dynamic process of structural change in relation to economic development. The analysis is carried out by specifying the characteristics of the structural change in five different groups of countries: countries with High income, Asian, Latin America and Sub-Saharan Africa.

JEL Classification numbers : E20, O40
Keywords : Structural change, Endogenous Growth, Industrialization, Innovation

1 Introduction

The structural change is generally analyzed as a process of sectoral reallocation of resources which accompanies economic growth. This reallocation relates to mainly labor movement of agricultural sector towards services and industry sectors. The results from this is as long as the economy develops, the shares of labor and added-value of traditional sectors fell and those of the modern sectors increase. The underlying mechanism arises from the improvement of the total productivity in the economy which makes it possible to release the

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resources of the traditional sector towards the modern sector. Kuznets [1966] had analyzed this phenomenon as one of the six major long-term growth stylized facts. Lewis [1954] had also considered the structural change as the main mechanism of economic development process. The sector allocation of the labor is thus seen as a pro-growth or pro-development phenomenon and even a historic process of stages of development (Rostow [1960]). The theoretical explanations are often presented in multi-sector models of neo-classic growth. The growth is drawn by an exogenous technical progress and this theoretical effort consists of deriving a path of balanced stationary growth, accompanied by a reallocation of labor from traditional sectors towards modern sectors. Two theoretical assumption are made. The first one is based on income effect which generates a structural change whereas the second proposes the role of the relative price of goods. The first refers to demand factors whereas the second proposes supply mechanisms. Most of the time, these models of growth describe trajectories of balanced growth or asymptotically balanced growth according to which growth rate is constant as well as the capital ratio output, real interest rate and the share of income. It thus describe a stylized fact raised by Kaldor (Kaldor [1961], Denison [1974], Barro and i Martin [1992]) and highlighted by models of balanced aggregate growth.

The first category of explanation is based on no-nomothetic utility functions. The marginal rate of substitution between the various goods changes as the economy develops, which generates different sectoral trajectories of growth. Authors like Kongsamut et al. [2001], Echevarria [1997], Laitner [2000], Caselli and Coleman [2001] and Gollin et al. [2002], obtain a structural change in an economy with two or three sectors in a non-homothetic preference. Kongsamut et al. [2001] arrived at the same conclusion by obtaining the same constant global growth and a structural change through imposing a restriction which coincide with certain parameters of their function of utility of the Stone-Geary type with the parameters of production function. They obtain a stationary path of growth where the shares of labor and added-value of the agricultural sector are decreasing constant for industry and increasing for the services. Echevarria [1997] uses a particular specification of the utility function which is not compatible with a path of balanced and constant growth. The total value of the consumption cannot grow at the same rate of exogenous technological growth.

The other explanation takes a starting point of the thesis suggested by Baumol [1967] which places emphasis on the unbalanced nature of economic growth resulting from the differential of productivity growth between sectors. Baumol [1967] divides the economy into two sectors, a modern sector which uses new technology and traditional stagnant sector which

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1. by supposing three consumer goods, one can specify a Stone-Gary utility function as $c(t) = a \log(c_a(t) - \bar{c}_a) + \beta \log(c_m(t)) + \gamma \log(c_s(t)) + \xi_a + \xi_s$ with $c_a$ et $c_s$ is positive. The income effects are generated by the terms $\bar{c}_a$ and $\bar{c}_s$.

2. The function is of type: $c(t) = a \log(c_a(t)) + \beta \log(c_m(t)) + \gamma \log(c_s(t)) - \eta \left( \frac{1}{c_a} + \frac{1}{c_m} + \frac{1}{c_s} \right)$

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uses labor as unique input. Manufacturing costs and prices of the stagnant sector which rises indefinitely, whereas those of the modern sector are constant. And then a decline trend of the production in the stagnant sector whose demand is not highly price elastic. Moreover, if the relationship between productions of the two sectors remains constant, employment moves towards the stagnating sector and the proportion of labor in modern sector tends towards zero. This process is described as “syndrome of cost of Baumol”. Ngai and Pissarides [2007] gets a result compatible with the facts of Kaldor in a multisector basic model with several consumer goods and only one capital equipment provided by a manufacturing sector. The functions of production are identical in all the sectors except for the growth of their total productivity of factors (PTF). Each sector produces a differentiated good, built-in with a constant elasticity substitution utility function. A low elasticity of substitution between final goods leads to a transfer of employment towards the sectors with low growth of the PTF. They show that the share of labor and added-value of the agricultural sector drop, and that of the services increase, whereas that of the manufacturing sector drop less than agriculture and increase less than the services sector. The basic mechanism is that differentiated technical progress affects the relative prices and generates a sectoral reallocation. Others works of Caselli and Coleman [2001] and Acemoglu and Guerrieri [2008], try to show that one can have changes of relative prices even if technical progress is neutral. Caselli and Coleman [2001] focusses on differentiation between skilled and unskilled labor. The fall of education costs led to the increase in the offer by skilled labor and consequently to lower the relative price of the non-agricultural products what leads to a sectoral reallocation of employment toward modern sectors. Acemoglu and Guerrieri [2008], presented a model with two sectors close to that of Ngai and Pissarides [2007], according to which the differential of sectoral capital intensities leads to an asymptotically balanced growth. Because the increase in the capital-labour ratio increases the output in the most intensive sectors capital.

The process of industrialisation starting at the end of the 18th century in Europe, is at the center of the discussion on the structural change and is often regarded as the source of delay for certain regions like Africa and explain the economic divergence at the global level (Buera and Kaboski [2012]). The success and the failure of industrialisation process becomes a significant factor for economic growth. The Literature of economic history of England’s industrialisation during the 18th century focusses on the progression of the agricultural productivity (Nurkse [1953], Rostow [1960], Mokyr [1989]). An economy which uses technology in its agricultural sector increases the agricultural productivity which makes it possible to transfer labour resources towards the other sectors in the economy. The existence of externalities or increasing outputs allows also the transfer of labor.

Our work is related to the approach adopted by Matsuyama [1992, 2008] which modelled
the link between the agricultural sector and industry sector productivity. It presents a simple model of structural change based on two sectors: agriculture and industry. Labor is used as unique factor of production. It combines at the same time demand effects through a function of Stone-Gary utility and a supply effect generated by a process of Learning by doing in the manufacturing sector which improves in an exogenous way the productivity in the agricultural sector. As the demand for agriculture has an elasticity lower than the demand of manufacturing goods, the increase in agricultural productivity releases labor. This mechanism is close to the work of Restuccia et al. [2008], Caselli [2005] and Gollin et al. [2002, 2006]. The essential argument is that the increase in agricultural productivity makes it possible to transfer labor towards the industrial sector and not the reverse.

