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GROWTH, INNOVATION, AND EMPLOYMENT OF THE HIGHLY TRAINED SSH RESEARCHERS

ABSTRACT

The first objective of this analysis is to develop an understanding of the trends in the employment of highly trained researchers in socio-economic sciences and humanities (SSH). This objective is realized by using either dynamic or static model specification, where employment of SSH researchers in ten (10) specific disciplines or specialities represent dependent variable, while the lagged number of SSH researchers, the number of SSH graduates, and R&D expenditure by sector of performance represent explanatory variables. In addition, this approach also enables the forecasting of employments trends of the entire sample of countries (EU-27), of two sub-samples of the countries (EU-15 and NEU-12). The next important objective of this study is to show the contribution of human capital to Europe's knowledge-based economy and society. This objective evaluates the interrelationship between growth, innovation, and human capital using either the static or dynamic model specification, where the share of the SSH tertiary students to total tertiary level students is used as an explanatory variable for human capital. This objective also enables robust result for either the entire sample or the two sub-samples of countries.

Key words: *education, employment of researchers, human capital, knowledge society, socio-economic sciences and humanities (SSH), EU members (EU-27)*

JEL classification: *I23, J24, O31, O43*

1. INTRODUCTION

Knowledge is gaining increasing importance in contemporary society as a factor of production and more importantly, of innovation and growth. Science systems are undergoing transformation in many European Union member states. The socio-economic sciences and humanities (SSH) acquired a special position in advanced European Union member states as a link between the university and industry. Thus the university in the Nederland has evolved from performing research and education functions to serving innovation-promoting knowledge functions (Hemert, 2009). At the same time the important task of the SSH in many less developed European Union member states is how to efficiently adjust the university education process to the functions and needs of the labour market, and in particular how to efficiently increase and improve skills (Papescu, 2009). More specifically, the problem is not a different perception of the knowledge society in these less developed countries, but a development gap between the advanced and less developed countries EU members which determines the different role of the socio-economic sciences and humanities there.

Accordingly, the hypothesis is that the development gap in terms of GDP per capita between fifteen core European Union member states (EU-15) and twelve new European Union states (NEU-12)[1] is related to the different total number of researchers per thousand employees, the different stock of the of patents, or the different share of tertiary social sciences and humanities graduates to all tertiary level graduates. For instance, the share of social sciences and humanities graduates of the EU-15 represents approximately 41% of the total tertiary level graduates of these countries from 1999 to 2008 as an explanatory variable for human capital, while the similar percentage of SSH graduates of the NEU-12 represents approximately 49% of the total tertiary level graduates of the same countries from 1999 to 2008.[2]

In this way the model specifications are first estimated using the entire sample of 27 European Union member countries (EU-27) and then estimated on two sub-samples of countries (that is, the EU-15 and NEU-12). The first part of this analysis explains in detail the contribution of human capital to a knowledge society. The Agenor and Neanidis's (2010) theory supposes that the key variable of education may influence growth both directly and indirectly, while innovation operates only directly on growth. The present study introduces a transformed model of the authors cited that takes into account both the direct and indirect effects of education and other introduced explanatory variables on growth, and the effects of education and other introduced proxy variables on innovation. Therefore this study takes into account the interrelationship between education, innovation, infrastructure and per capita output growth. This aim is achieved by employing an empirical specification that estimates four equations, one for each of these key variables.

The second part of this analysis provides a comprehensive answer to the question of the employability of SSH researchers, where the model specification allows also forecasting of the employment of SSH researchers for the entire sample of European Union member countries (EU-27), and two sub-samples countries (EU-15 and EU-12). An important advantage of this analysis is that a relatively comprehensive panel database enables estimation and forecasting of the employment of SSH researchers even for each of the particular European Union member states.

The presentation of the project proposal is structured as follows. Section Two explains in details the model and methodology for the largest part titled the *Contribution of human capital to a knowledge society*, while Section Three presents the theoretical literature, the model and methodology for the part of the analysis titled *Labour market prospects for SSH researchers*. The Section Four presents Concluding remarks.

