Economic Growth, Human Capital and Structural Change: An Empirical Analysis

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Abstract

Human capital is identified as one of the main determinants of economic growth and plays an important role in the technological progress of countries. Nevertheless, existing studies have to some extent neglected the importance of human capital on growth via the interaction it can have with a country’s industrial specialization. Additionally, the emphasis is mainly placed on supply-side determinants, being demand-side factors quite neglected, particularly the relevance of the processes of structural change. Thus, using a growth model which integrates variables from both the supply side and demand side, we assess the direct and indirect effects of human capital on economic growth, including in the latter the interaction of human capital with the industrial specialization of countries. Based on econometric panel data estimations involving a set of OCDE countries over 1960-2011, we found that the countries’ productive specialization dynamics is a crucial factor for economic growth. It is also shown that the interaction between human capital and structural change towards high knowledge-intensive industries impacts on the economic growth. However, the sign of this effect depends on the type of country and length of the period of analysis. Specifically, in the long term and in developed countries, where knowledge-intensive industries already account for a great share of the economy, the impact of the interaction between human capital and structural change is positive. In the case of less developed countries, and considering a shorter time period, the effect of human capital via specialization in high-tech and knowledge-intensive activities emerged as negative.

Keywords: Economic Growth; Human Capital; Structural Change; Panel Data

JEL Codes: J24, O3, O4, O47
1. Introduction

The analysis of the determinants of economic growth has been the subject of extensive literature, especially since the start of the 1990s. Some authors (e.g., Barro, 1991; Mankiw et al., 1992; Mauro, 1995) estimated the impact of some variables on economic growth through cross-section analysis and concluded that human capital plays an important role in counties’ economic growth.

Neoclassical and endogenous growth theory identified and analyzed some determinants of economic growth such as foreign trade, government consumption and geography, as well as institutions, namely the case of political instability (Barro, 1991; Levine and Renelt, 1992; Acemoglu et al., 2001; Moral-Benito, 2012). The most common determinants in the analysis of economic growth are nevertheless, the initial GDP, population growth, investment in physical capital, and human capital stock (e.g., Barro, 1991; Hanushek and Woessmann, 2012; Aisen and Veiga, 2013).

The concept of human capital can be interpreted as the set of intangible resources embedded in the labor factor which have improved its productivity. These are associated to knowledge and skills acquired through education, experience and health care (Schultz, 1961; Becker, 1962).

Human capital has a direct effect on economic growth because individuals with more education are more productive and innovative leading to the creation of new products and improving the productivity of factors (Romer, 1990; Benhabib and Spiegel, 1994; Teixeira and Fortuna, 2011; Bodman and Le, 2013). On the other hand, human capital enhances technology adoption from neighbor countries through the absorption of ideas and equipment imports (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994; Teixeira and Fortuna, 2011). Human capital also has indirect effects namely via interaction with the productive structure of countries. Concretely, the specialization of a country in technologically advanced activities improves the impact (positive) of human capital on economic growth (Silva and Teixeira, 2012).

Theoretical approaches related to Economic Evolutionism reveal a need to add demand-side factors to economic growth analysis (Witt, 2001; Metcalfe et al., 2006, Dietrich, 2012; Teixeira, 2012). Certain changes in demand favoring more diverse and complex products lead to structural changes, i.e., changes in sectoral composition and in the economic specialization by boosting technological innovation and creating new products (Saviotti and Pyka, 2012;
Silva and Teixeira, 2012). In this line of thought, ‘high-tech’ industries have higher growth rates of productivity and therefore contribute more than proportionally to economic growth (Silva and Teixeira, 2012). This contribution tends to increase the more intense the absorption capacity and innovation becomes, related to higher levels of human capital (Nelson and Phelps, 1996; Teixeira and Fortuna, 2011).

This paper seeks to integrate in a single model supply-side variables linked to the endogenous growth theory, and also demand-side variables linked to structuralism and evolutionism, namely the specialization pattern of countries. More specifically, the aim of this paper is to estimate the direct effects of human capital on economic growth as well as indirect effects embodied in the interaction between human capital and the countries’ productive structure, while controlling for other determinants reported in the literature. Our hypothesis is that a country with a higher level of human capital will grow faster the higher the level of specialization in high-tech and knowledge-intensive industries, in which skilled labor has an important role.

In methodological terms, we use panel data econometric methods. We study a sample of developed countries where industries that require qualified workers have increased their relative importance in the economy.

The paper is organized as follows. The following section presents a literature review on the relationship between economic growth and the three main variables of this study: human capital stock, structural change and the interaction between the two. Section 3 presents methodological considerations as well as a statistical description of the data for the relevant variables. In section 4, we discuss the empirical results. The final section presents the main contributions of this study, policy implications, limitations and paths for future research.

2. Literature review about determinants of economic growth

Many authors (e.g., Barro, 1991; Levine and Renelt, 1992; Mankiw et al., 1992; Mauro, 1995; Rajan and Zingales, 1996; Easterly and Levine 1997; Hall and Jones, 1999; Hanushek and Woessmann, 2008; Hanushek, 2013) analyze the impact of human capital on economic growth (usually measured as the annual growth rate of gross domestic product (GDP), in real terms).

