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Human capital, structural change and growth: the role of export discoveries and entrepreneurship

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Abstract: Human capital measures (schooling) are poorly significant in explaining growth for developing countries. An explanation is that increases in human capital have no significant effect on growth if this human capital is misallocated and underemployed. In a simple two-sector model of a small open economy, we show that the effect of education on growth is more significant if the country has entered into the structural change that raises the demand for skilled labour. We give a special attention to the role of entrepreneurs in the increase in the demand for skills in the modern sector and propose to link it to the literature on export discoveries. We then derive an econometric specification from a simple two-sector model of growth with structural change and different levels of skills. From a sample of emerging economies including five MENA countries, we provide econometric evidence that the reduction in the traditional share of GDP and an increased amount of discoveries in export both have a positive influence on growth rates. We also show that if the drop in traditional activities is to matter for growth, it is less through the skill reallocation from traditional to modern activities, even though export diversification is a factor of higher growth, than through the enhancement of the effect human capital has on the growth of GDP. Then, if the reallocation of skills is to matter, it is more probably through shifts among the industrial sector, from the older to the newer activities than across sectors, from the traditional to the modern.

1. Introduction

Education is a key theoretical factor in economic growth and development. However, empirical evidence is mixed and aggregate studies generally fail to assess the nature of that relationship. Moreover, human capital has been rarely linked to the process of structural change underlying both the development process and the deepening of integration to the global economy. Openness to trade and to FDI implies significant shifts regarding the structure of employment, production and exports. Education and skills are necessary a central feature of this structural reallocation of resources. Firstly, factor endowments determine the very nature and direction of the structural shifts encompassed by a growing economy. Secondly, it is the interaction of a given level of schooling with the needs from structural change that matters the most for growth and not a high level of education alone. This paper focuses upon the last dimension.

Human capital measures (schooling) are poorly significant in explaining growth for developing countries (Benhabib and Spiegel, 1994). This is a paradox in regard of the huge case for human capital as a major source of growth in the modern theory, but also when considering the microeconomic evidence on the returns to education. The puzzling point is that it is possible for human capital to have a high private rate of return but only a weak contribution to growth. A series of explanations of the discrepancy between empirics and theory have been proposed[1]. In some cases, the contribution of human capital to growth can be weighed down by its low quality or by the poor organizational performances of the firms. Another explanation is that increases in human capital have no significant effect on growth if this human capital is misallocated and underemployed. Underemployment of workers with higher skills than what is required to operate their tasks has been widely observed in developing countries. Veganzones-Varoudakis and Pissarides (2007) point out that in the Middle East and North African (MENA) countries the qualified workers can be diverted from employment in growth-enhancing activities, a lot of it must have stood idle, engaged in "rent-seeking" or less productive activities (not properly recorded in national income statistics, such as the running of social services). This is particularly true when the institutional structure of the labour market is such that "rent seeking" or other less productive activities yield a higher private return to the individual than do growth-enhancing activities (Veganzones-Varoudakis and Pissarides, 2007). But it also could be the case that the demand for skills in the modern sector is too low relatively to the disposable amount of human capital in the economy. This is particularly true in economies that are in the wake of escaping from a low level development trap and experience too low levels of investments in equipments and a bad allocation of labour and skills across sectors. In this context, skill mismatches and market rigidities may lead to the underemployment of the skills already produced by the combination of private and public investments.

Veganzones-Varoudakis and Pissarides (2007) have pointed out that human capital in the MENA region grew steadily throughout the period of low TFP growth. But the same has been observed in many latin American countries during the eighties and nineties. But East Asian economies have not been an exception to the rule. it has been pointed out by Wood (1994) that "Korea and Taiwan both greatly raised their literacy rates in the 1950s prior to the rapid expansion of labour intensive exports in the 1960s". The expansion of secondary and higher education was even so rapid that "educated unemployment" began to appear (Wood, 1994: 212).

[1] A first explanation is that human capital is generally poorly proxied in empirical studies, with the consequence of a misspecification of the relationship between education and the stock of human capital (Woeβman, 2000).

Human capital flight is another symptom of the lack of demand for skills in the developing countries, even if there are other pull and push factors. Shortages of skilled labour are even associated to the migration of human capital in many developing countries. The disequilibria entrenched in the deep changes in production may engender simultaneous dearth and excess of skills on domestic labour markets. These precise structural shifts in the size of sectors or in the size of firms make it tricky for government and for private agents to address the demand for skills by a convenient supply of human capital. The provision of human capital trough complementary government and private investments can indeed be too high for the lagging needs of the industries in developing countries.

The problem of the misallocation of factors has been addressed in the literature for a long time as it was a key feature of the dualist models (Lewis, 1954; Fei and Ranis, 1964; Jorgenson, 1967; Harris and Todaro, 1970). Basically, the problem of misallocation of labour comes out because of the discrepancies in productive efficiency across sectors. The former works did focus mainly on the static efficiency losses and gains associated with various allocation patterns, and on the physics of migration from one sector to another. A series of formal models have recently demonstrated how the uneven distribution of sectoral total factor productivity (TFP) growth rates entails shifts in industrial employment shares that take place over long periods and how responsive to these shifts is growth (Echevarria, 1997; Kongsamut et al., 2001; Ngai and Pissarides, 2007).

Our approach is less formal and our goal is to test if the misallocation of human capital and lacking structural change can be responsible for the weak impact of skills on the growth performance. A more general outcome of our paper is to contribute to explain why increase in human capital does not account for a significant share of the variation in growth in standard econometric work. In a simple two-sector model of a small open economy, we show that the effect of education on growth is more significant if the country has entered into the structural change that raises the demand for skilled labour. Until structural change has raised the demand for skilled labour, growth in education has poor social return and private payoff. Our model is close to the models used by Poirson (2001), Temple and Woeβmann (2006) or Nelson and Pack (1999), excepted that we bring in human capital and skills as key factors in the reallocation process and we introduce the entrepreneurship (Nelson and Pack, 1999; Gries and Naudé, 2008) to assess the problem of the demand for skills in labour markets that are not necessarily in equilibrium. We next derive form the formal model a standard Solow-augmented model modified to allow for structural change that we test on a panel of developing countries.

The next section is a survey of the different strands of the literature that have addressed partially the question of structural change and human capital. Then, the model is developed in the section 3 and the econometric analysis is presented in section 4. Section 5 concludes.

2. Human capital, structural change and growth: A review of the literature

The literature on human capital and structural change is quite mixed. Endogenous growth models have highlighted the role played by human capital in externalities and in R&D activities that both generate increasing returns. Another formal approach consists of models explaining the way structural change and labour shift from one sector to another affect long run productivity and growth trends. Finally, a series of recent papers have made a special case for misallocation especially in skills and have given more relevance to the old issue of the allocation of labour entrenched in the traditional models of dualism.

A major strand of the contemporary theoretical literature tries to assess the role of human capital in endogenous growth models, with a special emphasis on the formation of low level traps. Basically, two theoretical frameworks are used in order to analyze the relationship between education and growth. Human capital acts on growth either through the externalities that increase productivity, or through its effects on learning by doing or on R&D.

In the first approach, growth is the result of the accumulation of human capital (Lucas, 1988). The basic assumption of Lucas (1988) is that investment in human capital generates positive externalities in the production of final goods. Azariadis and Drazen (1990), Durlauf (1993), Galor and Tsiddon (1997) and others have shown that externalities from social interactions, between generations at the aggregate level and between households at the neighbourhood level produced by the accumulation of human capital allow for increasing productivity and sustained growth. In all this work, nonconvexities in the accumulation of human capital make the private rate of return depend on some broader human capital aggregate. Actually private rates of return are quite low in environments short on human capital, quite high in environments where skills are growing fast, but they may decline in better endowed industrialized economies (Azariadis and Drazen, 1990). Increasing returns are directly caused by this sensitive dependence of private yields on aggregate levels. Laggard economies fail to escape the low level equilibrium trap because the poverty and low level of human capital produces only weak individual incentives that perpetuate it (Azariadis and Drazen, 1990). There is little space for factor misallocation in this context of one sector general equilibrium models. But the idea that there is a threshold of human capital below which externalities fail to materialize is useful to understand that despite significant increases in the stocks of education, human capital accumulation may not succeed in impelling growth because critical thresholds have no been reached.

The second approach generally models explicit relationship between human capital and technological change. Some models follow the seminal work from Nelson and Phelps (1966), in which growth is driven by the social ability to innovate or imitate technologies form the frontier. This ability is in turn affected by the stock of human capital. Other models assume that human capital is the key asset in the production of the R&D sector, and that the production present different law of returns among sectors. Redding (1995) shows that human capital and R&D are complements for growth so that low level equilibrium traps can occur due to an insufficiently trained workforce or a low quality of products. It means that if a low quality of products is viewed as a low degree of diversification of the modern sector, a shortage in demand for skills can impede the operation of human capital on productivity and growth. That is what London et al. (2008) show in a model of growth R&D similar to Redding (1995) in which they introduce a skill-loss effect due to an inappropriate allocation of human capital across sectors. The misallocation is simply assumed to be the result of disequilibrium in the labour market. In this paper we go further as we argue that this misallocation of human capital can also be due to inadequate shifts in the sectoral structure of production that do not generate a sufficient demand for skills in the modern sector.

What we propose is not another model of endogenous growth based on the complementarities between human capital and technological catching-up. Although there is a wide literature on this question, these models rarely address the question of structural change. The shifts in the structure of production are significant features of the development process though and they may be of great consequence for the accumulation of productive assets and for the dynamics of their productivity too. Indeed Nelson and Pack (1999) and others have shown that it has been of considerable importance for the sustainability of their growth pattern that significant changes in the production pattern occur in order both to avoid diminishing returns on factor accumulation and to feed a demand for skills.