The weakness of these models consists are of describing the endogenous economic forces which make it possible to support the structural change. This literature ignore the contribution of endogenous growth theory which completely changed the comprehension of economic growth mechanisms by giving up the neo-classic assumption of growth drawn by an exogenous technical progress. This mechanism is absent in the models of structural change based on neo-classic two sectors growth models. Pionnier works of [Romer, 1986, 1987, 1990] and Lucas [1988], placed the emphasis on the accumulation of human capital, existence of externalities and development of activities of innovation and R&D as principal mechanisms for increase in productivity and economic growth. We will present a model which is close to the model of Romer [1987], while adding agricultural sector and two goods consumed in the economy. This modeling makes endogenous growth of agriculture productivity through an endogenous increase of innovation in the economy as well as generates an endogenous structural change. This work is organized in the following way: A second empirical section analyzing the stylized facts of structural change by exploiting new dataset. The third section develops a model of endogenous structural change inspired of Romer [1987] and Matsuyama [1992]. The last section will be devoted to the conclusion.

2 Stylized facts

Empirically, the structural change is the reallocation of resources between three sectors: agriculture, industry and services. It is generally appreciated by the modification of sectoral shares of employment or added-value. This is why the examination of the structural change for a country or an region requires the availability of a long run sectoral dataset. Indeed, the structural change is a dynamic process and transversal for the economy as a whole. The recent development of some datasets makes it possible to supplement the traditional literature including work pionniers of Clark [1957], Chenery [1960], Kuznets [1966], and
Syrquin [1988]. The improvement of the quality of data allowed Herrendorf et al. [2013] and Rodrik [2013c] to use new data including that from OECD countries, Asian and of Latin America. The availability of the data on the African countries (see de Vries et al. [2013]) enables us to extend these facts stylized to this area where structural change is crucial. The dataset is built starting from the 10 sectors GGDC data and from African\(^3\). The two dataset make it possible to combine a set of data for 10 Asian countries, 9 in Latin America, 9 in Europe, 10 in Africa as well as the United-States. The data covers 10 sectors of the economy for the period 1950-2010 and contains in particular sectoral added-value at current price and sectoral employment in thousands of people. The two principal aggregates measuring the structural change are the share of the added-value and employment. The shares of employment are calculated by using the number of worker\(^4\) whereas the shares of the added-value are calculated as the ratio of nominal added-value on the total nominal added-value.

**Table 1 – Added-Value Shares**

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<tbody>
<tr>
<td>Asia</td>
<td>0.19</td>
<td>0.35</td>
<td>0.09</td>
<td>0.34</td>
<td>0.26</td>
<td>0.36</td>
<td>0.44</td>
<td>0.39</td>
<td>0.54</td>
</tr>
<tr>
<td>Latin America</td>
<td>0.13</td>
<td>0.18</td>
<td>0.09</td>
<td>0.34</td>
<td>0.32</td>
<td>0.33</td>
<td>0.52</td>
<td>0.50</td>
<td>0.58</td>
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<td>0.32</td>
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<td>0.25</td>
<td>0.64</td>
<td>0.56</td>
<td>0.72</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
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<td>0.34</td>
<td>0.23</td>
<td>0.27</td>
<td>0.24</td>
<td>0.26</td>
<td>0.46</td>
<td>0.43</td>
<td>0.51</td>
</tr>
<tr>
<td>World</td>
<td>0.18</td>
<td>0.26</td>
<td>0.14</td>
<td>0.31</td>
<td>0.29</td>
<td>0.29</td>
<td>0.51</td>
<td>0.46</td>
<td>0.57</td>
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**Table 2 – Labor Shares**

<table>
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</thead>
<tbody>
<tr>
<td>Asia</td>
<td>0.34</td>
<td>0.53</td>
<td>0.21</td>
<td>0.25</td>
<td>0.19</td>
<td>0.25</td>
<td>0.40</td>
<td>0.30</td>
<td>0.54</td>
</tr>
<tr>
<td>Latin America</td>
<td>0.33</td>
<td>0.45</td>
<td>0.19</td>
<td>0.22</td>
<td>0.21</td>
<td>0.21</td>
<td>0.44</td>
<td>0.33</td>
<td>0.61</td>
</tr>
<tr>
<td>OECD</td>
<td>0.10</td>
<td>0.17</td>
<td>0.03</td>
<td>0.11</td>
<td>0.36</td>
<td>0.23</td>
<td>0.60</td>
<td>0.47</td>
<td>0.74</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>0.63</td>
<td>0.73</td>
<td>0.54</td>
<td>0.13</td>
<td>0.10</td>
<td>0.13</td>
<td>0.25</td>
<td>0.16</td>
<td>0.34</td>
</tr>
<tr>
<td>World</td>
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<td>0.42</td>
<td>0.32</td>
<td>0.22</td>
<td>0.24</td>
<td>0.19</td>
<td>0.42</td>
<td>0.35</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Tables (1) and (2) show the overall employment moved during the fifty last years of the agricultural sector from (26%) down to (14%) and that of the industrial sector from (24%) down to (19%) and the profit of the services sector from (35%) upward to (50%). This resulted in the fall of the agricultural added-value from (26%) to (14%), and a stabilization in the industry sector around 29%, which sees an increase in the services sector from (46%) to (57%). The stabilization in the industry in spite of the fall of its share in employment is explained largely by the productivity gains carried out in the industrial sector. This phenomenon is very decided between the zones. The sector of the services is that which absorbs the

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3. The 10-sector GGDC database provides a set of data internationally comparable in the long run on the sectoral productivity in Asia, Europe, Latin America and the United States. The covered variables are annual series of the added-value, the deflators, and the people employed for 10 great sectors. It is composed of series of 10 countries of Asia, 9 in Latin America and 9 in Europe and in the United States. The sectoral database of Africa provides a set of data internationally comparable in the long run for the eleven countries of sub-Saharan Africa. The covered variables are the added-value at current price and constant, the deflators and the people employed (distribution according to the sex) for ten great sectors of the economy. The two bases are directly comparable and constitute relevant information to analyze the structural change.

4. It is possible to calculate employment effective according to the number of hour worked. Unfortunately this last variable is available by sector only for the OECD countries.
most labour and provides more added-value varying of 51% in Africa to 72% in the OECD countries. An African specificity is that the agricultural sector absorbs the most employment with height of 54%.

For OECD countries, the structural change is manifested by the decline in agricultural, industrial employment and the increase in services. A small share of the agricultural added-value around 2%.

For Asian countries, the history showed a transfer of labor towards industry and services sectors which increase in their respective shares of employment and added-value. The fall of agricultural employment is followed by significant drops in the added-value in the sector to the level of 10%. The African process is similar to the Asian countries in its global trends and relationship which also saw a drops of labor in agricultural sector towards industrial services sectors. We found the same trend of increase in the share of added-value in the industrial and services sectors. However, the difference is that sub-Saharan African countries kept 54% of employment in agricultural whereas it represents only 21% in Asia. In the same way the agricultural added-value accounts for only 9% in Asia but 23% in Africa.