Human capital is the set of intangible resources embedded in the labor factor which improve its productivity. These are related to the knowledge and skills acquired through education, experience and health care (Schultz, 1961; Becker, 1962).
As well as physical capital accumulation, acquiring skills and knowledge is a means of capital formation by delaying consumption with the aim of increasing future income. Human capital improves the quality of labor, increasing its productivity (Mankiw et al., 1992; Woessmann, 2003; Bodman and Le, 2013). It is usually considered that an additional school year will increase the productivity and efficiency of workers, and consequently, their income (Hall and Jones, 1998). In other words, different individual earnings are associated to different levels of investment in education (Woessmann, 2003). Similarly, differences in the average schooling of countries are related to different economic growth rates. For example, Easterly and Levine (1997) found that the low economic growth observed in African countries is due, in part, to low rates of schooling.

Human capital is the driver of Research and Development (R&D), which enhances innovation and technological progress, thus leading to increased productivity and creation of new products (Romer, 1990; Benhabib and Spiegel, 1994; Teixeira and Fortuna, 2011; Bodman and Le, 2013). This means that the more educated the workforce of a country, the greater the benefits of the R&D activities in terms of economic growth. Human capital promotes the absorption of new ideas (absorption capacity) and products already created by other countries. This fosters a faster convergence of economies by importing equipment and technologies (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994; Bodman and Le, 2013). Through the mechanisms described above, human capital will encourage greater investment in physical capital (Benhabib and Spiegel, 1994).

Finally, human capital also affects economic performance indirectly. According to Sianesi and Reenen (2003), human capital tends to improve the health levels, environmental conditions, criminal rates, social cohesion and civic participation. This variable also stimulates the productivity of more educated workers. Therefore, investment in education has an impact not only in individual returns, but also drives a spillover effect that produces social benefits.

According to neoclassical theory, human capital contributes to a faster convergence of countries to the steady-state levels of income per capita (Mauro, 1995). A positive result can evidence a catching-up effect for poor countries compared to rich countries. If the former present a high initial stock of human capital, they will grow faster and converge to the income levels of the richest countries (Azariadis and Drazen, 1990; Benhabib and Spiegel, 1994; Hanushek, 2013).
To assess the impact of human capital on economic growth, we need to measure the stock of this variable in each country. Hence, researchers use several proxies for the human capital stock such as: literacy rate (Azariadis and Drazen, 1990; Romer, 1990), primary and secondary school enrolment rates (Barro, 1991; Levine and Renelt, 1992; Mauro, 1995; Batten and Vo, 2009), and average schooling years of adults (Benhabib and Spiegel, 1994; Rajan and Zingales, 1996; Easterly and Levine, 1997; Hall and Jones, 1999; Temple, 1999; Lee and Barro, 2001; Temple and Woessmann, 2006; Moral-Benito, 2012; Bodman and Le, 2013). It is found that the average schooling years of the workforce is the most common measure of the human capital stock. The literacy rates and enrollment rates are a flow variable, reflecting only the investment in human capital, which affects this stock with a time lag (Woessmann, 2003). The measures used in empirical studies reflect imperfectly the human capital stock of a country. This is because there are some mistakes in databases, inadequate measures are used (Woessmann, 2003), and factors like experience, informal education, the depreciation of capital and the quality of education systems are not included in the analysis (Sianesi and Reenen, 2003). On the other hand, average schooling does not include the differences in skills learned across countries and it implies that an additional school year increases human capital at a constant rate (Woessmann, 2003). Although they are directly related, schooling only contributes to economic growth if it allows for the acquisition of those skills. These can be learned outside the formal education system (e.g., family, peers, culture) (Hanushek and Woessmann, 2008).

Most studies show a positive and significant relationship between human capital and economic growth (Barro, 1991; Mankiw et al., 1992; Easterly and Levine, 1997; Hall and Jones, 1999; Bodman and Le, 2013) regardless of the proxy used (e.g., the average schooling of the working population and initial enrollment rate).

Nevertheless, Levine and Renelt (1992), Benhabib and Spiegel (1994), Mauro (1995), Rajan and Zingales (1996) and Moral-Benito (2012) did not find any statistically significant effect of human capital on economic growth. In particular, when enrollment rates in primary and secondary education are used as control variables, the results are not usually very robust. This could be due to the high correlation between human capital and the estimated variables in the econometric regressions. The use of small and unrepresentative samples can also affect the results (Temple, 1999).

Hanushek and Woessmann (2008, 2012) and Hanushek (2013) also show weak results when average schooling years are used as a measure of human capital and these authors introduce
quality of education variables in the models. When average schooling years are used as a measure of human capital, we assume that learning grows at the same rate in all countries (Woessmann, 2003). Since growth is driven by skills acquired by individuals and not by education itself, the quality of education measures gain importance in the literature. To bridge this point, measures are introduced that differentiate the quality of education in countries. These can be: the share of public and/or private expenditures on education in real GDP, student-to-teacher ratio, wages of teachers and length of school year (Barro and Lee, 1996; Hanushek, 1996; Woessmann, 2003). In order to capture the differences in the knowledge learned across countries, many authors (e.g., Lee and Barro, 2001; Hanushek and Woessmann, 2008; 2012, Hanushek, 2013) employ the results of international assessment tests as a proxy of quality of education (e.g., PISA - *Programme for International Student Assessment* - and TIMSS – *Trends in International Mathematics and Science Study*) and they find a significant positive impact of these on economic growth. However, Breton (2011) concludes that average schooling years is the most robust measure of the human capital stock since the quality of education is already implicit and the correlation between average schooling and the results of the assessment tests is very high. 