Another recent strand of the theoretical literature is apparently more relevant for our purpose. It studies the process of change in the sector structure of labour or income and its implications for growth. The first approach consists off formal models of structural change and growth which derive relationships between TFP growth or demand elasticity's differentials and various patterns of growth in the framework of two or three sector models. They generally exhibit long-run path of endogenous balanced growth with simultaneous shifts in sectoral structure. There are two challenging explanations for structural change in this theoretical literature but they can coexist in a single model. The first one is often called the "technological" one because it explains structural change by the coexistence of different rates of TFP growth among sectors. A typical example is Echevarria (1997) who shows from a Solow-type model with multiple consumption goods and non-homothetic preferences that uneven productivity increases among sectors produces different GDP growth rates at different stages of development. Echevarria (1997), Kongsamut et. al. (2001), and Ngai and Pissarides (2007) all study the conditions for structural change and balanced growth in the frame of multi-sector growth. They show that even with ongoing structural change, the economy's aggregate ratios can be constant so that they allow for aggregate balanced growth. In a slightly different framework, Laitner (2000) shows that the average propensity to save get higher while the economy is going more industrialized and that the reproducible capital becomes the key factor at the expense of land. Matsuyama (1992) shows in a two-sector endogenous growth model that openness of markets affects the relationship between productivity and growth. But Etcheverria (1997) has also introduced the assumption of differentiation in income elasticities for different goods that owes structural change to occur even if TFP growth is similar in all sectors. As in Matsuyama (1992), Caselli and Coleman (2001) and Gollin *et al*. (2004), these models generally specify preferences of the representative consumer in a Stone-Geary fashion as the share of agricultural goods in household expenditure declines while development proceeds. A recent example is provided by Foellmi and Zweimuller (2008) who give formal demonstration that non-linear Engel-curves for consumer goods cause continuous structural change in the way of rising and falling sectoral employment shares. But their model nevertheless exhibits a steady growth path and even multiple equilibria once the introduction of endogenous product innovations generates complementarities between aggregate and sectoral growth.

Our paper belongs to the other strand of the literature which tries to examine the effects on structural change on TFP growth without any attempt to derive long run optimal paths of development. Our approach is close to those of Nelson and Pack (1999), Temple and Woeβman (2006), Landon-Lane and Robertson (2003) and Poirson (2001) or Imbs and Warcziag (2003). It has been widely shown that large differences in output per worker between rich and poor countries can be partially attributed to differences in Total Factor Productivity (TFP) (Banerjee and Duflo, 2005; Caselli, 2005; Hall and Jones, 1999; Klenow and Rodríguez-Clare, 1997). Research traditionally focuses on differences in technology within representative firms in order to explain the underlying causes of large TFP differences. Howitt (2000) and Klenow and Rodríguez-Clare (2005) have explained the large TFP differences by the slowness of the technology diffusion from the frontier to laggard countries. These models of *within*-firm inefficiency provide an explanation for variations of the firm efficiency across countries. Recent papers by Restuccia and Rogerson (2008) and Hsieh and Klenow (2007) adopt a different approach and suggest that misallocation of resources across firms can have important effects on aggregate TFP. Dobson and Kashyap (2006), Allen et al. (2007), and Dollar and Wei (2007) have recently provided evidence about the amount to which capital is still misallocated in China and India despite the significant reforms that have been undertaken in recent years (Young, 2000; Kochar et al., 2006; Aghion et al., 2008). These papers suggest that a better allocation of capital between firms and more generally between industries with discrepancies in TFP levels would increase growth. The role of capital reallocation may be as important as the role of more traditional labour shifts across sectors in order to understand how structural change affects growth. This is the reason why we include in our model shifts in capital accumulation from the less to the more productive industries.

Models of structural change fundamentally see development as a disequilibrium process. The models of endogenous growth generally exhibit balanced growth patterns whereas the necessary structural change associated with growth and development requires unbalanced growth at the sectoral level[2]. For Nelson and Pack (1999), the rate at which the disequilibrium is narrowed and eliminated can be measured by the dynamics of capital's share over the development traverse. They argue that the reallocation of factors between crafts and manufactures sectors can explain the stability of the returns to physical and human capital despite the huge accumulation effort made by East Asian industrializing countries. Ventura (1997) had already underlined that the shifts in the production structure allow avoiding falling returns to human capital for open economies. Ciccone and Papaioannou (2005) emphasizes that in countries with high tariffs, the effects of education levels and improvements on output growth in schooling-intensive industries are often statistically insignificant. The model of Foellmi and Zweimüller (2008) addresses the two-way causality between economic growth and structural change. Complementarities between aggregate and sectoral growth gives rise to multiple equilibria providing a possible explanation for development failures. Indeed, Nelson and Pack (1999) show that levels of education and accumulation of skills have generally no effect on the growth of output in schooling-intensive industries in countries with high tariffs.

It has once been an important case for now advanced economies like Korea and Taiwan that their human capital endowment may have been too large for the needs of the economy. But Nelson and Pack (1999) and Redding (1996) have both underlined the key role of entrepreneurs and firms in raising the returns form schooling by the technological upgrading of production and by the discoveries in terms of new products or new processes. In a well-known model of endogenous growth from the complementarities between human capital accumulation and investments in R&D, Redding (1996) argues that subsidies for human capital accumulation can raise the expectations of both households and entrepreneurs and drive the economy towards "high skills" equilibrium. He then says that there is evidence that such an implicit subsidy could have played a significant role in Korea's economic and industrial success. Redding suggests that the initial rise of high-skill unemployment be explained by a too rapid increase in human capital "provision" for the level of economic development of those countries. But he points out that the resulting increase in the supply of skills raised entrepreneurs incentives to invest in high-technology rather than traditional sectors and products. Nelson and Pack (1999) reach the same conclusion from a different starting point.

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[2] For a general multisector R&D model that articulate the two requirements, see Meckl (1999)

Conventionally, if the marginal product of human capital is relatively low in crafts, whatever the skill level of that capital, the movement of workers to sectors where the marginal product is higher should raise total output without any change in the total inputs of capital and labour. In a MRW model with controls for the sectoral shifts in factors allocation, Landon-Lane and Robertson show that labour reallocation can increase the return to physical capital by around 30% in many countries. As an economy escapes the low level equilibrium, production and employment simultaneously experience significant shifts towards more modern activities and a large increase in schooling and human capital. Yuki (2008) recently shows that the distribution of wealth and sufficient productivity of the traditional sector are required for a successful pattern of structural change and growth towards steady state equilibrium to appear.

Nelson and Pack (1999) heavily underline the role played by structural changes such as the increase in the size of firms in the growth pattern of East Asian economies. But they also insist on the joint and complementary role of human capital and entrepreneurship in the building up of technological capacities and in the discovery and development of new industries.

The point is that a growing economy is typically made of emerging sectors in which the demand for skills is not necessary balanced by a corresponding supply. But industries suffering from skilled labour shortage can hide a general surplus of human capital until a significant level of diversification of the structure of production is reached. At a macro level, there is not enough accumulation of capital in a sufficient number of industries to offset the fast increasing disposable amount of skills produced by the growing economy. Consequently, the complementarities between education and technological improvements can not really take place and the economy can be trapped despite the growing investments in human capital if the structural changes in production are lagging behind.

As in our paper, some of these authors consider the implications of structural change for growth regressions, but our contribution differs in two particular respects. Firstly we consider two levels of skills in the labour force in our analysis of the sectoral misallocation of human capital. Secondly, we introduce the entrepreneurship (Nelson and Pack, 1999; Gries and Naudé, 2008) so as to assess the problem of the demand for skills in labour markets that are not necessarily in equilibrium. We then derive an econometric specification from this two sector model of growth using discoveries (Klinger and Lederman, 2004; Carrère et al., 2007) as proxies for the entrepreneurs dynamism and usual proxies for the misallocation and skill shifts effects. As in the works from Temple and Woeβmann (2006) and Poirson (2001), the structural change term is essentially treated as an explanatory variable whose coefficient is estimated from the data.

We then test an econometric model on a panel of developing countries with interactive factors and non linearity so as to assess the way schooling and structural change interact in the growth process. Structural change can be introduced in a Solow augmented model of growth as in Temple and Woeβmann (2006). This strategy is appealing because human capital is explicitly modellized as a source of growth in the core model. Following Imbs and Warcziag (2003) or Temple and Woeβmann (2006), structural change is a shift in the sector composition of output or labour and it can be proxied by a measurement of the product or labour shares for non agricultural sectors. But, another strand of the recent literature sees structural change in a more international dimension as it appears in the process of product and export diversification (Klinger and Lederman, 2004; Carrère et al., 2007; Hesse, 2007). Both these empirical approaches will be tested in the framework of our model.

Indeed, there are several notions of structural change that matter for the assessment of the human capital contribution to growth. Factor shifts from crafts to manufactures is the historical one as it constitutes a legacy from old dualist models. But, structural change can be assessed in a different and alternative ways such as the rise in the size of firms and in their ability to adopt advanced technologies, the pattern of discoveries and diversification of production across more and new industries. Lucas (1988) once underlined that across nations, "the poorest countries tend to have the lower growth; the wealthiest next; the middle income countries highest". Etchevarria (1997) argued several years later that this assessment could be explained by changes in sectoral composition which are driven by different income elasticity for primaries, manufacturing and services. The sectoral shares of production explain a large part of the difference in growth rates observed among economies. Manufacturing activities grow faster because they enjoy higher levels of technical change and because all the engines of endogenous technical change (scale effects, learning-by-doing, investment in human capital, R&D, new products) are more important in manufacturing. Consequently, the amount of diversification of manufacturing activities has probably a key impact on growth as a dimension of structural change. Imbs and Warcziag (2003) have pointed at that diversification has a hump-shaped relationship with the level of development too. Shifts in the shares of production are probably associated to a diversification process that pushes further the productivity frontier of the economy.

3. A simple model of growth with two sectors and three factors

We consider a two-sector dual open economy with two goods. The traditional sector is associated with crafts and produces the good Y_c whereas the modern sector is associated with industry and produces the good Y_m. The traditional good Y_c is taken as numeraire and the modern good has a q which is determined by the world market. The two goods are exportables and they are produced by three different assets: physical capital K , unskilled labour L_1 and skilled labour L_2.

Real aggregate output can be written as:

$$(1)\ Y = \frac{Y_c + qY_m}{\Omega(1,q)}$$

Where Ω is the price deflator.

The production functions of the traditional and industrial sector can be expressed as

$$(2)\ Y_c = A_c F(K_c, L_{c1}, L_{c2})$$
$$(3)\ Y_m = A_m F(K_{m,} L_{m1}, L_{m2})$$

Where A_c, A_m stand respectively for the Total Factor Productivity (TFP) in the traditional and in the modern sector.