Transfer of labor towards the industrial sector is too weak in Africa (10% to 1%), with a weak improvement of the industry added-value share from 24% to 27%.

For Latin American countries, there is a stabilization in labor share of the industrial sector which was accompanied by a fall in the industrial added-value and a huge transfer of labor from agricultural sector to services sector. There is also a significant drops of agricultural added-value and a considerable increase in services Sector. The figures (1) and (2) represent the process of structural change according to time. The vertical axes represent the share of employment or the added-value for three sectors: agriculture, industry or services. The data are represented by bubbles whose size is proportional to the size population. The horizontal axis represents the years.

The downward trend of added-value shares or labor in agricultural sector and the rise of the services sector is a clearly identified process in the graphs. However for the industrial sector, the profile of employment or added-value profile seems very disparate between countries. The profile of industry seems sometimes stagnant, decreasing or growing and even follow a hump shape. This is why we broke up the data into four samples: OECD countries, the Latin America, Asia and Africa. The figures (3) and (4) are shared in four panels: Agriculture, services, industry and manufacturing industries. Each panel is also broken up into four another under-panel: OECD countries including United States, Asian, Latin America and African countries.

The graphs clearly show the process of change against time. During the last fifty years we find a drop in labor and added-value shares for agriculture in all the regions with certain
Figure 3 – Shares of added-value

(a) Panel A

(b) Panel B

(c) Panel C

(d) Panel D

Figure 4 – Share of labor

(a) Panel A

(b) Panel B

(c) Panel C

(d) Panel D
stabilization at very low levels for OECD countries. Indeed, the structural change took place well before the 1960s in the OECD countries which explains why the share of the added-value is stable during 1960-2005. The shares of added-value in the services sector increased during the period for all the region and without exception. However, with regard to industry, the appreciations are mitigated. For OECD, there exists clearly a downward trend of employment and added-value of industry sector or manufacturing sector. However for the other regions and in particular Africa, we recorded a certain stabilization of the two shares in the general industries in general or manufacturing industries in particular. We observe also that employment and added-value shares follow a hump shape in Asia that is to say; there is an increase for lower levels of development and decreasing for higher levels of development. This conclusion is confirmed by the study Herrendorf et al. [2013], which examines various datasets and arrives at the same conclusion.

For better understanding of the phenomenon of structural change according to the development level, the figures (5) and (6) present the shares of employment and added-values sectoral according to the log of the GDP per capita in dollars of 1990 which relate to the whole sample. It is also noted that, the development process measured by the increase in the income per capita is accompanied by a particular shape of structural change. As the GDP per capita increases, employment moves toward agricultural sector and other sectors at the same time the share of added-value in agricultural sector decreases in a linear way according to the level of the income per capita. This linearity is reversed when one examines services sector where it is noticed that the share of employment and the added-value increases linearly according to the level of development. However the industrial sector or that of manufacturing industries displays a non-linear relation. Indeed, the share of employment or the added-value increases for low levels of GDP per capita falls when the country becomes more developed. This evolution like a hump shape shows that the share of labor or added-value of industry increases at the beginning of the development and drops later. This process of structural change could be described as the reallocation of resources from agricultural sector towards

\begin{table}
\centering
\caption{Log du PIB par tête en dollar USA 1990}
\begin{tabular}{lccc}
\toprule
 & mean & mean & mean \\
\midrule
Asie & 8.23 & 7.39 & 9.19 \\
Amérique Latine & 8.44 & 8.13 & 8.78 \\
OCDE & 9.46 & 8.94 & 10.02 \\
Afrique sub-Saharienne & 6.94 & 6.78 & 7.09 \\
Total & 7.57 & 7.26 & 7.90 \\
\bottomrule
\end{tabular}
\end{table}
industry and services sectors which is at low level of development, then the reallocation of
the resources coming from agriculture and industry towards the services when the level of
development increases. This process of disindustrialization, especially in OECD countries,
as the income increases starting from a given development threshold could be explained by
the delocalization of the industrial activities or insertion in the global values chain.

To avoid the problem of aggregation between different regions, we broke up the sample
into four regions like previously. The figures (7) and (8) describe this process according to
the sectors and regions.

With regard to the share of employment in industry, it clearly brings out a hump shape
curve for the OECD countries and Asian in particular. The share of employment thus seems
to evolve in a non-linear way with the level of economic development. However the examina-
tion of the graphs (7) concerning the share of the sectoral added-value shows the bell-shaped
curve for the added-value of the industrial sector describes well the process of structural
change in Asian countries. The structural change seems to be completed in OECD countries
whose evolution of the industrial added-value shares are decreasing during all the period
considered. Africa seems to be in the increasing phase of the bell-shaped curve whereas the
Latin America seems to be at the top of the bell-shaped curve since during all the period,
the share of the added-value of industry increases slightly. Africa seems to be very heteroge-
neous having countries whose share of the added-value of industry is in growth, stagnation or
according to a bell-shaped curve. The graph (9) shows that the structure change following a
bell-shaped curve is checked for the added-value in Botswana and Mauritius industry sector,
whereas for the eight others African countries, the share of the added-value of industry is
stagnant if not slightly increasing. The industrialisation does not seem to play a significant
role in the development process of the these African countries (Rodrik [2013c,a, 2014] and
de Vries et al. [2013]).

For better determining this process of structural change, one carries out an econometric
estimate in panel of the following equation:

\[ S_j = \alpha + \beta \log y_i + \delta \text{year} \]  

\( j = \text{industry, agriculture, service}, \) \( i \) are the country and \( S_j \) are the share of the added-
value of the sector \( j \) or the share of labor of the sector \( j \). Several regressions were made but
we report only those based on the use of the method of least squares generalized to estimate
the parameters in a linear model of regression where the errors are correlated in series. More
precisely, the errors are supposed to continue an autoregression process of first order\(^5\).

\(^5\) One uses the order prais under Stata.
**Figure 5** – Shares of added-value according to the level of development

(a) Panel A

(b) Panel B

(c) Panel C

(d) Panel D

**Figure 6** – Shares of labor according to the level of development

(a) Panel A

(b) Panel B

(c) Panel C

(d) Panel D
**Figure 7** – Shares of added-value by region according to the level of development

(a) Panel A  
(b) Panel B  
(c) Panel C  
(d) Panel D

**Figure 8** – Shares of labor by region according to the level of development

(a) Panel A  
(b) Panel B  
(c) Panel C  
(d) Panel D
Tables (1), (2) and (3) reports the econometric results for the share of the added-value as dependant variable whereas tables (4) (5) and (6) reports the results of the estimate of the equation for the share of employment as dependant variable. The share of the agricultural added-value as well as the share of employment are correlated negatively with the level of development (Table (1) and (4)). The downward trend of added-value share in Agriculture is confirmed for all regions since the coefficient $\delta$ is significant and negative. The share of agricultural employment in the OECD countries and Asia does not seem to show a linear trend downwards significant even if the level of employment in these two regions is most negatively correlated with the level of development. The coefficients of correlation for Asia between the share of employment or the added-value with the level of development are highest.