From the above, we assume that:

**H1: Countries with a higher stock of human capital tend to grow faster than others.**

The productive structure of an economy and especially its dynamics is recognized as an important determinant of economic growth. Thus, the concept of “structural change” emerges, which refers to shifts in sectoral composition, where certain industries gain relative shares in economy (Montobbio, 2002; Silva and Teixeira, 2012).

Orthodox literature assumes homogeneity assumptions in order to ensure the general equilibrium (Peneder, 2003). With the aggregated effects of macroeconomics, we cannot see the sectors’ different patterns in productivity (Metcalfe *et al.*, 2006). Industries within an economy have distinct characteristics such as: intensity of physical and human capital, technical progress, economies of scale and exchange characteristics (Marelli, 2004). It is, therefore, natural that each sector has its own dynamic and a different growth rate. Transformation in sectoral composition is continuous, constantly observing an increase of the importance of some industries in the economy as well as the decline of others.

Structural change can be caused by exogenous forces, such as changes in consumption patterns in favor of goods with high income elasticity of demand. Thus, sectors that have
higher income elasticity of demand see their relative importance in the economy rise (Peneder, 2003).

According to Metcalfe et al. (2006), economic growth is the result of structural configurations of the economy and its dynamics. More productive industries, that Baumol named ‘progressive’ (Hartwig, 2012), gain a greater relative share in the economies because they offer better wages, attracting more qualified and skilled individuals. These phenomena cause direct effects on growth by creating new ways of production that will result in a more efficient reallocation of resources and greater earning capacity (Zagler, 2009; Noseleit, 2013). Therefore, structural change in favor of a specialization in progressive sectors and/or technologically more advanced ones leads to economic growth (Peneder, 2003; Silva and Teixeira, 2012).

In this sense, structuralist theories stress that economic specialization by itself is not sufficient to generate economic growth (Aditya and Acharyya, 2013), depending on the sector that dominates the economy. According to these approaches, economic growth can be the result of a shift in specialization towards industrial products (Aditya and Acharyya, 2013). In fact, it appears that most industrialized regions observe greater economic growth than mainly agricultural regions (Marelli, 2004). Furthermore, specialization in agricultural products makes the country more vulnerable to external shocks, according to Aditya and Acharyya (2013).

Change in structure is also present in evolutionism approaches. According to these, economic growth depends on the capacity for self-transformation of an economy (Metcalfe et al., 2006). More specifically, the capacity that an economy has to generate new goods and services, creators of value added and, thus, new activity sectors, affects economic growth (Zagler, 2009; Saviotti and Pyka, 2012). It is important, however, that the appearance of new products coexists with the demand for them, as emphasized by Saviotti (2001).

According to several authors (e.g., Witt, 2001; Metcalfe et al., 2006; Dietrich, 2009), the demand-side has been relatively neglected in traditional economic growth analyses, particularly in more orthodox theories, analyzing predominantly the supply-side. The evolution of demand is an important driver of structural change to ensure the need to re-invent and produce new goods and innovation is the underlining concept of this process (Saviotti and Pyka, 2012). Changes in consumption patterns reflect changes in learning, knowledge and specialization (Witt, 2001; Saviotti and Pika, 2012).
According to evolutionist theories, the market is the result of a continuous process of transformation fruit of innovation (Justman and Teubal, 1991; Saviotti and Pika, 2012). Under Schumpeterian conceptions, radical changes in innovation contribute significantly to economic development (Saviotti, 2001). The presence of innovation affects a firm's behavior and its earnings. Therefore, the incorporation of earnings from Research and Development (R&D) also contributes to the definition of the heterogeneity of industries (Peneder, 2003).

Innovation is closely associated to creativity and development of knowledge. This can be applied and acquired within firms and they are transmitted between industries through the market (Metcalfe et al., 2006). Furthermore, the innovation that emerges in firms fosters the creation of new goods and services, which reflects new growth opportunities. Innovation is a characteristic of entrants and it is the result of the vision of entrepreneurs who recognize new business opportunities. These innovative firms reveal great adaptability and promote a more efficient reallocation of factors than incumbents, which has a positive direct effect on economic growth (Noseleit, 2013). Innovation also produces an indirect effect on economic growth through the creation of positive externalities. Spillovers are created with technological progress, since knowledge is spread by industries belonging to the same frontier (Romer, 1990; Peneder, 2003).

The creation of goods and services is related to technological progress. Technological progress is an important determinant of economic growth to allow accumulation of capital, the existence of economies of scale, and greater efficiency in the allocation of resources and productivity gains through innovation (Romer, 1990; Hartwig, 2012). Thus, countries with a more technologically advanced productive specialization have higher growth rates.