L_{c1} and L_{c2} are the number of unskilled and skilled workers who are employed in the crafts sector. L_{c2} represents skilled workers that are engaged in tasks unrelated to their training or education. It is therefore a measure of misallocation of the human capital in that economy as these workers prefer being under-employed in the traditional sector than being unemployed because of a dearth in the demand for skills from the modern firms.

Similarly, L_{m1} and L_{m2} are the number of unskilled and skilled workers who are employed in the modern manufactures sector. Note that the modern firms are assumed to provide work for both skilled and unskilled labour; the former being occupied in high productivity tasks and the last is engaged in low productivity tasks.

Workers receive a wage equal to their marginal productivity but this wage is the same for all the workers of the craft sector, whatever they are skilled or unskilled:

$w_{c1} = A_c F'_{lc1} = w_{c2} A_c F'_{lc2}$

Similarly, in accordance with their lower level of productivity, unskilled workers in the modern sector are entitled with the same wage as unskilled workers employed in the traditional sector:

$w_{c1} = A_c F'_{lc1} = w_{c2} A_c F'_{lc2} = w_{m1} = A_m q F'_{lm1}$

Consequently, there is positive wage differential noted k between the wage received by the skilled workers of the modern sector receive and the one received by any other category of workers. This discrepancy is explained by a skill premium associated with the use of high skills in high productivity tasks:

$$w_{m1} = A_m F'_{lm1} < w_{m2} A_m F'_{lm2}$$

We assume that there is perfect capital mobility between the two sectors so as the following identity is always true:

$$r = A_c F'_K = q A_m G'_K$$

with r is the rate of return of physical capital accumulation. As in Temple and Woeβman (2006) and Poirson (2001), the physical capital depreciation is ignored.

The real national income is given by:

$$(4)\ Y = w_{c1}L_{c1} + w_{c2}L_{c2} + w_{m1}L_{m1} + w_{m2}L_{m2} + r K_c + r K_m$$

Then, the labour and capital shares (respectively η and 1-η) in the national income can be expressed as :

$$\frac{(W_{c1}L_{c1} + W_{c2}L_{c2} + W_{m1}L_{m1} + W_{m2}L_{m2})}{Y} = \eta^{3}$$

[3] $\alpha = (w_{c1}L_{c1} + w_{c2}L_{c2} + w_{m1}L_{m1})/Y$ is the share of the low wages $\beta = (w_{m2}L_{m2}) / Y$ is the share of the high wages.

$$(1 - \eta) = \frac{(rK_c + rK_m)}{Y} = \frac{rK}{Y}$$

The wage differential between the skilled workers of the modern sector and the skilled workers of the traditional sector is considered as a sufficient incentive for the last to search a job in the modern sector. The propensity to migrate from the traditional to the modern sector is noted p and as in Temple and Woeβmann (2006) it is seen as the main measurement of the extent of structural change and assumes to depend on the ratio of wages in the two sectors:

$$\text{(5) } p = -\frac{\Delta a}{a}$$

$$\text{with } a = \frac{L_{c1}}{L}$$

The wage differential can be written as following:

$$\frac{w_{m2}}{w_{c2}} = \frac{w_{m2}}{w_{c1}} = k$$

As the measure of the wage differential k represents a skill premium, $k > 1$ and we assume that this wage differential is constant whatever the allocation resulting from the workers migration between sectors[4].

Following Temple and Woeβman (2006), we express the relationship between the propensity to migrate and the wage differential as:

$$p = \Psi \frac{x}{1+x}$$

where the parameter ψ captures the speed of adjustment to the long-run equilibrium[5], and where p is the probability of a successful match with an modern firm, and this match probability is increasing in the intersectoral wage ratio and as the skilled workers increase the intensity of their job search[6].

Note that x = $\Psi(\frac{w_{m2}}{kw_{c1}} - 1) = \frac{P}{1-p}$ and after transformation, we obtain an expression of the wage ratio as a function the speed of adjustment Ψ and the skill premium k:

[4] This is a difference with the model of Temple and Woeβmann (2006). The differential k is strictly superior to 1, and the skills migration from crafts to manufactures do not eliminate the differential because the skills are sector specific.

[5] A key assumption of the Temple and Woeβmann (2006) model is that the strength of this response is roughly the same in every country so that ψ is initially assumed to be constant across countries.

[6] Note that is k can be equal to unity as assumed in the model of Temple and Woeβmann (2006), then the propensity to migrate p is driven to zero and the skilled labour migration from crafts to manufactures ceases.

$$(6)\ k(1+\frac{1}{\Psi}(\frac{p}{1-p}))=\frac{w_{m2}}{w_{a1}}$$

With no wage differential across sectors, the growth of real aggregate income would be:

$$(7)\ \frac{\frac{dy}{dt}}{Y}=\frac{\dot{Y}}{Y}=s(t).\frac{\dot{Y}c}{Yc}+(1-s(t))\frac{\dot{Y}m}{Ym}$$ [7]

where $\frac{Y_c}{Y_c+qY_m}=s(t)$ is the output share for the traditional sector and 1-s(t)=$\frac{Ym}{Y_c+qY_m}$ is the corresponding share for the modern sector.

Using the standard results, the variation of the aggregate Solow residual (Z) can be expressed as:

$$(8)\ \frac{\dot{z}}{z}=\frac{\dot{Y}}{Y}-(1-\eta(t))\frac{\dot{K}}{K}+\eta(t)\frac{\dot{L}}{L}$$

Where η(t) is the labour wage share of the national income and (1- η(t)) is the capital share of the national income. Equation (8) can be rewritten:

$$(8)'\ \frac{\dot{z}}{z}=(1-s(t))\frac{\dot{A}m}{Am}+s(t)\frac{\dot{A}_c}{Ac}$$

Following Temple and Woeβmann (2006), it can be written that equation (8) and (8)' are two expressions of the Solow residual respectively expressed as output growth minus an average of input growth rates weighted by the aggregate factor shares, and as a sum of the TFP growth from each sector weighted by the aggregate sector shares.

We have already pointed at that k is actually greater than one since skilled workers from the manufacture sector are paid a premium relative to other workers. This premium can decrease but we assume that it never becomes nil even if the skills migrate form crafts to manufactures. Then, equation (7) for GDP growth can be rewritten as (7)':

$$(7)'\ \frac{\dot{Y}}{Y}=(1-s(t))\frac{\dot{A}_m}{A_m}+s(t)\frac{\dot{A}c}{Ac}+(1-\eta(t))\frac{\dot{K}}{K}+\eta(t)\frac{\dot{L}}{L}+\frac{\dot{m}_2}{m_2}(\phi(k-1)(1-a-c)+k\phi(1-a-c)\frac{p}{\Psi(1-p)}(\frac{\dot{m}_2}{m_2})$$ [8]

where $\phi=\frac{w_{a1}.L}{Y}$ is the share of wages in global income. This expression is very close to the Temple and Woeβmann (2006) equation (12). A minor difference is indeed that the term $\frac{\dot{m}_2}{m_2}$ in

[7] Voir démonstration en annexe.
[8] Demonstration can be found in Annex.

equation (7)' describes the variation of the share of the total labour force accounted for by skilled workers occupied in manufactures, and the weight is (1 – a – c) where c is the total share of unskilled workers in the labour force ($c = \frac{L_{c1} + L_{m1}}{L}$)[9]. In Equation (7)', output growth is then explained together by the TFP, the accumulation of physical capital and labour, and a better allocation of skills among the two sectors. The term ($\frac{\dot{m}_2}{m_2}$) can also be understood as a measure of the skill-loss reduction.

A shortfall of this preliminary approach is that it focuses only on the mechanisms governing the migration from crafts to manufactures from the supply side. The sectoral shifts in labour shares is only modelled as a consequence of the search for "better jobs" in terms of matching between tasks and skills and of consequently in terms of the wages that are paid. But we believe that it is relevant to introduce in that model the behaviour of the entrepreneurs whose investment decisions are of considerable consequence for the probability of skilled workers from crafts to find a job in the modern sector. Entrepreneurs can choose to invest their capital either in the modern or in the traditional sector depending on the differentials of profit between them. Of special relevance for structural shifts towards modernization is the choice made by the entrepreneurs owning physical capital in the traditional sector (k_a) and wishing for investing it in the modern sector because of the higher returns and benefits anticipated. This shift in the sectoral capital shares should simultaneously better the allocation of resources as more skilled workers could escape from crafts because of the increase in the job opportunities associated with the rise in investment in the modern sector.

So as to express the propensity of entrepreneurs from the traditional sector to invest in the manufactures, we must now formulate different assumptions regarding the differentials of average products among sectors. We firstly assume that the average productivity of labour in general and of the skilled workers in particular is lower in the traditional sector (*ac*) than in the modern sector (*am*):

$$\frac{Y_c}{L_{c1} + L_{c2}} \leq \frac{qYm}{L_{m1} + L_{m2}}$$

$$ac = \frac{Y_c}{L_{c2}} \leq am = \frac{qY_m}{L_{m2}}$$

However, we assume that the production functions are constant and that the average products for capital and for unskilled labour are the same in the two sectors.