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[1] The sample of 27 European Union countries and the two sub-samples of countries are presented in Appendix A.
[2] UNESCO Institute for Statistics, and own calculation.

2. CONTRIBUTION OF HUMAN CAPITAL TO A KNOWLEDGE SOCIETY

2.1. The Model

This study introduces an overlapping-generations (OLG) model suggested by Agenor and Neanidis (2010) as a theoretical basis. In this model education, public capital and innovations are all determinants of long-run growth. The authors used the terms public capital and infrastructure interchangeably as it is common in the literature. Infrastructure affects the economy in different ways: thought productivity in the production of final goods, thought the diffusion rate of new technologies, innovations capacity, and the economy's ability to produce human capital. The last influence is consistent with a number of studies that have documented a positive impact of infrastructures services on educational attainment. Nevertheless, it has been shown that a better transportation system lied to higher attendance rates, especially in rural areas. In this way the primary objective of the Agenor and Neanidis was to evaluate the inter-relationship between the stock of public capital (or infrastructure), and human capital, innovation and per capita output growth while controlling for the effect of public R&D spending on innovation.

The model delivers several testable hypotheses with respect to the effects of infrastructure, and at the same time with respect to the effects of public spending on R&D on growth. The former effect operates both directly and indirectly trough the capacity to innovate and human capital accumulation, while the later effect contributes to growth by fostering innovation. Cited authors tested these implications by using sample of 38 industrial and developing countries. This sample of *countries represents the OECD members (30) and affiliate countries (8)*. The estimation techniques include the standard estimation techniques (fixed effects model, random effects model), and dynamic GMM system estimator.

2.2. Transformed model

The present study uses suppositions presented by the Agenor and Neanidis theoretical model and at the same time introduces either new proxy variables or differently formed proxy variables in the four equations, one for each of the key variables: growth, innovation, education, and infrastructure. The supposition is that the transformed OLG model specifications *show better estimation results on the introduced sample of 27 developed or semi-developed countries which are members of the same economic and political union - EU*. Following the log-log space, the specifications that estimates the growth (1), innovation (2), education (3) and infrastructure (4) of the 27 European member states as dependent variables can be written as follows:

$$growth_{it} = \alpha_0 + \alpha_1 initGDP_{it} + \alpha_2 innov_{it} + \alpha_3 ifstruct_{it} + \alpha_4 educ_{it} + \\ + \alpha_5 capinv_{it} + \alpha_6 fdi_{it} + \alpha_7 migstock_{it} + \sum_{k=1}^{n} \xi_k X_{k,it} + \mu_i + \varepsilon_{it} \qquad (1)$$

$$innov_{it} = \beta_0 + \beta_1 initGDP_{it} + \beta_2 ifstruct_{it} + \beta_3 educ_{it} + \beta_4 patstock_{it} + \\ + \beta_5 capinv_{it} + \sum_{k=1}^{n} \lambda_l Z_{l,it} + \mu_i + u_{it} \quad (2)$$

$$educ_{it} = \gamma_0 + \gamma_1 initGDP_{it} + \gamma_2 ifstruct_{it} + \gamma_3 patstock_{it} + \\ + \sum_{k=1}^{n} \lambda_l Z_{l,it} + \sum_{j=1}^{q} \theta_j W_{j,it} + \mu_i + v_{it} \quad , \quad (3)$$

$$ifstruct_{it} = \delta_0 + \delta_1 initGDP_{it} + \delta_2 urban_{it} + \delta_3 popdens_{it} + \\ + \sum_{k=1}^{n} \lambda_l Z_{l,it} + \mu_i + z_{it} \quad (4)$$