For the services, the share of employment and that of the added-value have a positive deterministic linear trend except for the share of labor in Latin America services sector. The dynamics of the increase in services shares thus is well highlighted in the econometric estimate. The services labor share is also correlated positively with the level of development thus showing another aspect of the process of structural change. A paradoxical result emerges in Asia and Africa where the share of the added-value in services seems to be negatively correlated with the level of development (Table (2) whereas the share of employment is
positively correlated.

For the industrial sector, the shares of employment and added-value are positively correlated with the level of development for all regions. The downward trend of employment share in the OECD countries is the strongest followed by Asia and marginally by Latin America countries. Africa does not display this downward trend of the industrial employment what could be explained as not being a completed structural change. With regard to the share of the added-value of the industrial sector, the OECD countries seems in a path of deindustrialisation benefiting Asia region as we find out a downwards trend in OECD countries and upwards in Asia. No trend is statistically significant for the Latin America and Africa regions what confirms our intuitions starting from the graphs.

To determine the hump shape curve effect in the industrial sector, one adds the log of the GDP per capita squared to capture this nonlinearity effect. The equation is the following one:

\[ S_j = \alpha + \beta \log y_i + \gamma \log y_i^2 + \delta \text{year} \] (2)

Tables (7) and (8) reports the econometric estimates of the equation (2). It arises clearly as at the global level the nonlinear effect exists as well for employment as for the added-value. Asia displays also this phenomenon of hump shape curve for the two measurements. However for the OECD countries, this non-linear effect appears only in the share of the industrial employment; The share of the industrial added-value displays only a downward trend. Nonlinearity exists in Africa with regard to the share of employment but completely absent for the share of the added-value. The Latin America is a typical case where the effect of nonlinearity is absent in the estimate of the structural change as well by using the measurement of the added-value share as of employment share.

In short, the last fifty years show that for certain countries, structural transition is completed or committed like countries with high income and Asian. For others, Latin American or African countries, the transition are slow and incomplete. Indeed, the employment share of agriculture dropped in an important way. However, while agriculture employment shares are decreasing during the period and reach very low levels in Asia and high-income countries, these shares are always very high in Latin America and Africa. This finding implies that the relatively low rate of transition between agriculture and nonagricultural activities is one of the facts concerning the economic development of Latin America and Africa. At the same time, the share of the services strongly increased in Latin America and Africa with a certain stagnation of industry shares in Latin America and Africa. It is thus obvious that the fall of agriculture employment share involved an increase of services share, while the share
of industrial sector was almost stable. Which are the mechanisms which make it possible to obtain a complete structural change? Why does one observe in all the countries a fall of agricultural employment share? How could the growth of the productivity induce this structural change? What are the endogenous factors of the structural change?

The next section develops a model of innovation and research and development that generates an endogenous structural change.

Economy has four sectors: traditional (agriculture) and two industrial sectors (manufacturing, intermediate) and a final R&D. A single factor of production, labor available in fixed quantity $L$ and allocated only between three sectors. The manufacturing sector does not use labor services. There are two types of agents: households and firms. Two goods are produced for final consumption: the agriculture sector produces a food commodity $Z$ and the manufacturing sector produced a durable consumption good $Y$.

### 2.1 Producers

**Production of durable consumer goods**

The durable consumption good, $Y$, is produced by combining only a variety of intermediate goods $\Phi = (x(v, t) : \in [0, N \subset R^+])$. The quantity $x(v, t)$ refers to the level of production of the variety of good $v$ used in the sector of durable goods. The number $N(t)$ represents the input more recently invented so that the interval $[0, N]$ represents the range of intermediate goods available for producing the final production. The production function is:

$$Y(t) = \left( \int_0^{N(t)} x(v, t)^{\frac{\gamma - 1}{\gamma}} dv \right)^{\frac{1}{\gamma - 1}} \tag{3}$$

with $\gamma > 1$. The increase in the number of varieties of differentiated intermediate goods rises the total factor productivity in the manufacturing sector. The representative producer of the manufacturing sector purchases inputs $x(v, t)$ producers of intermediate goods priced at $p(v, t)$. The demand of intermediate inputs is:

$$x(v, t) = \frac{p(v, t)^{-\gamma}}{Y(t)^{\gamma}} \tag{4}$$

**Production of intermediate goods**

Each unit of intermediate goods is produced using $1/k$ labor unit. Total employment in this sector is:

$$(L_i(t)) = \frac{1}{k} \int_0^{N(t)} x(v, t)dv \tag{5}$$
Intermediate goods firms are monopolistic competition in differentiated goods which are sold
to the consumer durables sector. Each of the firms faced the following problem :

$$\max_{x(v,t)} \pi(v,t) = p(v,t)x(v,t) - \frac{1}{k}w(t)x(v,t)$$  \hspace{1cm} (6)

With $w(t)$ labor wage rate. Using (2), the equilibrium is characterized by a standard
mark – up rule :

$$p(v,t) = mw(t)k$$  \hspace{1cm} (7)

With $m = \frac{\gamma}{(\gamma-1)} > 1.$ the coefficient of mark - up. The profit is then written :

$$\pi(v,t) = \frac{w(t)x(v,t)}{(\gamma-1)k}$$  \hspace{1cm} (8)

**Research & Development sector**

We assume that new technologies or processes for the production of intermediate goods
are invented in a sector of R &D that uses a $L_{R}(t)$ unit of labor. Labor productivity in this
sector depends on the knowledge accumulated in the activity of the invention. So when a
new process for new manufactured input is known, it becomes immediately a public good
free of charge in the sector of R &D.

The decision of producing new process of intermediate input is determined by the unit
cost of innovation :

$$q(v,t) = \frac{w(t)}{BN(t)}$$  \hspace{1cm} (9)

Before embarking on a process of manufacturing a new input, the potential firm in the
intermediate goods sector must acquire a production licence. Once the license is obtained, no
other firm could produce the corresponding product. As monopolistic competition prevails,
the productive exploitation of the patent allows to charge the input $x(v,t)$ at a price higher
than its marginal cost and the profit $\pi(v,t)$. The potential firm engages in the purchase and
exploitation of the patent only if the present value of the stream of profit $q^a$ is not less than
$q(v,t)$, where :

$$q^a(v,t) = \int_{t}^{\infty} e^{-r(\tau-s)}\pi(v,\tau)d\tau$$  \hspace{1cm} (10)

With $r(t)$ the real interest rate.