$\frac{L_{m2}}{L} = 1 - \frac{L_{c2}}{L} - \frac{L_{m1} + L_{c1}}{L}$

9 $\frac{L_{c2}}{L} = a$

$\frac{L_{m1} + L_{c1}}{L} = c$

$$\frac{Y_c}{K_c} = \frac{qYm}{K_m}$$

$$\frac{L_{c1}}{Y_c} = \frac{L_{m1}}{qY_m}$$

Under these assumptions, rewriting the global output of the economy per worker from the Equation (1) gives:

$$(9)\quad \frac{Y}{L} = \frac{1}{\Omega}(\frac{Y_c}{L} + \frac{q.Y_m}{L}) = \frac{1}{\Omega}(\frac{Yc}{L_{c2}} * \frac{L_{c2}}{L} + \frac{Y_m}{L_{m2}} * \frac{L_{m2}}{L})$$

Or else,

$$(9')\quad \frac{Y}{L} = \frac{1}{\Omega}(\frac{Y_c}{L} + \frac{q.Y_m}{L}) = \frac{1}{\Omega}(ac * a + am * m_2)$$

If we compute the average costs and average profits functions of each sector, we obtain:

$$(10)\quad CMc = \frac{w_{c1}L_{c1} + W_{c2}.L_{c2} + rK_c}{Y_c}$$

$$(11)\quad CMm = \frac{w_{m1}L_{m1} + W_{m2}.L_{m2} + rK_m}{qYm}$$

Now, if we differentiate these functions across sectors, we can write:

$$(12)\quad \Delta CM = \frac{w_{c1}L_{c1} + W_{c2}.L_{c2} + rKc}{Yc} - \frac{w_{m1}L_{m1} + W_{m2}.L_{m2} + rK_m}{qYm}$$

And after transformation:

$$(12')\quad \Delta CM = wc2(a'c - kam') = -\Delta\pi$$

The terms *ac'* and *am'* in Equation (12') are the inverse of the average products. If the difference term $(a'c - kam')$ is higher than zero, then the average cost is higher in the traditional sector and the average profit is consequently lower if the price of the modern good is higher than the price in the traditional sector (q>1). The higher profits offered by modern activities constitute the incentives for entrepreneurs to migrate their capital from crafts to manufactures.

The profit differential between the two sectors feeds the shift of physical capital from crafts to manufactures and consequently determines the pace of structural change. Then it can be written that:

$$(13)\quad \frac{\frac{d\left(\frac{K_c}{K_m}\right)}{dt}}{\frac{K_c}{K_c}} = \frac{\dot{K}_c}{K_c} - \frac{\dot{K}_m}{K_m} = e(\Delta CM) = e(w_{c2}(a'c - kam'))$$

In this expression, the term *e* stands for the strength of the response of entrepreneurs to the higher profitability in the modern activities. As in Nelson and Pack (1999), the term *e* can be assumed to depend on the effectiveness of entrepreneurship[10].

If $z = \frac{K_m}{K}$ and $\omega = \frac{Kc}{K}$, and considering that :

$$\frac{\dot{K}}{K} = \frac{\dot{K}_m}{K} + \frac{\dot{K}_c}{K} = \frac{\dot{K}_m}{K} * \frac{K_m}{K_m} + \frac{\dot{K}_c}{K}\frac{K_c}{K_c} = \frac{\dot{K}_m}{K_m} * z + \frac{\dot{K}_c}{K_c} * \omega$$

Then,

$$\frac{\dot{K}}{K} - \frac{\dot{K}_m}{K_m} * z = \frac{\dot{K}_c}{K_c} * \omega$$

And consequently,

$$\frac{1}{\omega}\frac{\dot{K}}{K} - \frac{\dot{K}_m}{K_m} * \frac{z}{\omega} = \frac{\dot{K}_c}{K_c}$$

Substituting for this last expression in Equation (13) gives:

[10] In their paper Nelson and Pack (1999) discuss the political determinants for the size of *e*: *"Without entering the quagmire of the determinants of entrepreneurial abilities, the strength of incentives must certainly have mattered. Two economic policy variables would have reinforced any culturally favourable conditions. The first is the emphasis on exports for much of the period that encouraged firms to sell in the international market. They were thus able to avoid the diminishing returns to selling in a more slowly growing domestic market, typical of import substitution regimes. Second, as part of the export orientation of these economies, the real exchange rate was kept relatively constant, thus maintaining the profitability of exporting even when domestic costs were increasing. It is also possible that, especially in Korea, the substantial implicit subsidies given to individual firms led to a perception that the government would stand behind firms that were risk taking. But in other less successful countries, made- to-measure tariffs could be viewed as having performed the same role. Thus, it is likely that export orientation and the maintenance of the real exchange rate were more important factors."*

$$\frac{\frac{d(\frac{K_c}{K_m})}{dt}}{\frac{K_c}{K_c}}=\frac{1}{\omega}\frac{\dot{K}}{K}-\frac{\dot{K}_m}{K_m}*\frac{z}{\omega}-\frac{\dot{K}_m}{K_m}=e(\Delta CM)=e(wc2(a'c-kam'))$$

And then

$$\frac{\frac{d(\frac{K_c}{K_m})}{dt}}{\frac{K_c}{K_c}}=\frac{1}{\omega}\frac{\dot{K}}{K}-\frac{\dot{K}_m}{K_m}(\frac{z}{\omega}-1)=e(\Delta CM)=e(wc2(a'c-kam'))$$

If we express this last equation as a function of $\frac{\dot{K}}{K}$, it becomes:

$$(14)\quad \begin{aligned}\frac{\dot{K}}{K}&=\omega e(wc2(a'c-kam'))+\frac{\dot{K}_m}{K_m}(\frac{z}{\omega}-1)\omega\\ \frac{\dot{K}}{K}&=\omega e(wc2(a'c-kam'))+\frac{\dot{K}_m}{K_m}(z-\omega)\end{aligned}$$

Substituting for the expression of $\frac{\dot{K}}{K}$ in Equation (14) in Equation (7') gives:

$$(15)\quad \frac{\dot{Y}}{Y}=(1-s(t))\frac{\dot{A}_m}{A_m}+s(t)\frac{\dot{A}c}{Ac}+\frac{\dot{K}}{K}+\eta(t)\frac{\dot{L}}{L}-(\eta(t)(z-\omega))\frac{\dot{K}_m}{K_m}+\frac{\dot{m}_2}{m_2}(\phi(k-1)(1-a-c)+k\phi(1-a-c)\frac{p}{\Psi(1-p)}(\frac{\dot{m}_2}{m_2})-\eta(t)\omega e(wc2(a'c-kam')$$

That means that output growth is explained by TFP increases, the accumulation of productive assets, a better allocation of skills and capital in the modern sector, and by a constant proportional to both the profitability differential between sectors $(w_{c2}(a'c-kam')$ and to the strength of entrepreneurship in this economy (*e*). From this expression of GDP growth, we derive a simple econometric specification and test it in the next section.

4. Econometric analysis

4.1. Model, estimators and data

Our goal in this empirical section is to examine how the growth effect of human capital may depend on the degree of structural change experienced by an economy. Thus far, there are two possible empirical approaches. Poirson (2001) and Temple and Woeβmann (2006) have regressed a measure of TFP growth, using growth accounting. But they include a proxy of the structural change among the standard explaining variables of productivity. The other approach consists in estimating simple Solow-augmented models of growth with structural change explicitly appearing among the determinants of growth. We believe that this approach is more convenient for our purpose mainly because it allows using a non linear specification with interactions between explaining factors of growth.

Our model is a linear growth regression specification which is further extended to account for interaction terms between the measure of human capital and proxies for country characteristics in term of structural change. Finding suitable proxies for these variables is not an easy task mainly because the lack of statistical information relative to the shares of the value added produced and of the labour employed in the traditional sector. The share of the value added in agriculture is a common proxy for the traditional activities[11]. We also use a measure of the diversification of export because it informs together on the entrepreneurial ability to invest in new industrial activities (a proxy of the term *e*) and on the way the economy is inserted in trade and in the global division of labour.

Our growth equation is basically a Solow-augmented model of growth rewritten to take account of the interactions between structural change and human development. From the Solow growth model of Equation (16)

$$(16) \quad \mathrm{Log}(Y_{iT}/Y_{i0}) = \alpha + (e^{-bT} - 1)\,\mathrm{Log}(Y_{i0}) + \varepsilon$$

We derive in Equation (16') a Solow-augmented equation by introducing the controls for the standard determinants of the steady state

$$(16') \quad \mathrm{Log}(Y_t/Y_0) = \alpha + \beta \mathrm{Log}(Y_0) + \delta\,(\mathrm{pop}) + \chi\,(\mathrm{invest}) + \psi\,(\mathrm{human}) + \alpha_{it} + \varepsilon_t$$

Where $\beta = (e^{-bT} - 1)$ is the convergence coefficient, Pop is the growth rate of population, Invest is the the rate of increase in physical capital and human capital is the level of human capital disposable at the beginning of the period. However cross-sections require estimated parameters to be identical across countries and estimations may be biased consecutively. Another pitfall of this approach in term of conditional convergence is that estimated terms are very sensitive to the initial point of the analysis, especially when the length of the time period T is short. Another approach has been suggested by Quah (1993) that the introduction of an auto-regressive term in equation the previous equation could produce a better assessment of the growth process. Islam (1995) has tested a form similar to Equation (17) on panel data with ϕ_{it} are the fixed or random effects that allow for the explaining variables to be strictly exogenous to error terms[12] :

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[11] Note that alternative measures such as the incidence of child labour are likely to be indicative of the relative importance of the traditional sector for several reasons as argued by Landon-Lane and Robertson (2003) both because the vast majority of child labour in developing economies, is employed in agriculture, wholesale and retail trade and services and not in modern activities, and because the incidence of child labour is higher in activities where there are no specific skills or occupations where economic activities are elementary.