Empirically, Nelson and Pack (1999) note the rapid catching-up of Asian countries associated with increasing specialization in activities with high technological content, and argue that the fast growth in these economies is the result of the assimilation of technological innovations and structural changes. Linked to demand issues, Aditya and Acharyya (2013) find that, in dynamic terms, export specialization in high-tech goods has a positive relationship with economic growth.¹

¹Although structural change is, in general, a necessary condition for the occurrence of economic growth, it can also be a byproduct of this process, i.e., economic growth also leads to structural change (Justman and Teubal, 1991; Dietrich, 2012). In this view, economic growth creates incomes that enable the evolution of consumption patterns, increasing the demand for more sophisticated goods. This issue does not lie within the scope of this paper and therefore it is not explored empirically.
Zagler (2009) focuses on the direction of structural change, emphasizing the idea that the occurrence of structural change may involve costs. On the one hand, “technological unemployment” can occur with the closing of incumbents and their replacement with new activities (Zagler, 2009; Noseleit, 2013), i.e., what Schumpeter called the 'creative destruction' process. On the other hand, structural change can have negative effects on economic growth if there is a large increase in demand for low productive sectors (Dietrich, 2009). In this case, most of the expenditure is channeled towards the 'non-progressive' sector, i.e., the sector that is not becoming more productive. These observe a growth in wages at the same rate of progressive sectors, unaccompanied by increases in productivity which leads to the economy’s stagnation (Hartwig, 2012). This last phenomenon is called ‘Cost Disease’ by Baumol. From the above it is conjectured that:

**H2:** Countries that experience changes in productive structures towards a greater share of technology/knowledge-intensive activities will tend to observe higher economic growth.

According to Justman and Teubal (1991), the structuralist approach considers human capital as a major determinant of economic growth since this factor enhances structural change. Thus, human capital is critically important in the evolution of countries’ specialization (Afonso, 2012). The productive specialization of economies depends on their endowment factors, whereby technologically more advanced industries will tend to locate in countries with a high stock of human capital.

Ciccone and Papaioannou (2009) also emphasize the positive relationship between education and ‘virtuous’ structural changes, i.e., when technology-intensive activities gain a relative share in the economy. Therefore, structural change and the virtuous specialization of economies depend on new information, new skills and workers’ productivity, factors which are closely related to the stock of human capital (Justman and Teubal, 1991; Afonso, 2012).

The accumulation of human capital enables new business opportunities and endows the agents with management skills and technological knowledge (Justman and Teubal, 1991). Countries with highly skilled workers tend to be more efficient in activities that incorporate more advanced technologies. From a micro perspective, firms that have employees with a high level of human capital adopt complementary technologies in order to achieve maximum efficiency. It follows that the accumulation of human capital enhances the role of Research and Development (R&D) in the economies by promoting the creation of new products (Caselli and Coleman, 2006; Bodman and Le, 2013). Therefore, human capital affects the
technological progress of countries (Nelson and Phelps, 1966; Romer, 1990; Benhabib and Spiegel, 1994; Vandenbussche et al., 2006; Coleman, 2006). On the other hand, it reduces the costs of implementing these technologies (Kim and Lee, 2009).

The process of innovation requires a certain level of human capital to actually occur (Vandenbussche et al., 2006). The sectors that arise through structural change require the acquisition of new skills by workers from the declining industries in order to be absorbed by the first ones (Zagler, 2009).

As previously mentioned (Section 1.1), individuals acquire a set of important skills to perform certain functions, particularly those involving adaptation to change, through formal education (Nelson and Phelps, 1966). In addition, the productivity gains resulting from technological progress depend on both the accumulation of physical capital and human capital, and these gains are greater the higher the stocks of these factors (Ciccone and Papaioannou, 2009). Physical capital and human capital are complementary since increases in the stock of physical capital lead to an increase in the marginal productivity of human capital and vice-versa (Caselli and Coleman, 2006). In this context, high-tech activities observe a great increase in productivity which leads to the creation of value added and employment growth in industries (Ciccone and Papaioannou, 2009).

The technological catching-up process and structural change related to the transfer of technology from developed countries to developing ones may be enhanced (in economic growth terms) when the country has a higher level of human capital, which increases its absorption capacity (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994). Through this process, developing countries can have productive structures with more technological content via imitation. However, a successful imitation needs a minimum threshold of human capital (Vandenbussche et al., 2006; Teixeira and Fortuna 2011). A fortiori, creative and innovative processes require greater stocks of human capital (Vandenbussche et al., 2006).

The interaction between human capital and structural change is clearly explaining by Gürbüz (2011) who highlights the situation of North and South countries. Southern countries, during their tertiarization, specialized in labor-intensive services and absorbed low-skilled workers from rural migration; in contrast, northern countries specialized in high-tech, tradable products, which require a high level of human capital. According to this author, the accumulation of human capital is a necessary condition for a virtuous structural change, i.e., an increasing share of the most productive sectors.
Regarding the demand-side, human capital makes consumers more sophisticated. This means that if consumers are more highly educated, they will be more likely to seek 'high-tech' products, which positively contributes to virtuous structural change (Justman and Teubal, 1991).

Structural change is also enhanced by entrepreneurs (Justman and Teubal, 1991; Dias and McDermott, 2006; Saviotti and Pyka, 2012), because they invest in more innovative and modern sectors. Recognizing a business opportunity, entrepreneurs create new technologically advanced and efficient firms, which contribute to structural change (Noseleit, 2013). Entrepreneurs are, in general, more ‘talented’ than other workers and they invest in their human capital, via professional experience, in order to enhance their own talent. The skills acquired by entrepreneurs allow them to create new ideas and generate new businesses (Iyigun and Owen, 1999). Entrepreneurs also foster the reallocation of productive factors (such as labor) among sectors (Noseleit, 2013). The latter look for more productive agents so that they can integrate the most innovative and technologically advanced activities, which require certain skills and knowledge. Therefore, entrepreneurs create an attractive environment for the accumulation of human capital by workers through education, since the expected return is higher (Dias and McDermott, 2006; Noseleit, 2013). This means that economic growth will be higher the more numerous and talented the entrepreneurs and the higher their stock of human capital (Iyigun and Owen, 1999; Dias and McDermott, 2006).