The flow of new manufacturing processes is evolving according to :

$$\dot{N}(t) = bL_{r}(t)N(t) \quad \text{si} \quad q(v,t) = q^a(v,t)\quad \dot{N}(t) = 0 \quad \text{si} \quad q(v,t) > q^a(v,t)$$

16
The condition of non-arbitrage\textsuperscript{6} translates into equality of the real interest rate to the effective return of innovation:

\[ r(t) = \frac{\pi(v,t)}{q(v,t)} + \frac{\dot{q}(v,t)}{q(v,t)} \]  

(11)

\textbf{Agricultural sector}

The agriculture good \( Z(t) \) is produced using labor \( L_z(t) \). The agriculture sector enjoys the externality of the stock of knowledge accumulated in the activity of R & D. The externality is represented by the term \( A(t) \) which will be specified later. Technology is linear and constant returns to scale:

\[ Z(t) = A(t) L_z(t) \]  

(12)

The wage rate is determined by:

\[ w(t) = p_z(t) A(t) \]  

(13)

\textbf{2.2 Consumers}

Each consumer has a fixed dotation of labor that is paid in form of wage rate \( w(t) \). The only asset \( M(t) \) available represents the possession patent rights, \( N(t) q(v,t) \), and conveyed a rate of nominal return \( i \).

The representative consumer consumes two goods \( C_y(t) \) and \( C_z(t) \). Its instantaneous utility function is:

\[ Z(t) = \frac{\sigma}{\sigma - 1} \left( C_y^{\beta-\gamma} C_z^{1-\beta} \right)^{\frac{\sigma-1}{\sigma}} \]  

(14)

He chooses a plan of consumption \( (C_y, C_z) \) and assets management that solve the following problem:

\[
\max_{C_y, C_z} W(t) = \int_0^\infty [U(C_y, C_z)] e^{-\rho t} dt
\]

s.c

\[ M(t) = i(t) M(t) + w(t) L(t) - p_y(t) C_y(t) - p_z(t) C_z(t) \]

\textsuperscript{6} this condition is obtained by differentiation of (8).
It is well known that this type of program could be resolved in two stages. In the first
place, the consumer maximizes an instant utility \( U \) for a given expense \( E(t) \) allocated between
the consumption of the two goods. This program is written :

\[
\max_{C_y, C_z} U(t) = C_y(t)^\beta (C_z(t) - \theta)^{1-\beta} \\
\text{s.c} \\
p_y(t)C_y(t) + p_z(t)(C_z(t) - \theta) \leq E(t)
\]

Along an optimal path, the share of total consumption between the two types of goods
is determined by the equality of the marginal utilities to the relative price of two goods. It
is determined by :

\[
\frac{p_y(t)p_z(t)}{p_y(t)} = \frac{\beta(C_z(t) - \theta)}{(1 - \beta)C_y(t)} \tag{15}
\]

Marshallian demand functions are :

\[
C_y(t) = \beta \frac{E(t)}{p_y(t)} \\
C_z(t) - \theta = (1 - \beta) \frac{E(t)p_z(t)}{p_y(t)}
\]

The indirect utility function is determined by :

\[
u(t) = ep(t)y^\beta p(t)z^{(1-\beta)}E(t) \tag{16}\]

By setting an aggregate consumption, \( C \), of both goods to which we associate an index
price \( P(t) \). We then get \( C(t) = \frac{E(t)}{P(t)} \) and \( P(t) = ep(t)y^\beta p(t)z^{(1-\beta)} \) with \( c = \beta(1-\beta)^{(1-\beta)} \). Second, the consumer solves an intertemporel optimization problem :

\[
\max_{C(t)} W(t) = \int_0^\infty \frac{\sigma}{\sigma - 1} C(t)^{\frac{\sigma+1}{\sigma}} e^{-\rho t} dt \\
\text{s.c} \\
\dot{M}(t) = i(t)M(t) + w(t)L(t) - P(t)C(t)
\]

Aggregate consumption evolves according to :

\[
\frac{\dot{C}(t)}{C(t)} = \sigma \left( i(t) - \frac{\dot{P}(t)}{P(t)} - \rho \right) \tag{17}\]

18
2.3 Symmetric equilibrium of steady growth

The symmetric equilibrium of steady growth is defined by a constant and common growth rate of real variables, $g$, the equilibrium of markets and the symmetrical behavior of intermediate goods firms $p_x(v,t) = p_x$ and $x(v,t) = x$. Prices and the profits of the symmetric equilibrium are defined by:

$$p_x(t) = m \frac{w(t)}{k}$$

$$\pi(t) = \frac{w(t)x(t)}{(\gamma - 1)k}$$

The equilibrium of labor market leads to:

$$L(t) = (t)L_i + L_r(t) + L_z(t)$$

With $X(t) = N(t)x(t)$, the total supply of intermediate goods, the volume of production of manufacturing goods is equal to:

$$Y(t) = A(t)X(t)$$

with $A(t) = N(t)^{1 \gamma - 1}$ the average index of technical progress which is growing at the rate $g_A = \frac{1}{\gamma - 1}g_N$. By replacing $X(t)$ by (3), we obtain $Y(t) = A(t)kL(t)i$. Since the durable consumption good is a combination of these intermediate goods, the aggregate value shall be equal to the expenditure on consumer durables:

$$p_y(t)Y(t) = N(t)p_x(t)x(t)$$

This allows us to determine the prices of manufacturing goods $p_y$ so that:

$$p_y(t) = p_x(t)/A(t)$$

In steady growth, $X(t)$ is constant. We derive then from (10) and (19) the following relationships: $g_y = g_A$, $g_z = \epsilon g_A$. By taking the price of the durable good as reference $p_y = 1$, we obtain from (21) $g_{p_x} = g_A$ and therefore (16) allows to write $g_{p_x} = g_w = g_A$ and (9) to have $g_x = g_q$. Finally using (11), he just $g_{p_x} = (1 - \epsilon)g_A$ from where $g_p = (1 - \beta)(1 - \epsilon)g_A$ and $g_C = (\beta + (1 - \beta)\epsilon)g_A$ note $g$ the growth rate of consumption or the aggregate supply of the two goods in the economy. National revenue $RN$ is equal to:

$$RN(t) = q(t)N(t) + p_y(t)Y(t)p_z(t)Z(t)w(t)L(t) = +\Pi(t)$$

It increases at the rate $g_A$. 