[12] Baltagi (2001).

$$(17) \quad Log(Y_{it}/Y_{it-1}) = \alpha + \beta Log(Y_{it-1}) + \delta\,(pop_t) + \chi\,(invest_t) + \psi\,(human_t) + (\phi_{it}) + \varepsilon_t$$

for t = 1,…, T periods, and i = 1,…, N countries

The introduction of structural change in the previous equation gives:

$$(18) \quad Log(Y_{it}/Y_{it-1}) = \alpha + \beta Log(Y_{it-1}) + \delta\,(pop_t) + \chi\,(invest_t) + \psi\,(human_t) + \Theta va_t + \zeta div_t + (\phi_{it}) + \varepsilon_t$$

with va_t is the measure of the share of the value added in traditional activities and div_t is the measure of diversification in exports. Panel-data estimation allow for the control for non observed heterogeneous conditions across countries by the individual country effects. In consistent models, these effects are assumed to be non orthogonal with the explaining variable x_i if Cov $(\phi_{it}, x_i) \neq 0$, put differently, it means that $E(\phi_i/x_1, \ldots x_{iT}) = E(\phi_i/x_i) = g(x_i)$. The term ϕ_{it} become consequently dummy variables whose value is 1 for the country *i* at time *t* and 0 otherwise. Each country is then concerned by the constant term in regression model but also by a constant ϕ_{it} that contains information relative to the country *i* and the period *t*. Note that individual effect can be randomly defined as a random variable associated to the error term ε_{it} under the hypothesis of the absence of correlation between the individual effect and the explaining variable x_i : Cov $(\phi_{it}, xi)=0$, hence, $E(\phi/x_1,\ldots xi_T)=E(\phi_i/Xi) = 0$). Random effect models are theoretically more efficient than fixed effects and they allow for introducing regional of group of countries dummies. But panel data with individual effects do not solve for all the problems associated with growth regression (Caselli et al., 1996). As shown in equation (19), the simultaneous presence in the equation of the specific term (ϕ_{it}) and of the lagged endogenous variable (Y_{it-1}) produces an endogeneity bias in estimations.

$$(19) \quad Log(Y_{it}) = \alpha + \theta Log(Y_{it-1}) + \delta\,(pop_t) + \chi\,(invest_t) + \psi\,(human_t) + \Theta va_t + \zeta div_t + (\phi_{it}) + \varepsilon_t$$

$\forall$ t = 1,…, T périodes et $\forall$ i = 1,…, N pays

where $\theta = (1+\beta)$. If $E(\varepsilon_{it} / Y_{it}) \neq 0$, then the estimation of equation (19) is biased and θ can be understated. Moreover, there are problems of heterogeneity (Holtz et al., 1988; Arellano and Bond, 1991). A first solution is to use the method of instrumental variable as well as the General Method of Moments in order to control for endogeneity and to derive convergent estimators. According to Arellano and Bond (1991), it first consists in getting a first-order difference equation (3') in order to remove the fixed effect. The equation (19) can be rewritten as follows:

$$(20) \quad \Delta Log(Y_{it}) = \alpha + \theta\Delta Log(Y_{it-1}) + \delta\Delta(Pop_t) + \chi\Delta\,(invest_t) + \psi\Delta(human_t) + \Theta\Delta va_t + \zeta\Delta div_t + (\phi_{it}) + \varepsilon_t$$

By construction, the difference in error term $(\varepsilon_{it} - \varepsilon_{it-1})$ is correlated with $(Y_{it-1} - Y_{it-2})$. The second step consists in using instruments (for $T \geq 2$). In generalizing the GMM, Arellano and Bond (1991) suggest to instrument $(Y_{it-1} - Y_{it-2})$ by all available lags on the delayed endogenous variable in level, and to instrument $(X_{it-1} - X_{it-2})$ and $(Z_{it-1} - Z_{it-2})$ by their value in level delayed by one lag or more. The Sargan test is subsequently used to assess the validity of the instruments. However, according to Blundell and Bond (1998), when the dependent variable and the explanatory variable are continuous, the lagged levels of the variables are not reliable instruments for the first-order difference equation (20). The GMM-system method consists in piling up the model in difference with the model in level. From then on, we add up the instruments for regressions in level that are the lagged differences of the related variables. Hence, we use the exogenous variables of the (y_{it-2}, y_{it-3},…,y_{it-n}) and (x_{it-1}, x_{it-2},…, $_{it-n}$) (x_{jt-1}, x_{jt-2},…, x_{jt-n}) …. as the instruments for equations in first-order difference while the variables in difference Δy_{it-1} , Δx_{it-1} and Δx_{jt-1} … are the instruments of the equations in level[13].

The previous specification has been estimated on a panel of 21 middle income and emerging countries from Asia, Latin America and Middle East and North Africa[14]. The time coverage is 1967-2005 and the data are computed as averaged variations or levels on five years periods. This averaging authorizes for a correction of cyclical moves and is a good approximation of long run evolution of each variable. The choice of the proxies describing structural change has been discussed above.

4. 1. Results and comments

The results for the system-GMM estimation of equation (19) have been reported in Table 1.

Table 1 : Regressions for the GDP growth rate: 1967-2005

Observations : 198 Groups : 21	GMM Wald chi2(1)=4558.71 Prob > chi2 = 0.000 Number of instruments: 33	GMM system Wald chi2(1)=28736.7 Prob > chi2 = 0.000 Number of instruments : 40
Initial GDP per capita	0.5976837 (2.49)***	0.8228606 (3.50)***
Constant	-1.01^e+11 (-0.51)	3.60^e+11 (1.90)**
Population	0.10628 (3.89)***	0.74364 (9.5) * **
Diversification	7.40^e+10 (0.35)	1.04^e+12 (6.17)***
Investment	1.255704 (3.19)***	1.094566 (2.91)***
VA	-9.59^e+09 (-2.50)**	-5.57^e+09 (-1.64)*
Human Capital	4.65^e+09 (2.65)***	4.02^e+11 (1.90)**

[13] These instruments are valid only under the assumption of a non correlation between exogenous variables and non observed individual effects $E(x_{it},f_i) = 0$.

[14] Algeria, Argentine, Brazil, China, Chile, Egypt, India, Indonesia, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Singapore, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Vietnam. Data are from the World Bank WDI, except for human capital proxied by the rates for schooling (Barro and Lee, 2000). The data for the year 2005 are from the WDI.

Sargan test J test (suridentification)[15]	chi2(34) = 139.1515 Prob > chi2 = 0.0000	chi2(34) = 204.4664 Prob > chi2 = 0.0000
Arellano-Bond test order 1 Ho :no autocorrelation	z = -3.75 Pr > z = 0.0000*	z = -1.975 Pr > z = 0.0736**
Arellano-Bond test order 2 Ho : no autocorrelation	z = 01.1297 Pr > z = 0.2586	z = .1.3281 Pr > z = 0.1841

*(1%) ;**(6%) ; ***7%. Sources: WDI , Barro and Lee.

Before commenting the results, notice that the validity of the instruments is confirmed in both cases by the Sargan/Hansen test, and that the Arellano and Bond test (Arellano and Bond, 1991) indicate a negative autocorrelation of the first order for the error terms in difference and no second order autocorrelation. In the two models, the coefficient for the core variables of the Solow augmented model are of the expected sign and highly significant (*Initial GDP*, *Investment*, *Labour, human capital*)[16]. As regards our concern about structural change, the coefficient for the traditional share of the value added (VA) exhibits a significantly adverse association with GDP growth. It means that growth is higher where the share of traditional activities is lower in our sample of developing economies. The slowness of the shifts from crafts to manufactures is detrimental to growth. Moreover, the estimate for the diversification of exports presents a significantly positive influence on GDP growth. This result suggests that the capacity of entrepreneurs to introduce new exportables through new investments in modern activities is a key factor in explaining higher growth for a given level of the other explaining factors.

The previous results provide evidence for the significant influence of structural changes on growth. But they do not say anything about the way human capital and shifts in the structure of production interact with each other in GDP growth. Subsequently, interactive variables have been introduced in Equation (20) and we have estimated non linear specifications of our model. It allows examining how the effect of human capital on growth evolves with the degree of structural change and of diversification of exports. Because of obvious problems of colinearity, we have regressed growth on the previous exogenous variables plus an interactive term (Human Capital*Diversification in (1) and Human Capital*Value Added in (2)) minus the corresponding variable for structural change (Diversification in (1) and Value Added in (2)).

Results are reported in the table 2. First, notice that the addition of interactive terms in the model does not modify neither the results for the Sargan and Arellano and Bond tests nor the signs and significance of the core variables. That means that the model is stable and that sensitivity tests should confirm this stability of the estimated parameters. The results for the model (1) show that the effect of human capital on growth is higher when diversification is larger, but it is not affected by the share of the traditional share of the value added. It is at the same time an interesting and a deceiving outcome. On the one hand, it implies that in our sample of countries, the shifts from crafts and agriculture to modern industries has no impact on the contribution of human capital to growth.

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[15] Under the null hypothesis that all instruments are exogenous *J* is distributed as a chi-square with m-r degrees of liberty is the number of instruments minus the number of endogenous variables.

[16] As mentioned above, the coefficient for the speed of global convergence is computed as (θ-1).

Table 2 : Regressions for the GDP growth rate : 1967-2005

Number of Groups : 20	(1) GMM system Interactive Div. Wald chi2(5)=42090.2 Prob > chi2 = 0.000 Number of instruments:40	(2) GMM system Interactive VA Wald chi2(5)= 687.57 Prob > chi2 = 0.000 Number of instruments:40
Initial GDP per capita	.5200745 (2.35)***	.4953911 (2.19)***
Constant	-.0291023 (-1.11)	-2.47e+11 (-1.57)
Population	.1084366 (3,95)***	-
Diversification	-	4.58e+11 (3.40)***
Investment	1.015424 (2.98)***	.9486625 (2.71)***
VA	-5.24e+09 (-2.66)***	-
Human Capital	8.05e+09 (5.28)***	7.68e+09 (6.74)***
Human Capital*Diversification	4.88e+09 (1.88)**	-
Human Capital*VA	-	1.93e+07 (0.25)
Sargan test J test (suridentification)[17]	chi2(34) = 211.3515 Prob > chi2 = 0.0000	chi2(115) = 194.0527 Prob > chi2 = 0.0000
Arellano-Bond test first order Ho :no autocorrelation	z = -1.8463 Pr > z = 0.0648	z = -2.19 Pr > z = 0.029
Arellano-Bond test second order Ho : no autocorrelation	z = -1.1483 Pr > z = 0.2508	z = |-1.1581 Pr > z = 0.2468

*(1%) ;**(6%) ; ***7%. Sources: WDI , Barro and Lee.

[17] Under the null hypothesis that all instruments are exogenous *J* is distributed as a chi-square with m-r degrees of liberty is the number of instruments minus the number of endogenous variables.

However, estimates in Table (1) provide evidence that the reduction in the traditional share of GDP has a positive influence on growth rates. This amounts to saying that if the drop in traditional activities is to matter for growth, it is not through the skill reallocation from traditional to modern activities. On the other hand, export diversification is a factor of higher growth, directly but also through the enhancement of the effect of human capital on the increase of GDP. Then, the point could be that if reallocation of skills is to matter, it is more probably through shifts among the industrial sector, from the older to the newer activities than across sectors, from the traditional to the modern.