H3: The impact of human capital on the economic growth of a country is greater the more specialized the economy is in high technology/knowledge-intensive activities.

There are a set of determinants of economic growth recurrently reported by several studies regarding economic growth. Thus, we may consider factors such as: initial GDP per capita (Barro, 1991; Easterly and Levine, 1997; Moral-Benito, 2012), population growth (Dreher, 2006; Aisen and Veiga, 2013), physical capital accumulation/investment (Barro, 1991; Benhabib and Spiegel, 1994; Fabro and Aixalá, 2009; Aisen and Veiga, 2013), public consumption (Barro, 1991; Levine and Renelt, 1992; Moral-Benito, 2012; Afonso and Jalles, 2014) and institutions (Mauro, 1995; Hall and Jones, 1999; Acemoglu et al., 2001; Dreher, 2006; Hanushek and Woessmann, 2008).
3. Methodology

3.1. Econometric specification and option for panel data estimation

Panel data estimations have a few advantages over the traditional *cross-country* models (cf. Table 1). This technique serves to study the dynamics of adjustment and to estimate their effects over a long period of time. On the one hand, panel data can analyze a set of variables for a great number of countries, which provides more information. Panel data estimations also assume that countries are heterogeneous, with specific and unobservable characteristics. ‘*Cross-section*’ and ‘*times series*’ estimations do not control for this heterogeneity, meaning the results may be biased (Greene, 2011).

Therefore, to estimate the effects of relevant variables on economic growth, namely human capital and its interaction with the productive structure, we opted for the estimation of panel data, such as in more recent studies with similar aims (e.g., Dreher, 2006; Batten and Vo, 2009; Aisen and Veiga, 2013; Iqbal and Daly, 2014).

According to the literature review and the hypotheses to be tested, the econometric model specification (*à la MRW*) to estimate is:

\[ y_{it} = \beta_1 + \beta_2 HC_{it} + \beta_3 SC_{it} + \beta_4 (HC\times SC)_{it} + \beta_5 Y_{i0} + \beta_6 I_{it} + \beta_7 G_{it} + \beta_8 CP + \beta_9 Inst_{it} + u_i + \varepsilon_{it} \]

where \( i \) represents the countries’ index and \( t \) represents time.

- **\( y \)**: the logarithm of GDP *per capita*
- **\( HC \)**: a measure of the human capital stock
- **\( SC \)**: a measure of structural change
- **\( HC\times SC \)**: the interaction between the measures of human capital stock and structural change
- **\( Y_{i0} \)**: the initial GDP *per capita* in each decade
- **\( I \)**: a measure of investment in physical capital
- **\( G \)**: a measure of the share of public consumption in GDP
- **\( CP \)**: a measure of population growth
- **\( Inst \)**: a measure of the institutional characteristics of the country
- **\( u \)**: the unobserved time-invariant fixed effect
- **\( \varepsilon \)**: the unobserved random coefficient
3.2. Description of the proxies and data sources

The present paper considers a sample of 30 countries (26 are European and the others are: Japan, South Korea, United States and Australia). We started by analyzing a time period of at least 50 years, from 1960-2011, and we considered 21 countries because of the availability of data. Over a shorter period (1990-2011), 30 countries in total were included in the analysis.

In order to measure the dependent variable, economic growth, we use the logarithm of GDP per capita as a proxy. To this end, we resorted to the dataset *Penn World Table* (version 8.0) (Feenstra et al., 2013) which reports the values for real GDP at constant 2005 prices (in mil. US$).

The average years of schooling of adults is the most widely used proxy of human capital (e.g., Rajan and Zingales, 1996; Easterly and Levine, 1997; Hall and Jones, 1999; Temple and Woessmann, 2006; Moral-Benito, 2012; Bodman and Le, 2013). Thus, according to the available literature, we use educational attainment for the population aged 25 and over to measure the stock of human capital from the Barro and Lee (2010) dataset. The Barro and Lee dataset is widely used in the literature on economic growth, and it has been updated over the last few years. Barro and Lee’s (2010) data cover the period from 1950 to 2010 and are related to 146 countries. These are disaggregated for periods of 5 years and come from UNESCO, Eurostat, national statistical agencies, etc.. For the present study, we consider the average attainment value for each five-year period for all years within the same timeframe.

As mentioned previously, structural change refers to long-term shifts in the sectors of an economy. To measure these shifts, we use employment composition data and its evolution over the period under review. These values come from the EU KLEMS (O'Mahony and Timmer, 2009) dataset, available at www.euklems.net, which gives us (among other variables) the number of employees in each industry. The several economic activities are divided according to the ISIC REV.3 classification (*‘International Standard Industrial Classification’*). We use these values as a share of the total employment in each economy. Subsequently, we grouped the data depending on the intensity of knowledge that each activity requires. This classification is based on Peneder (2007) who divides each industry into: ‘very low’, ‘low’, ‘medium-low’, ‘intermediate’, ‘medium-high’, ‘high’ and ‘very high’. Since EU KLEMS only provides data from the period between 1972 and 2007, we estimated the values for the remaining missing years. To this end, we assume that the share of each industry during the period between 1960 and 1971 evolves at the same average growth rate of the next 10
years. Similarly, the values of the subsequent years up to 2007 are calculated assuming the average growth rate of the previous 10 years.