2.4 Structural change

Structural change is described by the reallocation of employment among the three sectors, namely agriculture, intermediate goods, and R&D. As it is the engine of growth, structural change is expected to lead to a reallocation of employment to the more modern sector from the agricultural sector. In a closed economy \( C_z(t) = A(t)^r L_z(t) \) and \( C_y(t) = A(t)X(t) \) allowing to insert them into the relationship (13) and get:

\[
\frac{p_y(t)p_z(t)}{p_z(t)} = \frac{\beta(A(t)^r L_z(t) - \theta)}{(1 - \beta)A(t)X(t)}
\]

(25)

The Equalization of labor marginal productivity between sectors allows obtaining from (11) and (16):

\[
p_z(t)A(t)^r = \frac{kp_z(t)}{m}
\]

(26)

Taking \( p_y = 1 \), and using (21), \( p_x(t) = A(t) \) and (23) becomes:

\[
\frac{1}{p_z(t)} = \frac{\beta(A(t)^r L_z(t) - \theta)}{(1 - \beta)A(t)kL_i(t)} = \frac{A(t)^r}{mkA(t)}
\]

(27)

Simplification allow obtaining two following relations describing the sector allocation of labor between the agricultural sector and intermediate goods:

\[
L_z(t) = \left(1 - \frac{\beta}{1 - \gamma}\right) \left(\frac{\gamma}{\gamma - 1}\right) \left(L_i(t) + \theta A(t)^{-r}\right)
\]

(28)

\[
L_i(t) = \left(\frac{\beta}{1 - \beta}\right) \left(1 - \frac{\gamma}{\gamma}\right) \left(L_z(t) - \theta A(t)^{-r}\right)
\]

(29)

Although there is a positive correlation between employment in the agricultural sector and the intermediate goods sector, there exist also a negative correlation between agricultural employment and technological progress generated by the R&D or the increase in the number of intermediate goods produced by the economy \( \frac{\partial L_z}{\partial A} < 0 \). This relationship is reversed between the intermediate goods sector employment and technical progress \( \frac{\partial L_z}{\partial A} > 0 \). As \( A \) is increasing at a constant rate. Economic growth led to a decline in agricultural employment and a growth of industrial employment in the intermediate goods sector. In absence of externality in the agricultural sector, agricultural employment becomes constant. Its presence allows both to increase productivity in the agricultural sector and free labor to the manufacturing sector. This structural change in the allocation of employment acts as a benefit for the engine growth sector which is the research and development. Indeed, the use of the constraint of availability of labor (18) allow obtaining:
\[ L_r(t) = L(t) - \left( \frac{(\gamma - \beta)}{\beta(\gamma - 1)} \right) L_i(t) - \left( \frac{(\gamma - \beta)}{\beta(\gamma - 1)} \right) \theta A^{-\epsilon} \]  

(30)

Or alternatively:

\[ L_i(t) = \left( \frac{\beta(\gamma - 1)}{(\gamma - \beta)} \right) L(t) - \left( \frac{\beta(\gamma - 1)}{(\gamma - \beta)} \right) L_r(t) - \theta A^{-\epsilon} \]

The sectoral allocation mechanisms are also exercising for the benefit of the R&D sector which is the engine of growth. As \( \gamma > \beta \), employment in the industrial sector is decreasing function of employment in the sector of research and development but growing with innovation. This mechanism of structural change in the allocation of employment is generated mainly by innovation and the R&D. It is very subtle for two reasons. More the economy produces innovation; more productivity increases in agriculture and higher the number of goods produced by the industrial sector. This mechanism of productivity frees up the labor of the two sectors to research and development sector, which in turn produces innovation. The mechanism is endogenous and the virtuous circle of structural change is endogenous.

To understand these mechanisms, we differentiate the equation (26) and (28). We get the dynamics of labor allocation linked to the economic growth:

\[ g_{L_z} = \left[ \left( \frac{1 - \beta}{\beta} \right) \left( \frac{\gamma}{\gamma - 1} \right) l_{i,z} \right] g_{L_i} - \epsilon \left( 1 - \left( \frac{1 - \beta}{\beta} \right) \left( \frac{\gamma}{\gamma - 1} \right) l_{i,z} \right) g_A \]  

(31)

\[ g_{L_R} = l_{i,r} g_{L_i} - \left( \frac{\gamma - \beta}{\beta(\gamma - 1)} l_{i,r} \right) g_{L_i} + \epsilon \left( l_{i,r} - \left( \frac{\gamma - \beta}{\beta(\gamma - 1)} l_{i,r} \right) - 1 \right) g_A \]  

(32)

\[ A = l_{i,z} = L_{L_z} \text{ and } l_{i,r} = L_{L_r} \]

The dynamics of structural change is determined by endogenous technical progress generated by the increase in the number of goods or technical knowledge. It is obvious that the expression (29) shows that endogenous technological progress led to the decline of the allocation of labor to the traditional agricultural sector. This mechanism is due to the presence of the externality. If \( \epsilon = 0 \), the impact of \( g_A \) disappears from the equation (29). Therefore, through the improvement of the productivity in the agricultural sector that labor is released from agriculture. Equation (30) traces a positive impact of \( g_A \) on the allocation of labor in the engine sector of the economy while having a negative relationship between growth of industrial employment and research and development which is not the case with agricultural employment. Indeed, even if there is a positive relationship between agricultural and industrial employment, endogenous technical progress will release the agricultural workforce. However, the R&D employment undergoes two different mechanisms: the increase in the

\[ 7. \text{ one omits the variable } t \]
labor force in the intermediate goods sector reduced while endogenous technical progress increases it.

2.5 determination of endogenous growth rate

The endogenous character of the growth comes from the fact that the rate of growth $g$ and $g_A$ are related to the Knowledge growth rate $g_N$ which depends only on the share of labor allocated to R&D activity. These relationships are:

\[ g = (\beta + (1 - \beta)\epsilon)g_A \]  
(33)

\[ g_A = \left(\frac{1}{\gamma - 1}\right)g_N \]  
(34)

\[ g_N = BL_r \]  
(35)

We have just to find the endogenous determinants of $L_R$ to explain those of $g_N$, $g_A$ and $g$. A simple way to characterize the endogenous growth path is to consider a steady allocation of labor so that:

\[ g_{L_i} = g_{L_r} = g_{L_z} = g_L = 0 \]  
(36)

This constant allocation also corresponds to the absence of transitional dynamics in the model when considering homothetic preferences $\theta = 0$. Indeed, by inserting (34) in (29) and (30) or to consider $\theta = 0$ in (11), (13) and (19), one obtains the following relationships:

\[ L_z = \left(\frac{1 - \beta}{\beta}\right)\left(\frac{\gamma}{\gamma - 1}\right)L_i \]  
(37)

\[ L_r = L - \left(\frac{\gamma - \beta}{\beta(\gamma - 1)}\right)L_i \]  
(38)

The dynamics of labor allocation depends on the properties of the two equations (35) and (36). The first equation establishes a positive relationship between agricultural employment and employment in the intermediate sector. When $\beta < 1/2$, then $\left(\frac{1 - \beta}{\beta}\right) > 1$. A reduction of 1% from $L_i$ led to a more than proportional reduction of $L_z$ and vice versa it. This property is derived from the specification of the preferences of the consumer. So when $\beta$ is low, the consumer gives low weight to consumption of durable goods and therefore substitute strongly agricultural employment to employment of the good manufacturing.