where, i (t) is the country (time) index; $growth_{it}$ denotes the growth rate of per capita real GDP; $initGDP_{it}$ denotes the logarithm of initial per capita GDP; $innov_{it}$ represents innovation output, which is traditionally measured by the total number of patent applications in logarithmic form (which is defined as number of patents filed to the European patent office (EPO) by year of filing, according to the inventor's country of residence and normalize by million inhabitants); $educ_{it}$ represents education, measured as the share of SSH tertiary students in the total number of tertiary level students (which is newly defined); $ifstruct_{it}$ denotes a measure of the stock of infrastructure in the telecommunications sector, measured by the logarithm of the number of telephone lines per capita; $capinv_{it}$ is the variable for domestic capital investments measured by the gross fixed capital formation at current prices (which is introduced as a new variable in OLG model); fdi_{it} is the proxy variable for the foreign direct investments in logarithmic form, where a country's foreign direct investment net inflows are introduced (as the new variable in OLG model); $migstock_{it}$ is the stock of migrants population already resident in the host country defined as a percentage of the total population of the host country (as the new explanatory variable); $patstock_{it}$ is the stock of technical knowledge, proxied by the logarithmic stock of a country's patents, and $urban_{it}$ is the share of urban population defined as the share of total population. All variables except growth, education and urban population are in logs. The term μ_i captures the time invariant country-specific effects, and ε_{it}, u_{it}, v_{it}, z_{it} are the error terms.

Kibritcioglu et al. (2001) argued that economic growth is a complicated process that falls into the domain of many disciplines in the social sciences and humanities. Therefore it is natural to study fundamental aspects of economic growth by synthesizing research in relevant fields. They briefly discuss past growth theories and empirics, and present a broad framework to compare and evaluate work on economic growth from an interdisciplinary perspective. It is shown that there exists a two-way linkage between long-run economic growth and possible explanatory variables, and that long-run economic growth is determined by nine groups of the explanatory variables. Therefore the capital and labour, technology, geographical factors and climate, institutional factors and democracy, and income distribution represent the most important determinants for long-run economic growth, and conversely economic growth at the same time significantly influences the listed five group of factors. The first set of explanatory variables includes supply-side variables as for instance *domestic capital accumulation, increases in the labour stock, foreign direct investment and migration*, where the OLG model predicts only inclusion of private investments as an explanatory variable for the growth rate of per capita real GDP in equation (1).[3] Accordingly, it is possible to conclude that the overlapping-generations (OLG) model does not introduce the important set of explanatory variables.

This analysis includes three important factors which determine the long-run economic growth. The first new hypothesis of this analysis is that the growth rate of per capita real GDP as a dependent variable is determined by domestic capital investment,[4] where the gross fixed capital formation at current prices is introduced as a proxy variable for capital investments with a positive expected sign on this variable ($\alpha_5 > 0$). A similar supposition holds true also for innovation as a dependent variable in equation (2). For instance, Vieira et al., which included the gross fixed capital formation per employee (euros, at constant 2000 prices) as an explanatory variable, found significant values of the coefficients with a positive sign on this explanatory variable at the level of the 108 NUTS II regions from 1995 to 2002. In this way this variable is also included in equation (2). A positive sign is to be expected ($\beta_5 > 0$).

The second newly introduced supposition of this analysis predicts that foreign direct investments are positively correlated with the growth rate of per capita real GDP as a dependent variable. The foreign direct investment net inflows of the EU-15 and NEU-12 members are used as a proxy variable. A positive sign is to be expected ($\alpha_6 > 0$). The third introduced assumption in the model supposes that immigration labour force positively influences the growth rate of per capita real GDP. The stock of the origin country population already resident in the host country defined as percentage of the total population of the host country with the positive sign as expected ($\alpha_7 > 0$) is introduced as a proxy variable in the present analysis. Alternatively the annual inflow from the origin to the host country expressed as a percentage of the total population of the host country can be introduced in the equation (1).[5]

The next assumption is associated with the new definition of education as the proxy variable for human capital. For instance, the OLG model measures education with the share of tertiary level students relative to all students, while this analysis defines education with the share of SSH tertiary level students to all tertiary level students as an explanatory variable for human capital. Namely, Akcomak and Well (2009) *showed that the primary and secondary education measures are not expected to meter*