In line with the many empirical studies on economic growth (Barro, 1991; Levine and Renelt, 1992; Mauro, 1995; Moral-Benito, 2012), the physical capital accumulation (I) will be measured by investment share to GDP. Similarly, public expenditures (G) will be measured by public consumption to GDP ratio. There are many authors that resort to the Penn World Table dataset to determine economic growth (e.g., Easterly and Levine (1997) and Moral-Benito (2012) used the Penn World Table, Version 6.2). Therefore, besides GDP per capita, we used the Penn World Table (Version 8.0) (Feenstra et al., 2013) to obtain investment in physical capital and public consumption data.

Regarding institutional measures, this study uses the Civil Liberties Index and Political Rights Index from ‘Freedom House’, as in Moral-Benito (2012). These indexes are based on the evaluation of human rights specialists, scholars, journalists and politicians. They are measured using a scale of 1 to 7, being 1 the highest freedom level and 7 the lowest. Through these measures, we can analyze the impact of the quality of institutions and governability of a country on economic growth. The hypothesis to be tested is that freer and fairer countries have higher economic growth rates.

4. Empirical Results

We used 2 different panel data sets in order to estimate the specified model. The first one includes 21 OCDE countries, of which we have a balanced panel (the entire cross-section is observed every year), during the period from 1960 to 2011. The second panel adds 9 countries to the first, mostly belonging to Eastern Europe (Cyprus, Slovakia, Slovenia, Estonia, Hungary, Lithuania, Malta, Poland and Czech Republic). However, due to data unavailability, the period is shorter (1990-2011).

In the second panel, the economic growth analysis is to some extent impaired because the time horizon is too short (about 20 years), since the dynamics analyzed change very slowly over time. Nevertheless, the Eastern European countries included in the study have experienced great structural change due to the establishment of new industries and industrial relocation resulted from FDI (Foreign Direct Investment) since the 1990s (Janicki and Wunnava, 2004). Thus, the motivation to include these countries in our study lies in this last argument, despite the limited data available.
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<th>Proxy of the dependent variable</th>
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Table 1: Empirical studies on economic growth
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<th>Authors</th>
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<th>Countries (##)</th>
<th>Estimation Method</th>
<th>Proxy of the dependent variable (economic growth)</th>
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<td>Physical Capital: Gross capital formation (% GDP) by World Bank (2000)</td>
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<td>Physical Capital: Gross capital formation (% GDP) by World Bank (2000)</td>
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<td>Iqbal and Daly (2014)</td>
<td>1986-2010</td>
<td>52 middle-income countries</td>
<td>Dynamic Panel Data Models</td>
<td>GDP growth rate (annual %)</td>
<td>Human Capital: Human Development Index by UNDP</td>
</tr>
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<td>Physical Capital: Gross capital formation (% GDP) by World Bank (2000)</td>
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</tbody>
</table>

**Notes:**
- *Human Capital:* Includes education and health expenditures.
- *Physical Capital:* Includes gross capital formation as a percentage of GDP.
- *Institutions:* Includes economic freedom, political rights, and civil liberties indices.
- *Institutional Quality:* Includes corruption, freedom from corruption, and democratic force indices.
The model specified previously served to test the impact of the three main variables of economic growth: human capital measured by the average educational attainment of adults, productive specialization in ‘high-level’ industries measured by the share of employment in knowledge/technology-intensive industries (e.g., Financial Intermediation, Research and Development (R&D), Education), and the moderating effect of human capital on the productive structure. The estimation still includes a set of control variables related to investment, public consumption, population growth, and institutional environment, which the literature identifies as determinant factors of economic growth.

We use the panel data estimation as an econometric estimation technique. Within this framework, it is important to take into account the existence of two models: ‘random effects model’ and ‘fixed effects model’. The first assumes that the observations have unobserved individual effects that are constant over time and are correlated with the explanatory variables. Contrariwise, the fixed effects model considers that countries have specific effects, correlated with explanatory and non-random variables (Dreher, 2006; Batten and Vo, 2009).

The Hausman Test serves to objectively assess which of the two models mentioned above is the most suitable considering the available data. The null hypothesis ($H_0$) underlying the test is that the random effects model is more efficient than the fixed effects model. For our data, the Hausman Test has a $p$-value of 0.000 which means the null hypothesis ($H_0$) is rejected at a significance level of 1%. Thus, we opt for the fixed effects model, since it is the most efficient.

Table 2 presents the estimation for coefficients corresponding to each variable for both considered panels.

Both models present a good quality of adjustment reflected in a higher adjusted coefficient of determination ($\bar{R}^2$). Concretely, about 90% (96.7% in the second model) of the dependent variable around its sample mean is explained by the variables of the specified model. By observing the $F$ statistics and respective $p$-values, we can conclude that the models are globally significant, i.e., their explanatory variables relate statistically and significantly with economic growth.

Since we are working with fixed effects panel data, we cannot use time invariant variables. Thus, the estimation of the fixed effects model does not allow for the use of
the variable “Initial GDP”, measured by GDP per capita observed in 1960. Since the catching-up phenomenon is more relevant in the case of the poorest countries and we are considering countries with high levels of development, the estimation of Models I and II does not include this variable.