So there is a relationship of proportionality between employment for R &D and one dedicated to the production of durable goods. As $\gamma > \beta$, a given distribution of labour which increases the rate of growth of innovation, $g_N$, requires a change in the allocation for the
benefit of the research, \( g_N = B \left( L - \left( \frac{\gamma - \beta}{\beta (\gamma - 1)} \right) L_i \right) \). As \( L_i \) correlates positively with \( l_z \), growth requires the transfer of the workforce in the agricultural sector and the intermediate goods sector to the engine sector of growth which is the R&D. The latter allows, by the effects of externalities and the extension of the number of varieties to increase productivity in other sectors and thus compensate the decrease of labor employed by these sectors.

If in special circumstances, e.g. cost reduction, employment in intermediate goods sector is reduced, it releases then labor for the benefit of research sector which is beneficial to the growth.

Therefore, in arranging (32) and (33), one obtains:

\[
\frac{B L_i}{\gamma - 1} = \left( \frac{\beta (\gamma - 1)}{\gamma - \beta} \right) \left( \frac{B}{\gamma - 1} L - g_A \right)
\]

(39)

Knowing that total employment in the manufacturing sector is determined by (3) the symmetric equilibrium:

\[
L_i(t) = \frac{1}{k} N(t) x(t)
\]

(40)

Using (17) and (7) making the necessary substitutions in the expression of the profit \( \pi \), we get:

\[
\pi = \frac{w(t) x(t) / (\gamma - 1) k}{w(t) / BN(t)} = \frac{BN(t) x(t)}{(\gamma - 1) k} = \frac{B}{\gamma - 1} L_i
\]

However the amount \( \left( \frac{B}{\gamma - 1} \right) L_i \) can be obtained from (37).

From the condition of non-arbitration (9) when \( \dot{q}(t) = 0 \) and the expression of the growth rate described by (31), we then get the expression of interest real rate \( r \):

\[
r = \left( \frac{\beta}{\gamma - \beta} \right) BL - \left( \frac{\gamma (\gamma - 1) - (\gamma - \beta) (\beta + (1 - \beta) \epsilon)}{(\beta + (1 - \beta) \epsilon) (\gamma - \beta)} \right) g = \phi_1 BL - \phi_2 g
\]

(41)

With

\[
\phi_1 = \left( \frac{\beta}{\gamma - \beta} \right) \\
\phi_2 = \left( \frac{\gamma (\gamma - 1) - (\gamma - \beta) (\beta + (1 - \beta) \epsilon)}{(\beta + (1 - \beta) \epsilon) (\gamma - \beta)} \right)
\]

It describes a decreasing line between growth rate and real interest rate (RR line in figure 1) while the consumer behavior provides a positive relationship (Line DC in figure 1).

\[
r = \sigma^{-1} g + \rho
\]

(42)
Endogenous growth rate is determined by:

\[ g = \sigma^{-1} \left( \phi_1 BL - \rho \frac{1}{1 + \sigma \phi_2} \right) \]

**Figure 10 – Endogenous structural change**

The agricultural sector benefits from externalities generated by technical progress resulting from the activity of R &D. The industrial sector is growing much faster than the agricultural sector. A property of the model that corresponds to the stylized facts and which reflects unbalanced growth between the regions. So in absence of externality in the agricultural sector (\( \epsilon = 0 \)), it becomes stagnant. The term \( A \) represents both the productivity of the agricultural sector and the level of technical progress in the economy. There is thus a positive link between agricultural productivity and economic growth but in any case the R&D sector is the engine of growth. The important thing here, and unlike the model of Matsuyama [1992], is that agricultural productivity is endogenous.

### 3 conclusion

The objective of the paper is to propose a model of endogenous structural change which allows to bind the endogenous growth theory to the [Romer, 1987, 1986, 1990] with the concerns of the literature of structural change. This model helped to bridge the gap between the two literature and give endogenous foundations to the intuitions of Matsuyama [1992] the
process of structural change through endogenous increases in the productivity of agriculture and the endogenous process of industrialization.

The model could be improved by explicitly introducing another sector of service or by analyzing the impact of open economy open and particular trade in intermediate goods on the process of structural change.

Références


### Table 4 – Dependant variable: share of agriculture added-value

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Asia</th>
<th>Latin America</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>-0.078***</td>
<td>-0.031***</td>
<td>-0.113***</td>
<td>-0.069***</td>
<td>-0.036***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.008)</td>
<td>(0.010)</td>
<td>(0.012)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>year</td>
<td>-0.002***</td>
<td>-0.001***</td>
<td>-0.002***</td>
<td>-0.001***</td>
<td>-0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>4.004***</td>
<td>1.519***</td>
<td>4.309***</td>
<td>3.288***</td>
<td>5.453***</td>
</tr>
<tr>
<td></td>
<td>(0.614)</td>
<td>(0.332)</td>
<td>(1.059)</td>
<td>(0.771)</td>
<td>(1.553)</td>
</tr>
<tr>
<td>N</td>
<td>1722.000</td>
<td>318.000</td>
<td>453.000</td>
<td>399.000</td>
<td>552.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.285</td>
<td>0.535</td>
<td>0.631</td>
<td>0.319</td>
<td>0.187</td>
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</tbody>
</table>

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

### Table 5 – Dependant variable: share of services added-value

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Asia</th>
<th>Latin America</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>0.018**</td>
<td>0.028</td>
<td>-0.054***</td>
<td>0.049**</td>
<td>-0.034**</td>
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<tr>
<td></td>
<td>(0.008)</td>
<td>(0.018)</td>
<td>(0.017)</td>
<td>(0.022)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>year</td>
<td>0.002***</td>
<td>0.004***</td>
<td>0.006***</td>
<td>0.001</td>
<td>0.003***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.435***</td>
<td>-7.663***</td>
<td>-10.330***</td>
<td>-1.344</td>
<td>-4.759***</td>
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<tr>
<td></td>
<td>(0.769)</td>
<td>(0.745)</td>
<td>(1.666)</td>
<td>(1.371)</td>
<td>(1.512)</td>
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<tr>
<td>N</td>
<td>1540.000</td>
<td>318.000</td>
<td>271.000</td>
<td>399.000</td>
<td>552.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.306</td>
<td>0.897</td>
<td>0.261</td>
<td>0.442</td>
<td>0.186</td>
</tr>
</tbody>
</table>

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

### Table 6 – Dependant variable: share of industrie added-value

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
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<th>Latin America</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>0.047***</td>
<td>0.060***</td>
<td>0.092***</td>
<td>0.028</td>
<td>0.065***</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.018)</td>
<td>(0.016)</td>
<td>(0.021)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>year</td>
<td>-0.001</td>
<td>-0.005***</td>
<td>0.028***</td>
<td>0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.007)</td>
<td>(0.001)</td>
<td>(0.001)</td>
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<td>Constant</td>
<td>0.971</td>
<td>8.863***</td>
<td>-50.700***</td>
<td>-0.724</td>
<td>0.164</td>
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<tr>
<td></td>
<td>(0.776)</td>
<td>(0.759)</td>
<td>(12.392)</td>
<td>(1.274)</td>
<td>(1.411)</td>
</tr>
<tr>
<td>N</td>
<td>1722.000</td>
<td>318.000</td>
<td>443.000</td>
<td>399.000</td>
<td>552.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.151</td>
<td>0.846</td>
<td>0.127</td>
<td>0.248</td>
<td>0.113</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01
### Table 7 – Dependent variable: share of agriculture employment