An possible explanation of that result could be that our sample is essentially made of countries that have already reached a significant level of development and that consecutively experience more acute changes in the structure of their output and in the allocation of their skills inside the industrial activities than from traditional to modern ones. It could be worthy to replicate our estimations on less developed countries and to compare the results to the present ones.

Another explanation could be that growth regime in emerging countries is more dependant from the ability of domestic entrepreneurs to innovate and discover new exportables (De Pineres and Ferrantino, 2000; Hausman and Rodrik, 2003; Klinger and Lederman, 2004, Carrère et al., 2007; Hesse, 2007, Herzer et al., 2006) and the allocation of skills across old and new activities is a key factor of the discovery generation. Even if the I-W story (Imbs and Warcziag, 2003) remains consistent for emerging countries because the drop in agriculture and crafts still spurs growth, the H-K story (Hausman and Rodrik, 2003) is becoming more and more relevant as countries open their economy more widely and experience larger disposals of skills thanks to private investment and a public provision of infrastructure and financing. As soon as the purpose is to link human capital to structural shifts, it appears that the story is as much (if not more) a H-K one than a I-W one.

5. Conclusion

In this paper, we have argued that an explanation for the poor accountability of human capital variables in growth could be that increases in schooling may have no significant effect on growth if this human capital is misallocated and underemployed. In a simple two-sector model of a small open economy, we have shown that the effect of education on growth is more significant if the country has entered into the structural change that raises the demand for skilled labour. Moreover, we give a special attention to the role of entrepreneurs in the increase in the demand for skills in the modern sector and propose to measure it through the diversification of exports. In this framework, we have shown that both the shifts from crafts to manufactures and the diversification in manufactures enhance growth. We also have provided evidence that human capital and skills are more efficient for growth of GDP when structural change is higher especially in the intra-industrial dimension.

A shortfall of our econometric work is that it can not test the idea that, in a transitory period, the supply for skills may be too large for the needs of an economy. Another shortfall is that econometric analysis would gain to be held on a larger sample of developing countries to augment the probability that human capital could interact also with inter-sectoral change in spurring growth.

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Appendix 1: The growth equation

Output growth is given by the expression $\dfrac{\frac{dY}{dt}}{Y}=\dfrac{\dot{Y}}{Y}$ determined from the output $Y=\dfrac{Y_c+Y_m}{\Omega}$. It follows that:

$$\frac{dY}{dt}=\dot{Y}=\frac{1}{\Omega}\dot{Y}c+\frac{1}{\Omega}q\dot{Y}m-\frac{(Yc+qYm)}{\Omega^2}\dot{\Omega}+\frac{(Ym)}{\Omega}\dot{q}$$

$$\frac{\dot{Y}}{Y}=\frac{\frac{1}{\Omega}\dot{Y}c+\frac{1}{\Omega}q\dot{Y}m-\frac{(Yc+qYm)}{\Omega^2}\dot{\Omega}+\frac{(Ym)}{\Omega}\dot{q}}{Y}$$

$$\frac{\dot{Y}}{Y}=\frac{\frac{1}{\Omega}\dot{Y}c+\frac{1}{\Omega}q\dot{Y}m-\frac{(Yc+qYm)}{\Omega^2}\dot{\Omega}+\frac{(Ym)}{\Omega}\dot{q}}{\frac{Yc+qYm}{\Omega}}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{Y}c+q\dot{Y}m-\frac{(Yc+qYm)}{\Omega}\dot{\Omega}+Ym\dot{q}}{Yc+qYm}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{Y}c}{Yc+qYm}+\frac{q\dot{Y}m}{Yc+qYm}+\frac{Ym}{Yc+qYm}\dot{q}-\frac{(Yc+qYm)}{\Omega\ Yc+qYm}\dot{\Omega}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{Y}c}{Yc}*\frac{Yc}{Yc+qYm}+\frac{\dot{Y}m}{Ym}*\frac{qYm}{Yc+qYm}+\frac{Ym}{Yc+qYm}\dot{q}-\frac{(Yc+qYm)}{Yc+qYm}\frac{\dot{\Omega}}{\Omega}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{Y}c}{Yc}*\frac{Yc}{Yc+qYm}+\frac{\dot{Y}m}{Ym}*\frac{qYm}{Yc+qYm}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{Y}c}{Yc}*s(t)+\frac{\dot{Y}m}{Ym}*(1-s(t))$$

Appendix 2

When using the expression $\frac{\dot{Y}}{Y}=\frac{\dot{Y}c}{Yc}*s(t)+\frac{\dot{Y}m}{Ym}*(1-s(t))$, let $A=\frac{\dot{Y}c}{Yc}*s(t)$ and $B=\frac{\dot{Y}m}{Ym}*(1-s(t))$ and let's compute both the expressions separately from the two production functions: $Y_a = A_cF(.)$ and $Y_m = A_mG(.)$. It gives:

$$\dot{Y}_c = A_cF'_{lc1}\dot{L}_{c1} + A_cF'_{lc2}\dot{L}_{c2} + A_cF'_{Kc}\dot{K}_c + F(.)\dot{A}c$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{A_cF'_{lc1}\dot{L}_{c1} + A_cF'_{lc2}\dot{L}_{a2} + A_cF'_{Kc}\dot{K}_c + F(.)\dot{A}c}{Y_c}$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{A_cF'_{lc1}\dot{L}_{c1}}{Y_c} + \frac{A_cF'_{lc2}\dot{L}_{c2}}{Y_c} + \frac{A_cF'_{Kc}\dot{K}_c}{Y_c} + \frac{F(.)\dot{A}c}{Y_c}$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{A_cLF'_{lc1}}{Y_c}*\frac{\dot{L}_{c1}}{L} + \frac{A_cF'_{lc2}L}{Y_c}*\frac{\dot{L}_{c2}}{L} + \frac{A_cF'_{Kc}K}{Y_c}*\frac{\dot{K}c}{K} + \frac{F(.)Ac}{Y_c}*\frac{\dot{A}c}{Ac}$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{w_{c1}}{Y_c}*L*\frac{\dot{L}_{c1}}{L} + \frac{w_{c2}L}{Y_c}*\frac{\dot{L}_{c2}}{L} + \frac{rK}{Y_c}*\frac{\dot{K}c}{K} + \frac{\dot{A}c}{Ac}$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{w_{c1}L}{Y}*\frac{Y}{Y_c}*\frac{\dot{L}_{c1}}{L} + \frac{w_{c2}L}{Y}*\frac{Y}{Y_c}*\frac{\dot{L}_{c2}}{L} + \frac{rK}{Y}*\frac{Y}{Y_c}*\frac{\dot{K}_c}{K} + \frac{\dot{A}_c}{A_c}$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{1}{s(t)}*\left[\frac{w_{c1}L}{Y}*\frac{\dot{L}_{c1}}{L} + \frac{w_{c2}L}{Y}*\frac{\dot{L}_{c2}}{L}\right] + \frac{(1-\eta(t))}{s(t)}\frac{\dot{K}_c}{K} + \frac{\dot{A}_c}{A_c}$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{1}{s(t)}*\left[\frac{w_{c1}L}{Y}*(\frac{\dot{L}_{c1}+\dot{L}_{c2}}{L})\right] + \frac{(1-\eta(t))}{s(t)}*\frac{\dot{K}_c}{K} + \frac{\dot{A}_c}{A_c}$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{1}{s(t)}*\left[\frac{w_{c1}L}{Y}*(\frac{\dot{L}_c}{L})\right] + \frac{(1-\eta(t))}{s(t)}\frac{\dot{K}_c}{K} + \frac{\dot{A}_c}{A_c}$$

$$Posons\,\frac{w_{a1}L}{Y} = \phi$$

$$\frac{\dot{Y}_c}{Y_c} = \frac{1}{s(t)}\left[\phi(\frac{\dot{L}_c}{L})\right] + \frac{(1-\eta(t))}{s(t)}\frac{\dot{K}_c}{K} + \frac{\dot{A}_c}{A_c}$$

Then A = $s(t)\frac{\dot{Y}_c}{Y_c} = \left[\phi(\frac{\dot{L}_c}{L})\right] + (1-\eta(t))\frac{\dot{K}_c}{K} + s(t)\frac{\dot{A}_c}{A_c}$

If we express $B = \frac{\dot{Y}m}{Ym} * (1 - s(t))$ from the production function $Y_m = A_m G)(.)$, it happens that :

$$\dot{Y}m = A_m F'_{lm1}\dot{L}_{m1} + A_m F'_{lm2} L_{m2} + A_m F'_{Km}\dot{K}_m + G(.)\dot{A}m$$
$$\frac{\dot{Y}m}{Ym} = \frac{A_m F'_{lm1}\dot{L}_{m1} + A_m F'_{lm2} L_{m2} + A_m F'_{Km}\dot{K}_m + G(.)\dot{A}m}{Ym}$$
$$\frac{\dot{Y}m}{Ym} = \frac{A_m G'_{lm1}\dot{L}_{m1}}{Y_m} + \frac{A_m G'_{lm2}\dot{L}_{m2}}{Y_m} + \frac{A_m G'_{Km}\dot{K}c}{Y_m} + \frac{G(.)\dot{A}_m}{Y_m}$$
$$\frac{\dot{Y}m}{Ym} = \frac{A_m G'_{lm1} L}{Ym} * \frac{q}{q} * \frac{\dot{L}_{m1}}{L} + \frac{A_m G'_{lm2} L}{Ym} * \frac{q}{q} * \frac{\dot{L}_{m2}}{L} + \frac{A_m G'_{Km}}{Y_m} * \frac{q}{q} * \frac{\dot{K}_m}{K} + \frac{G(.)A_m}{Y_m} * \frac{\dot{A}_m}{A_m}$$
$$\frac{\dot{Y}_m}{Y_m} = \frac{w_{m1}L}{Y_m} * \frac{1}{q} * \frac{\dot{L}_{m1}}{L} + \frac{w_{m2}L}{Ym} * \frac{1}{q} * \frac{\dot{L}_{m2}}{L} + \frac{rK_m}{Y_m} * \frac{1}{q} * \frac{\dot{K}_m}{K} + \frac{\dot{A}_m}{A_m}$$
$$\frac{\dot{Y}_m}{Y_m} = \frac{w_{m1}L}{Y} * \frac{Y}{qYm} * \frac{\dot{L}_{m1}}{L} + \frac{w_{m2}L}{Y} * \frac{Y}{qYm} * \frac{\dot{L}_{m2}}{L} + \frac{rK_m}{Y} * \frac{Y}{qYm} * \frac{\dot{K}_m}{K} + \frac{\dot{A}_m}{A_m}$$
$$\frac{\dot{Y}m}{Ym} = \frac{w_{m1}L}{Y}\left(\frac{Y}{qYm} * \frac{\dot{L}_{m1}}{L}\right) + \frac{w_{m2}L}{Y}\left(\frac{Y}{qYm} * \frac{\dot{L}_{m2}}{L}\right) + \frac{(1-\eta(t))}{(1-s(t))} * \frac{\dot{K}_m}{K} + \frac{\dot{A}_m}{A_m}$$
$$\frac{\dot{Y}m}{Ym} = \frac{1}{(1-s(t))} * \frac{w_{m1}L}{Y} * \frac{\dot{L}_{m1}}{L} + \frac{1}{(1-s(t))} * \frac{w_{m2}L}{Y} * \frac{\dot{L}_{m2}}{L}) + \frac{(1-\eta(t))}{(1-s(t))} * \frac{\dot{K}_m}{K} + \frac{\dot{A}_m}{A_m}$$