The human capital presents a significant positive impact in both models, which supports H1 (“Countries with a higher stock of human capital tend to grow faster than others”) and suggests, as postulated in the literature, that countries with a higher educational attainment of adults grow faster in the considered periods (1960-2011/1990-2011). This result meets the expectation that a higher stock of human capital improves the workforce’s skills, which has a positive impact on its productivity (Bodman and Le, 2013).

In addition, it is noted that the countries where structural change contributes to increasing the share of knowledge-intensive activities that require high skills, (e.g., Financial Intermediation, Computers, Research and Development and Education), tend, on average, to grow faster. Thus, H2 (“Countries that experience changes in productive structures towards a greater share of technology/knowledge-intensive activities will tend to observe higher economic growth.”) is also confirmed. Knowledge-intensive activities employ individuals with higher skills and knowledge because they are more productive (Hartwig, 2012) and capable of enhancing the emergence of new products and processes (Zagler, 2009). Therefore, the growth rates of countries that observe an increase in specialization in high-level industries tend to be higher.

Human capital also has a moderating effect, i.e., it has an indirect impact via productive specialization. However, H3 (The impact of human capital on the economic growth of a country is greater the more specialized the economy is in high technology/knowledge-intensive activities.”) is only confirmed in a much broader timeframe (1960-2011) (Model I). In this case particularly, the more educated the adult population, i.e., the higher their level of human capital, the higher the impact of a specialization in high-level industries on economic growth. The combination of a structural change in favor of more progressive, knowledge-intensive activities, with high levels of human capital, results in higher innovation in product and progress, which tends to generate increases in GDP per capita (cf. Justman and Teubal, 1991; Ciccone and Papaioannou, 2009).
Table 2: Estimation of the relationship between economic growth, human capital and productive structure (dependent variable: GDP per capita (in log), 1960-2011)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Proxy</th>
<th>Model I</th>
<th>Model II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Capital</td>
<td>Number of years of schooling of the population aged 25 or more (in log)</td>
<td>0.540*** (0.059)</td>
<td>1.000*** (0.127)</td>
</tr>
<tr>
<td>Structural Change</td>
<td>Share of 'high-level' industries in total employment</td>
<td>1.606** (0.637)</td>
<td>9.388*** (0.999)</td>
</tr>
<tr>
<td>Interaction between Human Capital and Productive Structure</td>
<td>Share of 'high-level' industries * Human Capital</td>
<td>0.342*** (0.051)</td>
<td>-0.375*** (0.086)</td>
</tr>
<tr>
<td>Investment</td>
<td>Investment rate</td>
<td>1.366*** (0.127)</td>
<td>0.334** (0.121)</td>
</tr>
<tr>
<td>Public Expenditures</td>
<td>Public Consumption in GDP</td>
<td>-2.160*** (0.224)</td>
<td>-2.369*** (-2.369)</td>
</tr>
<tr>
<td>Institutions</td>
<td>Political Rights index (1: the highest level … 7: the lowest level)</td>
<td>-0.248*** (0.024)</td>
<td>-0.144*** (0.022)</td>
</tr>
<tr>
<td></td>
<td>Civil Liberties index (1: the highest level … 7: the lowest level)</td>
<td>0.050** (0.023)</td>
<td>-0.085*** (0.016)</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>8.213*** (0.121)</td>
<td>7.193*** (0.301)</td>
</tr>
<tr>
<td>Global Effect of Human Capital</td>
<td>$\frac{\partial PIB}{\partial CH} = \beta_2 + \beta_4 \text{ High}$</td>
<td>0.589</td>
<td>0.936</td>
</tr>
<tr>
<td></td>
<td>$R^2$ Adjusted</td>
<td>0.900</td>
<td>0.967</td>
</tr>
<tr>
<td></td>
<td>Number of observations</td>
<td>1071</td>
<td>630</td>
</tr>
<tr>
<td></td>
<td>F statistic (p-value)</td>
<td>343.865 (0.000)</td>
<td>506.093 (0.000)</td>
</tr>
</tbody>
</table>

Note: Dependent variable: Logarithm of real GDP per capita, in constant prices; 'High-level' activities include: Financial Intermediation, Computers, Research and Development and Education; Standard deviations are in parentheses; *** (**) [*] Statically significant at 1% (5%) (10%).

In Model II, covering a shorter period (1990-2011) and more countries (added to Model I: Cyprus, Slovakia, Slovenia, Estonia, Hungary, Lithuania, Malta, Poland and Czech Republic), $H3$ is refuted. The estimation of the moderating effect of human capital on structural change is significantly negative. Thus, regardless of human capital having a positive direct (and significant) impact on economic growth, its indirect impact via the productive structure in favor of high-level industries is negative. We conclude that for the period in study (1990-2011) and the set of countries in this model, which includes a considerable number of Eastern European countries, economic growth is explained by the dynamics of human capital (education) and by the declining share of knowledge-intensive activities ('high-level'). It seems evident that in the sample with a shorter time horizon and transition economies, the matching between adult population with high
educational attainment and structural change towards a specialization in knowledge/technology-intensive activities does not contribute to higher economic growth. Nevertheless, the evidence shows that the overall effect (direct + indirect) of human capital on economic growth is higher in Model II than Model I.