<table>
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<th>World</th>
<th>OECD</th>
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<th>Africa</th>
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</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>-0.138*** (0.005)</td>
<td>-0.158*** (0.010)</td>
<td>-0.155*** (0.012)</td>
<td>-0.098*** (0.012)</td>
<td>-0.109*** (0.009)</td>
</tr>
<tr>
<td>year</td>
<td>-0.002*** (0.000)</td>
<td>0.000 (0.000)</td>
<td>-0.001 (0.001)</td>
<td>-0.005*** (0.000)</td>
<td>-0.003*** (0.000)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.484*** (0.437)</td>
<td>1.110** (0.536)</td>
<td>3.469*** (1.320)</td>
<td>10.546*** (0.756)</td>
<td>8.256*** (0.844)</td>
</tr>
<tr>
<td>N</td>
<td>1827.000</td>
<td>425.000</td>
<td>398.000</td>
<td>492.000</td>
<td>512.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.642</td>
<td>0.786</td>
<td>0.716</td>
<td>0.709</td>
<td>0.537</td>
</tr>
</tbody>
</table>

### Table 8 – Dependent variable: share of services employment

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Asia</th>
<th>LatinAmeri</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>0.044*** (0.005)</td>
<td>0.026** (0.011)</td>
<td>0.009 (0.016)</td>
<td>0.044*** (0.011)</td>
<td>0.056*** (0.008)</td>
</tr>
<tr>
<td>year</td>
<td>0.004*** (0.000)</td>
<td>0.005*** (0.000)</td>
<td>0.006*** (0.001)</td>
<td>0.005*** (0.000)</td>
<td>0.004*** (0.000)</td>
</tr>
<tr>
<td>Constant</td>
<td>-8.627*** (0.446)</td>
<td>-10.463*** (0.629)</td>
<td>-11.050*** (1.648)</td>
<td>-10.480*** (0.658)</td>
<td>-7.410*** (0.746)</td>
</tr>
<tr>
<td>N</td>
<td>1550.000</td>
<td>421.000</td>
<td>171.000</td>
<td>492.000</td>
<td>466.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.225</td>
<td>0.824</td>
<td>0.398</td>
<td>0.433</td>
<td>0.192</td>
</tr>
</tbody>
</table>

### Table 9 – Dependent variable: share of industry employment

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Asia</th>
<th>LatinAmeri</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>0.076*** (0.005)</td>
<td>0.127*** (0.010)</td>
<td>0.112*** (0.012)</td>
<td>0.073*** (0.010)</td>
<td>0.060*** (0.007)</td>
</tr>
<tr>
<td>year</td>
<td>-0.002*** (0.000)</td>
<td>-0.006*** (0.000)</td>
<td>-0.003*** (0.001)</td>
<td>-0.001** (0.000)</td>
<td>0.000 (0.000)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.017*** (0.409)</td>
<td>10.144*** (0.550)</td>
<td>5.967*** (1.263)</td>
<td>1.301* (0.674)</td>
<td>-0.438 (0.726)</td>
</tr>
<tr>
<td>N</td>
<td>1822.000</td>
<td>421.000</td>
<td>397.000</td>
<td>492.000</td>
<td>512.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.238</td>
<td>0.843</td>
<td>0.208</td>
<td>0.285</td>
<td>0.122</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

source

* p<0.1, ** p<0.05, *** p<0.01
### Table 10 – Dependant variable: Share of added value of industry with nonlinear effect

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Asia</th>
<th>Latin America</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>0.387***</td>
<td>0.089</td>
<td>0.586***</td>
<td>0.645</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>(0.062)</td>
<td>(0.380)</td>
<td>(0.103)</td>
<td>(0.411)</td>
<td>(0.158)</td>
</tr>
<tr>
<td>log GDP per Capita Square (1990)</td>
<td>-0.021***</td>
<td>-0.002</td>
<td>-0.030***</td>
<td>-0.035</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.020)</td>
<td>(0.006)</td>
<td>(0.024)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>year</td>
<td>-0.000</td>
<td>-0.004***</td>
<td>-0.001</td>
<td>-0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.068</td>
<td>8.373***</td>
<td>-0.664</td>
<td>-2.555</td>
<td>-0.096</td>
</tr>
<tr>
<td></td>
<td>(0.755)</td>
<td>(2.109)</td>
<td>(1.599)</td>
<td>(1.866)</td>
<td>(1.493)</td>
</tr>
<tr>
<td>N</td>
<td>1722.000</td>
<td>318.000</td>
<td>453.000</td>
<td>399.000</td>
<td>552.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.225</td>
<td>0.851</td>
<td>0.148</td>
<td>0.302</td>
<td>0.123</td>
</tr>
</tbody>
</table>

Source

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

### Table 11 – Dependant variable: Share of labor of industry with nonlinear effect

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Asia</th>
<th>Latin America</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP per Capita (1990)</td>
<td>0.150***</td>
<td>0.671***</td>
<td>0.581***</td>
<td>-0.003</td>
<td>-0.240***</td>
</tr>
<tr>
<td></td>
<td>(0.034)</td>
<td>(0.115)</td>
<td>(0.083)</td>
<td>(0.193)</td>
<td>(0.073)</td>
</tr>
<tr>
<td>log GDP per Capita Square (1990)</td>
<td>-0.005**</td>
<td>-0.031***</td>
<td>-0.028***</td>
<td>0.004</td>
<td>0.022***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.011)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>year</td>
<td>-0.002***</td>
<td>-0.005***</td>
<td>-0.003***</td>
<td>-0.001**</td>
<td>0.065***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.558***</td>
<td>6.291***</td>
<td>3.545***</td>
<td>1.574</td>
<td>-83.720***</td>
</tr>
<tr>
<td></td>
<td>(0.439)</td>
<td>(0.951)</td>
<td>(1.187)</td>
<td>(0.958)</td>
<td>(24.489)</td>
</tr>
<tr>
<td>N</td>
<td>1822.000</td>
<td>421.000</td>
<td>397.000</td>
<td>492.000</td>
<td>501.000</td>
</tr>
<tr>
<td>R-sq.</td>
<td>0.314</td>
<td>0.857</td>
<td>0.345</td>
<td>0.313</td>
<td>0.149</td>
</tr>
</tbody>
</table>

Standard errors in parentheses