Hence,

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \frac{w_{m1}L}{Y}\left(\frac{\dot{L}_{m1}}{L}\right) + \frac{w_{m2}L}{Y}\left(\frac{\dot{L}_{m2}}{L}\right) + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$
$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi\left(\frac{\dot{L}_{m1}}{L}\right) + \frac{w_{m1}L}{Y}\left(\frac{\dot{L}_{m2}}{L}\right) + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi\left(\frac{\dot{L}_{m1}}{L}\right) + \frac{w_{m2}L}{Y}\left(\frac{\dot{L}_{m2}}{L}\right) + \phi\left(\frac{\dot{L}_{m2}}{L}\right) - \phi\left(\frac{\dot{L}_{m2}}{L}\right) + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

However,

$$\frac{W_{m2}}{W_{c1}} = k(1+\frac{1}{\psi}(\frac{p}{1-p}))$$

Donc

$$W_{m2} = kW_{c1}(1+\frac{1}{\psi}(\frac{p}{1-p}))$$

et

$$W_{m2} = kW_{c1} + \frac{kW_{c1}}{\psi}(\frac{p}{1-p})$$

donc

$$\frac{W_{m2}L}{Y} = \frac{kW_{c1}L}{Y} + \frac{kW_{c1}}{Y\psi}(\frac{pL}{1-p})$$

And consequently,

$$\frac{W_{m2}L}{Y} * \frac{\dot{L}_{m2}}{L} = \frac{kW_{c1}L}{Y}\frac{\dot{L}_{m2}}{L} + \frac{kW_{c1}}{Y\psi}(\frac{pL}{1-p})\frac{\dot{L}_{m2}}{L}$$

$$\frac{W_{m2}L}{Y} * \frac{\dot{L}_{m2}}{L} = \frac{kW_{c1}L * L_{m2}}{Y}\frac{\dot{L}_{m2}}{L * L_{m2}} + \frac{kW_{c1} * L_{m2}}{Y\psi L_{m2}}(\frac{pL}{1-p})\frac{\dot{L}_{m2}}{L}$$

So, we can substitute the following expression

$\frac{W_{m2}L}{Y} * \frac{\dot{L}_{m2}}{L} = \frac{kW_{c1}L * L_{m2}}{Y}\frac{\dot{L}_{m2}}{L * L_{m2}} + \frac{kW_{c1} * L_{m2}}{Y\psi L_{m2}}(\frac{pL}{1-p})\frac{\dot{L}_{m2}}{L}$ in the expression B :

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi(\frac{\dot{L}_{m1}}{L}) + \frac{w_{m2}L}{Y}(\frac{\dot{L}_{m2}}{L}) + \phi(\frac{\dot{L}_{m2}}{L}) - \phi(\frac{\dot{L}_{m2}}{L}) + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

It follows that:

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi(\frac{\dot{L}_{m1}}{L}) + \frac{kW_{c1}L * L_{m2}}{Y}\frac{\dot{L}_{m2}}{L * L_{m2}} + \frac{kW_{c1} * L_{m2}}{Y\psi L_{m2}}(\frac{pL}{1-p})\frac{\dot{L}_{m2}}{L} + \phi(\frac{\dot{L}_{m2}}{L}) - \phi(\frac{\dot{L}_{m2}}{L}) + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

with,

$$\frac{kW_{c1}L * L_{m2}}{Y}\frac{\dot{L}_{m2}}{L * L_{m2}} = k\phi\frac{\dot{L}_{m2}}{L_{m2}} * \frac{L_{m2}}{L}$$

et

$$\frac{kW_{c1}L * L_{m2}}{Y\psi L_{m2}}(\frac{p}{1-p})\frac{\dot{L}_{m2}}{L} = k\phi\frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

If we sum these two expressions, we obtain :

$$k\phi \frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}} + k\phi \frac{\dot{L}_{m2}}{L_{m2}} * \frac{L_{m2}}{L} = k\phi \frac{L_{m2}}{L}(\frac{p}{\psi(1-p)}+1)\frac{\dot{L}_{m2}}{L_{m2}}$$

We can substitute this last expression in

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi(\frac{\dot{L}_{m1}}{L}) + \frac{kW_{c1}L * L_{m2}}{Y}\frac{\dot{L}_{m2}}{L * L_{m2}} + \frac{kW_{c1} * L_{m2}}{Y\psi L_{m2}}(\frac{pL}{1-p})\frac{\dot{L}_{m2}}{L} + \phi(\frac{\dot{L}_{m2}}{L}) - \phi(\frac{\dot{L}_{m2}}{L}) + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi(\frac{\dot{L}_{m1}}{L}) + k\phi \frac{L_{m2}}{L}(\frac{p}{\psi(1-p)}+1)\frac{\dot{L}_{m2}}{L_{m2}} + \phi(\frac{\dot{L}_{m2}}{L}) - \phi(\frac{\dot{L}_{m2}}{L}) + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

Or else,

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi(\frac{\dot{L}_{m1}}{L}) + k\phi \frac{L_{m2}}{L}(\frac{p}{\psi(1-p)}+1)\frac{\dot{L}_{m2}}{L_{m2}} + \phi(\frac{\dot{L}_{m2}}{L}) - \phi(\frac{\dot{L}_{m2}}{L}) * \frac{L_{m2}}{L_{m2}} + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

If we come back to our first expression of growth $\frac{\dot{Y}}{Y} = \frac{\dot{Y}c}{Yc} * s(t) + \frac{\dot{Y}m}{Ym} * (1-s(t))$ and if we substitute by the expressions A and B found above, we get:

$$s(t)\frac{\dot{Y}_c}{Y_c} = \left[\phi(\frac{\dot{L}_c}{L})\right] + (1-\eta(t))\frac{\dot{K}c}{K} + s(t)\frac{\dot{A}c}{Ac} +$$

$$(1-s(t))\frac{\dot{Y}m}{Ym} = \phi(\frac{\dot{L}_{m1}}{L}) + k\phi \frac{L_{m2}}{L}(\frac{p}{\psi(1-p)}+1)\frac{\dot{L}_{m2}}{L_{m2}} + \phi(\frac{\dot{L}_{m2}}{L}) - \phi(\frac{\dot{L}_{m2}}{L}) * \frac{L_{m2}}{L_{m2}} + (1-\eta(t)) * \frac{\dot{K}_m}{K} + (1-s(t))\frac{\dot{A}_m}{A_m}$$

Then,

$$\frac{\dot{Y}}{Y}=\left[\phi(\frac{\dot{L}_c}{L})\right]+(1-\eta(t))\frac{\dot{K}c}{K}+s(t)\frac{\dot{A}c}{Ac}+(1-\eta(t))*\frac{\dot{K}_m}{K}+(1-s(t))\frac{\dot{A}_m}{A_m}$$

$$+\phi(\frac{\dot{L}_{m1}}{L})+\phi(\frac{\dot{L}_{m2}}{L})+k\phi\frac{L_{m2}}{L}*\frac{\dot{L}_{m2}}{L_{m2}}+k\phi\frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}-\phi(\frac{\dot{L}_{m2}}{L})*\frac{L_{m2}}{L_{m2}}$$

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}c}{K}+\frac{\dot{K}_m}{K})+s(t)\frac{\dot{A}c}{Ac}++(1-s(t))\frac{\dot{A}_m}{A_m}+\phi(\frac{\dot{L}_{m1}}{L}+\frac{\dot{L}_{m2}}{L})$$

$$+k\phi\frac{L_{m2}}{L}*\frac{\dot{L}_{m2}}{L_{m2}}-\phi(\frac{\dot{L}_{m2}}{L})*\frac{L_{m2}}{L_{m2}}+k\phi\frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}+\left[\phi(\frac{\dot{L}_c}{L})\right]$$

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+s(t)\frac{\dot{A}c}{Ac}++(1-s(t))\frac{\dot{A}_m}{A_m}+\phi(\frac{\dot{L}_m}{L})$$

$$+\phi[k\frac{L_{m2}}{L}*\frac{\dot{L}_{m2}}{L_{m2}}-(\frac{\dot{L}_{m2}}{L})*\frac{L_{m2}}{L_{m2}}]+k\phi\frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}+\left[\phi(\frac{\dot{L}_c}{L})\right]$$

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+s(t)\frac{\dot{A}c}{Ac}++(1-s(t))\frac{\dot{A}_m}{A_m}+\phi(\frac{\dot{L}}{L})$$

$$+\phi[k\frac{L_{m2}}{L}*\frac{\dot{L}_{m2}}{L_{m2}}-(\frac{\dot{L}_{m2}}{L})*\frac{L_{m2}}{L_{m2}}]+k\phi\frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+\phi(\frac{\dot{L}}{L})+s(t)\frac{\dot{A}c}{Ac}+(1-s(t))\frac{\dot{A}_m}{A_m}$$

$$+\phi[k\frac{L_{m2}}{L}-\frac{L_{m2}}{L}]\frac{\dot{L}_{m2}}{L_{m2}}+k\phi\frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+\phi(\frac{\dot{L}}{L})+s(t)\frac{\dot{A}_c}{A_c}+(1-s(t))\frac{\dot{A}_m}{A_m}+$$

$$\phi[k-1]*(1-a-c)*\frac{\dot{L}_{m2}}{L_{m2}}+k\phi(1-a-c)(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

$$\phi\frac{\dot{L}}{Y}=\eta(t)\frac{\dot{L}}{Y}-(\eta(t)-\phi)\frac{\dot{L}}{Y}$$