[3] More precisely, the labour force is also introduced indirectly, as the total number of inhabitants (that is in initial GDP per capita).
[4] The OLG model predicts inclusion of private investment, while the transformed model includes total capital investment.
[5] For instance, Svaton and Warin (2007) introduce annual migrant inflow as dependent variable.

significantly for innovation capacity. Therefore the supposition is that human capital is positively correlated with the growth rate of per capita real GDP, and that human capital is also positively related with innovation. A positive sign is expected also on this explanatory variable ($\alpha_4 > 0$, $\beta_3 > 0$).

2.3. Methodology

Most studies have estimated different specifications of the growth equation by using cross-section data, but recently several authors have argued that standard cross-section data leads to biased results because they do not control for heterogeneous trading relationships. For this reason Rault et al. (2007) suggested implementation of the panel data and introduction of a fixed effects estimator (FE), random effects estimator (RE) or the so-called fixed effects vector decomposition (FEVD) method as estimation techniques.

In this way the present study carries out several preliminary estimations and tests in order to compare the results of the introduced estimation methods and to identify the most robust one. In terms of econometric terminology, this analysis primarily estimates the regressions using the fixed effects estimator and the random effect estimator. At the same time this analysis introduces the Generalized Method of Moments (GMM) system estimator as preferable panel techniques. It is known that the dynamic GMM estimation techniques address potential endogeneity of the right-hand-side variables. Thus the fixed effects and random effects estimator, and two parallel dynamic GMM estimation methods are introduced in present analysis as the preferable estimation techniques.[6]

2.4. Data

The sample of 27 European Union countries is presented in Appendix A (a list of fifteen core European Union members states, and a list of twelve so-called new European Union member countries. This entire sample of countries (EU-27) is determined by the primary objective of the present analysis, while the time period[7] is restricted by the availability of data on education. The variable descriptions and sources can be found in Table 1 in Appendix A. While the present section presents only the definition of the basic variables, the choice of all other important variables is explained in Appendix B.

2.5. Robustness check

The robustness of the estimation results is assured by introduction of the four different panel techniques. Therefore this analysis firstly estimates equations (1)-(4) independently of each other with the fixed- and random-effects estimator, and the secondly by two dynamic GMM procedures. However the robustness of the analysis is additionally ensured. When the countries are characterized by very different levels of

[6] The two dynamic procedures introduced are: the difference-GMM estimator developed by Arellano and Bond (1991), and the system-GMM estimator of Blundell and Bond (1998).
[7] In the beginning of December 2010, the data on education are available for an observed period of eleven years (from Eurostat).

socio-economic development, *the model is firstly estimated using the entire sample of 27 countries (EU-27) and then estimated on two sub-samples based on economic development.*[8] In this way the first sub-sample represents fifteen core EU member states (EU-15), while the second sub-sample represents the Central and Eastern European countries, Malta and Cyprus (NEU-12).

3. LABOUR MARKET PROSPECTS OF SSH RESEARCHERS

3.1. The Model

The neoclassical trade theory supposes that the long-term gains from trade always outweigh the short-term labour adjustment costs. There is a positive sum game and eventually, the gains will be large enough to compensate the losers. In the Heckscher-Ohlin (HO) model, a consequence of free trade will be a redistribution of employment from the import substitute industry to the export industry. The HO framework assumes that inter-industry labour movements are free, so that no cost adjustments arise. Labour economists do not agree with this idea and consider that there are short-run adjustment costs, in terms of lost production, unemployment and reduced wages. Furthermore, the trade-off between the gains of trade liberalization and short-term labour adjustment costs depend on the labour skills. Every industry requires a workforce equipped with specific skills and the inter-industry labour reallocation implies a loss of these skills and a short - term adjustment cost. However, if the migration of labour occurs within the same industry, the labour adjustment cost will be lower. These arguments led to the formulation by trade economists of the so called Smooth Adjustment Hypothesis (SAH).