Thus, we found that the effects of the interaction between structural change and human capital only appear in the long term, yielding opposite results in shorter periods that involve samples with transition economies.

Regarding the control variables, we found that high investment rates are related to higher economic growth, since high physical capital formation contributes positively to the productivity of production factors (Barro, 1991). In brief, economies with a high level of investment tend to grow faster than others. We also verified that investment/physical capital formation plays an important role in economic growth, both for the more developed, Western countries (Model I) and the more heterogeneous sample with Eastern European emergent economies (Model II). This evidence is in line with the results of Dreher (2006), Batten and Vo (2009) and Fabro and Aixalá (2009).

Our results confirm the idea that high public consumption can create market distortions, inefficiencies and crowding-out, that negatively affect economic growth Barro, 1991; Dreher, 2006; Moral-Benito, 2012; Afonso and Jalles, 2014); in both models – the estimate associated to the public consumption variable is significant (significance level of 1%). These results are in line with seminal studies (e.g., Barro, 1991) as well as more recent studies (e.g., Batten and Vo, 2009; Dreher, 2006; Afonso and Jalles, 2014).

Model I also confirms a negative relationship between population growth and economic growth, as suggested in the literature. Higher population growth reduces the capital/labor ratio, which affects negatively the GDP per capita (Mankiw et al., 1992). However, in Model II, based on a more heterogeneous sample that includes less developed countries, we find that higher population growth leads to higher economic growth.

The institutional and political measures present a statistically significant estimate. The ‘Political Rights’ index combines the degree of freedom in the electoral process, political participation and a decentralized political system (Moral-Benito, 2012), where lower values represent a higher level of democracy. Thus, since the result for the ‘Political Rights’ index is negative, we can conclude that more democratic, freer
countries have, on average, higher economic growth (in both models). The ‘Civil Liberties’ index includes freedom of belief and expression, associative freedom, respect for individual rights and laws that protect them. Similarly to the ‘Political Rights’ Index, lower values in this index mean a greater level of freedom. In Model II, the result for the ‘Civil Liberties’ index is negative (with a significance level of 1%), which means that countries with greater expression of individual freedoms tend on average to have higher economic growth. Thus, according to Fabro and Aixalá (2012), the institutional variables play an important role in boosting economic growth, by encouraging investment in physical and human capital and an efficient allocation of resources.

In Model I, we found the opposite result to the one expected. This may be due to the fact that for some countries included in this panel, the first years of the period studied (essentially the 1960s), in which they reveal very high economic growth rates, correspond to periods of dictatorial regimes, thus having also higher ‘Civil Liberties’ indexes.

Finally, our results support the relevance of institutional variables for economic growth. This is in line with the results obtained by Moral-Benito (2012), who estimated a 73-country panel over 40 years (1960-2000), and obtained a positive result in the ‘Political Right’ index and a negative result in the ‘Civil Liberties’ index.

5. Conclusions

Based on panel data covering 30 OCDE developed countries, this paper highlights the crucial role of structural change processes and their interaction with human capital on economic growth in the last few decades.

Our results suggest that, as supported in the literature, human capital plays a determinant role in economies growth, since a more educated adult population boosts the economic growth of countries. Secondly, it is shown that structural change is also a determinant of economic growth. Increasing specialization in knowledge/technology-intensive industries accelerates the economic growth of countries. Lastly, our results suggest that the contribution of human capital to economic growth is greater when the economy is more specialized in industries that require that same human capital. This means that the impact of human capital on GDP growth is amplified when knowledge-intensive industries, producing value-added goods and services, grow in importance in the composition of the economy. The interaction between human capital and structural
change towards 'high-level' industries is especially relevant in the richest and most developed countries, where these productive activities already represent a significant share of the economy. Moreover, the indirect effects of human capital via productive specialization in high-technology and/or knowledge-intensive activities are only visible over extended time horizons.

Thus, the present paper highlights the importance of the demand-side on economic growth, which has been neglected in the literature. More specifically, it confirms the crucial role that the productive specialization of countries plays in generating economic growth. It also evidences the indirect effect of human capital, when knowledge-intensive industries gain relative weight in the economies.

Following these conclusions, we put forward that the promotion of economic growth should not contemplate only investment in human capital through education, but also investment in technology/knowledge-intensive activities, generating high value added to the economies (e.g., Financial Intermediation, Computers, Research and Development and Education). Training and education as an investment in human capital should consider areas of knowledge and skills required by the dominant 'progressive' industries in the economy, i.e., those that experience increases in productivity and accelerate the rates of economic growth. Therefore, it makes sense to rethink the educational offer and system, and wager on vocational courses that meet market demands. The aim will be to promote the matching between skilled labor and economic activities that require these same qualifications. This implication is more relevant and a priority in richer countries.

This study has some limitations with respect to sample selection, including the small number of observations. Due to the unavailability of data and the aim of performing a long-term analysis, the cross-section is very small, containing only developed countries. This empirical analysis thus suffers from low heterogeneity with respect to economic development. Thus, the findings of this study cannot be extrapolated to the poorest economies, with different trends of structural change. Taking as a starting point the low heterogeneity of the countries belonging to the sample considered in this study, the analysis of the role of structural change and its interaction with human capital in economic growth could be extended to the least developed countries. Additionally, different taxonomies can be used to classify the industries so as to measure structural change phenomena. The application of a different taxonomy may also test the robustness of the results we obtained.
References


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