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+\eta(t)\frac{\dot{L}}{L}-(\eta(t)-\phi)\frac{\dot{L}}{Y}+s(t)\frac{\dot{A}_c}{A_c}+(1-s(t))\frac{\dot{A}_m}{A_m}$$

$$\phi[k-1]*(1-a-c)*\frac{\dot{L}_{m2}}{L_{m2}}+k\phi(1-a-c)(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

$$\eta(t) = \frac{w_{c1}L_{c1} + w_{c2}L_{c2} + w_{m1}L_{m1} + w_{m2}L_{m2}}{Y}$$

$$\eta(t) = \frac{w_{c1}(L_{c1} + L_{c2} + L_{m1}) + w_{m2}L_{m2}}{Y}$$

$$\eta(t) = \frac{w_{c1}(L_1 + L_{c2}) + w_{m2}L_{m2}}{Y}$$

$$\eta(t) = \frac{w_{c1}(L_1 + a * L) + w_{m2}L(1 - a - c)}{Y}$$

$$\eta(t) = \frac{w_{c1}(L_1 + a * L)}{Y} + \frac{w_{m2}L(1 - a - c)}{Y}$$

$$\eta(t) = \frac{w_{c1}(c + a)L}{Y} + \frac{w_{m2}L(1 - a - c)}{Y}$$

$$\eta(t) = \phi(a + c) + \frac{w_{m2}L(1 - a - c)}{Y}$$

$$w_{m2} = (kw_{c1} + \frac{p}{\psi(1 - p)} * kw_{c1})$$

$$\eta(t) = \phi(a + c) + (kw_{c1} + \frac{p}{\psi(1 - p)} * kw_{c1}) * \frac{L(1 - a - c)}{Y}$$

$$\eta(t) = \phi(a + c) + (w_{c1} + \frac{p}{\psi(1 - p)} * w_{c1}) * \frac{L(1 - a - c)k}{Y}$$

$$\eta(t) = \phi(a + c) + w_{c1}(1 + \frac{p}{\psi(1 - p)}) * \frac{L(1 - a - c)k}{Y}$$

$$\eta(t) = \phi(a + c) + \phi[(1 + \frac{p}{\psi(1 - p)}) * (1 - a - c)]k -$$

$$\eta(t) = \phi(a + c) + \phi(1 + \frac{p}{\psi(1 - p)}) * (1 - a - c)]k$$

$$\eta(t) = \phi[(a + c) + (1 - a - c)k + \frac{p}{\psi(1 - p)}k)\ ]$$

$$\eta(t)-\phi=\phi[1+(1-a-c)(k-1)+\frac{p}{\psi(1-p)}\ (1-a-c)\,k]-\phi$$

$$\eta(t)-\phi=\phi[(1-a-c)(k-1)+\frac{p}{\psi(1-p)}\ (1-a-c)\,k]$$

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+\phi(\frac{\dot{L}}{L})+s(t)\frac{\dot{A}c}{Ac}+(1-s(t))\frac{\dot{A}_m}{A_m}+\phi[k-1]*\frac{L_{m2}}{L}*\frac{\dot{L}_{m2}}{L_{m2}}+k\phi\frac{L_{m2}}{L}(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

Let $\frac{L_{c2}}{L}=a$ and $\frac{L_{c1}+L_{m1}}{L}=c$ be the share of skilled labour in the total labour force.

Then, the share of skilled workers performing a skilled job is given by :

$$\frac{Lm2}{L}=(1-a-c)$$

Consequently,

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+\phi(\frac{\dot{L}}{L})+s(t)\frac{\dot{A}c}{Ac}+(1-s(t))\frac{\dot{A}_m}{A_m}+$$
$$\phi[k-1]*(1-a-c)*\frac{\dot{L}_{m2}}{L_{m2}}+k\phi(1-a-c)(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

If $\phi\frac{\dot{L}}{Y}=\eta(t)\frac{\dot{L}}{Y}-(\eta(t)-\phi)\frac{\dot{L}}{Y}$

Then we can express the growth equation as :

$$\frac{\dot{Y}}{Y}=(1-\eta(t))(\frac{\dot{K}}{K})+\eta(t)\frac{\dot{L}}{L}-(\eta(t)-\phi)\frac{\dot{L}}{L}+s(t)\frac{\dot{A}c}{Ac}+(1-s(t))\frac{\dot{A}_m}{A_m}$$
$$\phi[k-1]*(1-a-c)*\frac{\dot{L}_{m2}}{L_{m2}}+k\phi(1-a-c)(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

But, $(\eta(t)-\phi)=\phi[(1-a-c)(k-1)+[\phi(1-a-c)(\frac{p}{\psi(1-p)})]$, (See annex 3)

Then, $(\eta(t)-\phi)\frac{\dot{L}}{L}=\phi[(1-a-c)(k-1)\frac{\dot{L}}{L}+\phi[(1-a-c)(\frac{p}{\psi(1-p)})]\frac{\dot{L}}{L}$

When substituting in the previous growth expression, it becomes :

$$\frac{\dot{Y}}{Y}=s(t)\frac{\dot{A}c}{Ac}+(1-s(t))\frac{\dot{A}_m}{A_m}(1-\eta(t))(\frac{\dot{K}}{K})+\eta(t)\frac{\dot{L}}{Y}-\phi[(1-a-c)(k-1)\frac{\dot{L}}{L}$$
$$-\phi[(1-a-c)(\frac{p}{\psi(1-p)})]\frac{\dot{L}}{L}+\phi[k-1]*(1-a-c)*\frac{\dot{L}_{m2}}{L_{m2}}+k\phi(1-a-c)(\frac{p}{\psi(1-p)})\frac{\dot{L}_{m2}}{L_{m2}}$$

$$\frac{\dot{Y}}{Y}=s(t)\frac{\dot{A}c}{Ac}+(1-s(t))\frac{\dot{A}_m}{A_m}(1-\eta(t))(\frac{\dot{K}}{K})+\eta(t)\frac{\dot{L}}{Y}+\phi[(1-a-c)(k-1)[\frac{\dot{L}_{m2}}{L_{m2}}-\frac{\dot{L}}{L}]+$$
$$\phi k[(1-a-c)(\frac{p}{\psi(1-p)})][\frac{\dot{L}_{m2}}{L_{m2}}-\frac{\dot{L}}{L}]$$

But, if $m_2=\frac{L_{m2}}{L}$, then $\frac{\dot{m}_2}{m}=\frac{\dot{L}m_2}{Lm_2}-\frac{\dot{L}}{L}$. When substituting this expression in the previous growth expression, it becomes Equation ():

$$\frac{\dot{Y}}{Y}=s(t)\frac{\dot{A}c}{Ac}+(1-s(t))\frac{\dot{A}_m}{A_m}(1-\eta(t))(\frac{\dot{K}}{K})+\eta(t)\frac{\dot{L}}{Y}+\phi[(1-a-c)(k-1)[\frac{\dot{m}_2}{m}]+$$
$$\phi k[(1-a-c)(\frac{p}{\psi(1-p)})][\frac{\dot{m}_2}{m}]$$

Appendix 3 : $(\eta(t)-\phi)=\phi[(1-a-c)(k-1)+[\phi(1-a-c)(\frac{p}{\psi(1-p)})]$

The wage share of total income is given by :

$$\eta(t)=\frac{w_{c1}L_{c1}+w_{c2}L_{c2}+w_{m1}L_{m1}+w_{m2}L_{m2}}{Y}$$

$$\eta(t)=\frac{w_{c1}(L_{c1}+L_{c2}+L_{m1})+w_{m2}L_{m2}}{Y}$$

With $\frac{L_{c2}}{L}=a$, $\frac{L_{m2}}{L}=(1-a-c)$ and $\frac{L_{c1}+L_{m1}}{L}=c=\frac{\mathrm{L}_1}{L}$

$$\eta(t)=\frac{w_{c1}(L_1+L_{c2})+w_{m2}L_{m2}}{Y}$$

$$\eta(t)=\frac{w_{c1}(L_1+a*L)+w_{m2}L(1-a-c)}{Y}$$

$$\eta(t)=\frac{w_{c1}(L_1+a*L)}{Y}+\frac{w_{m2}L(1-a-c)}{Y}$$

$$\eta(t)=\frac{w_{c1}(c+a)L}{Y}+\frac{w_{m2}L(1-a-c)}{Y}$$

$$\eta(t)=\phi(a+c)+\frac{w_{m2}L(1-a-c)}{Y}$$

But,

$$w_{m2}=(kw_{c1}+\frac{p}{\psi(1-p)}*kw_{c1})$$

$$\eta(t)=\phi(a+c)+(kw_{c1}+\frac{p}{\psi(1-p)}*kw_{c1})*\frac{L(1-a-c)}{Y}$$

$$\eta(t)=\phi(a+c)+(w_{c1}+\frac{p}{\psi(1-p)}*w_{c1})*\frac{L(1-a-c)k}{Y}$$

$$\eta(t)=\phi(a+c)+w_{c1}(1+\frac{p}{\psi(1-p)})*\frac{L(1-a-c)k}{Y}$$

$$\eta(t)=\phi(a+c)+\phi(1+\frac{p}{\psi(1-p)})*(1-a-c)]$$

$$\eta(t)=\phi[1+(1-a-c)(k-1)+\frac{p}{\psi(1-p)}\ (1-a-c)\,k]$$

Then,

$$\eta(t)-\phi=\phi[1+(1-a-c)(k-1)+\frac{p}{\psi(1-p)}\ (1-a-c)\,k]-\phi$$

$$\eta(t)-\phi=\phi[(1-a-c)(k-1)+\frac{p}{\psi(1-p)}\ (1-a-c)\,k]$$