Faustino and Leitao (2010) provide an empirical test of the well-known Smooth Adjustment Hypothesis using Portuguese trade data. According to this hypothesis, a higher share of intra-industry trade between observed country and the main trading partners leads to relatively lower adjustment costs in comparison to inter-industry trade between the same partners. These authors test the SAH by using a dynamic panel data analysis that takes into account lagged effects of changes in the Marginal Intra-Industry Trade (MIIT) index. The regressions introduces the absolute change in the total employment in a given industry as a proxy for trade adjustment costs. The main results imply that a higher marginal intra-industry trade leads to lower adjustment costs in the same year. Thus the coefficients of the MIIT index are negative and statistically significant in all regressions. These results provide support for the SAH. Nevertheless the coefficients of the lagged MIIT indicators (one or two period) are mostly positive but not significant throughout. These results highlight the importance of lagged trade indicators in affecting labour reallocation outcomes and thus adjustment costs.

[8] Measured by GDP per capita, the fifteen core EU member states are on the average more developed in comparison with the NEU-12.

Faustino and Leitao predicted that employment changes are a dynamic phenomenon.[9] They therefore introduced dynamic panel data and the lagged number of employed workers into the following equation:

$$\left|\Delta N\right|_{it} = \beta_0 + \beta_1 \left|\Delta N\right|_{i,t-j} + \beta_2 \Delta X_{it} - \beta_3 \Delta X_{i,t-j} + \beta_4 MIIT_{it} - \beta_5 MIIT_{i,t-j} + \\ + \mu_i + \varepsilon_{it}$$

where, N_{it} is the total employment in industry *i* in time *t*, Δ stands for the difference between years *t* and *t-n*, *X* is the vector of explanatory variables, excluding marginal intra-industry trade (*MIIT*). All variables are in logs except *MIIT*. μ_i is the unobserved time-invariant country-specific effects, and the ε_{it} is the error term. A similar specification of a dynamic empirical model was considered previously by Greenaway et al. (1999). They used the GMM-DIF estimator, whereas Faustino and Leitao applied the GMM system estimator (GMM-SYS) developed by Blundell and Bond (1988, 2000).

3.2. The adapted model

The dynamic-model, which tested SAH hypothesis, is not directly transferable in this analysis. Faustino and Leitao introduced the total employment in Portuguese manufacturing industries as a dependent variable from the Portuguese National Institute of Statistics and the Ministry of Labour, while this project introduces the total number of researchers employed in SSH specific disciplines as a dependent variable and data for explanatory variables from the same source, the UNESCO Institute of Statistics. Therefore the present analysis introduces not only a different source of data but also completely different model specification. *More specifically, this analysis introduces dynamic panel data and the lagged number of employed researchers*, *while the model specification is completely different.*

Thus the present analysis tests the following dynamic-model specification:

$$\left|\Delta N\right|_{it} = \alpha_0 + \alpha_1 \left|\Delta N\right|_{i,t-j} + \alpha_2 \Delta educ_{it} - \alpha_3 \Delta educ_{i,t-j} + \alpha_4 \Delta RDex_{it} - \\ - \alpha_5 \Delta RDex_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (5)$$

where N_t represents the total number of employed researchers in the specific discipline or specialities *i* in time *t*, Δ stands for the difference between years *t* and *t-n*, N_{t-j} is the lagged number of employed researchers (in preceding years), $educ_{it}$ represents education, measured as the number of graduates in each of the specific discipline or specialities *i* and time *t*, and $RDex_{it}$ represents R&D expenditure by sector of performance, measured in current 000 PPP prices. All variables are in logs. The term

[9] The supposition was that the employment changes involve labour adjustment costs in different periods of time.

μ_i captures the time invariant effects, and ε_{it} is the error term. As pointed out, the results of the dynamic version of the equation (5) are valid only if the instruments are not correlated with the residual, and if there is no second-order serial correlation.

It is supposed that the number of lagged number of researchers $N_{i,t-j}$ in the specific social sciences and humanities (SSH) discipline or specialization i in time $t-j$ is positively correlated with the total number of employed researchers of the same specific discipline or specialization i as a dependent variable in time t, where the number of employed researchers in the previous year ($t-1$) is primarily introduced as an explanatory variable for the lagged employment. Greenaway et al. (2009) supposed that the past change in employment may have a positive impact on the current variations in employment. Therefore a positive sign is to be expected on this proxy variable ($\alpha_1 > 0$).

Similarly it is supposed that education - $educ_{it}$ of SSH specific discipline is positively correlated with the total number of employed researchers in the same specific discipline or specialities as a dependent variable. This analysis defines education with the number of graduates in the specific social sciences and humanities (SSH) discipline or specialities i in time t as a proxy variable for human capital. A positive sign is expected also on this explanatory variable ($\alpha_2 > 0$).

The next supposition is also completely newly introduced. It is assumed that the R&D expenditure as a proxy variable for public spending by sector of performance as for instance the business enterprises, government, higher education, and private non-profits is positively related to the total number of employed researchers of the specific disciplines or specializations as a dependent variable. The intuition behind this supposition is that a higher R&D expenditure by sector of performance at the same time enables a larger total number of the employed researchers in the same sector of performance. This proxy variable is measured in current 000 PPP prices, where a positive sign is expected on this variable ($\alpha_4 > 0$).

This analysis at the same time tests the following static-model specification:

$$N_{it} = \beta_0 + \beta_1 N_{i,t-j} + \beta_2 educ_{it} + \beta_3 RDex_{it} + \mu_i + \varepsilon_{it} \qquad (6)$$

where, N_t represents the total number of employed researchers in the specific discipline or specialization i in time t, $N_{i,t-j}$ is the lagged number of employed researchers (in preceding years), $educ_{it}$ represents education, measured as the number of graduates in each of the specific disciplines or specializations i and time t, $RDex_{it}$ represents R&D expenditure by sector of performance, measured in current 000 PPP prices. All variables except trend are in logs. The term μ_i captures the time invariant effects, and ε_{it} is the error term. For instance, Bach et al. (2009) additionally introduced the time trend ($\left(\beta_4 trend_{t-j}\right)$ in a similar equation, where either a positive or negative sign is to be expected on this variable ($\beta_4 < 0$), or ($\beta_4 > 0$).

Forecasting as it pertains to policy making is typically conducted at the national level. Therefore Bach et al. (2009) introduced a similar model that has the lagged dependent variable on the right-hand to forecast the total number of employed workers for Germany. In this way equation (6) is introduced to form forecasts of the employed researchers either at the national level or for the entire sample of European Union member states (EU-27). The methodology offers two possibilities, dynamic forecasting and static forecasting: Dynamic forecasting introduces the Kalman filter at time $t+1$, or n^* step ahead, while the smoothed forecasting introduces the Kalman smooth over the entire forecast period. For instance, the first option perform a multi-step forecast for the total number of employed researchers of the specific discipline or specialities (N_{it}), where the initial observation in the forecast sample will use the actual values of the lagged number of researcher as explanatory variables (N_{it-3}, N_{it-2}, N_{it}) on the right side of the equation.

3.3. Methodology

This analysis estimates the regression equation (5) presented below using the Generalized Method of Moments (GMM) system estimator .[10] As the lagged dependent variable enters into the regression equation as the explanatory variable and other exogenous variables, this study introduces an instrumental variable approach. The prediction is that a dynamic econometric model similar to those used in empirical growth studies better fits the theoretical hypothesis. But the results of the dynamic version of the GMM estimator are valid only if the instruments are not correlated with the residual, and if there is no second-order serial correlation. This study carries out several preliminary estimations and tests in order to compare the results of the introduced estimation methods and to identify the most robust one.

By contrast, equation (6) is primarily estimated using the fixed effects estimator or random effects estimator. The same equation is used for forecasting.

4.4. Data

Most of the data are provided from the same source, the UNESCO Institute for Statistics. Data are previously taken from the individual national statistics with the approval of the authorities of the EU member countries. Consequently, these data have been harmonized at the international level. Since the database provides annual series for the past eleven years, we used data from 1996 to 2008.

The sample of 27 European Union countries is presented in Appendix A, together with the two sub-samples of countries (a list of fifteen core European Union members states, and a list of twelve new European Union member countries). The entire sample of countries (EU-27) is determined by the primary objective of the present study, while

[10] The system-GMM estimator of Blundell and Bond (1998) is introduced.

the time period[11] is restricted by the availability of data on a number of the employed SSH researchers, education, and R&D expenditure. In the beginning of December 2010, the data on the total number of employed researchers in the SSH specific discipline or specialization are available for a thirteen-year observed period (from 1996 to 2008).

This analysis introduces ten (10) different most important SSH researcher disciplines and specializations, presented in Appendix C /Researchers by field of science and sector of employment/, and which are provided from the UNESCO Institute for statistics.

5.5. Robustness check

The robustness of the estimation results is assured by the introduction of two different model specifications, and consequently two different applied panel estimation techniques. As pointed out, primarily we introduce a dynamic regression equation (5), which is estimated using the Generalized Method of Moments (GMM) system estimator. As the lagged dependent variable enters into the regression equation as an explanatory variable, the instrumental variable approach is introduced in order to obtain consistent estimates. This exacting estimation methodology is preferable when the instruments are not correlated with the residual, and when there is no second-order serial correlation. At the same time this analysis introduces the static regression equation (6), where either the fixed effects model (FE) or random effects estimator (RE) are introduced as preferable panel estimation techniques.

The robustness of the estimation results is additionally ensured by formation of two sub-samples of countries. Therefore both elsewhere presented equations are first estimated using the entire sample of 27 European Union states (EU-27) and later estimated on two sub-samples of member countries which are formed according to development differences[12] between the core European members (EU-15), and the so-called new European Union members (NEU-12).

4. CONCLUDING REMARKS

This analysis develops an understanding of the trends in the employment of highly trained SSH researchers, and also evaluates the contribution of human capital to Europe’s knowledge-based economy and society by introducing a general differentiation between the so-called “old” and the “new” EU members. Thus the important contribution of this analysis is that it enables differentiation between the entire sample of countries (EU-27), and two sub-samples, the EU-15 and NEU-12 countries, and that it enables implementation of different policy measures for different groups of countries. In this way the second part of the analysis titled Labour market prospects of the SSH researchers introduces either a dynamic or static model

[11] In the beginning of December 2010, the data on the total number of employed researchers in the specific discipline or specialities are available for a thirteen-year observed period (from 1996 to 2008).
[12] Measured by GDP per capita, the fifteen core EU member states are on the average more developed in comparison with the NEU-15.

specification using relatively comprehensive database, where the total number of employed SSH researchers in a specific discipline or specialization represents dependent variable, while the lagged number of employed researchers, the total number of tertiary level SSH graduates, and the R&D expenditure in the same discipline or specialities represent explanatory variables. The next contribution of this paper is that it enables systematic understanding of the labour market prospects for those advanced research degree graduates who find their employment in ten different and most important SSH researcher disciplines and specializations.

Another important contribution of the project proposal is that it enables understanding of the contribution of human capital to a knowledge society. The first part of the analysis thus focuses on the interrelationship between growth, innovation, and human capital using three different samples of countries. In this study the share of SSH tertiary students relative to total tertiary level students is used as an explanatory variable for human capital. This model specification shows all direct or indirect influences of education on innovation and economic growth and defines human capital widely. It is notable that neither the number nor the share of SSH researchers is introduced in the analysis as an explanatory variable for human capital. While the total number of researchers (per thousand employees) is usually introduced as a proxy variable for technological differences, the alternative interrelationship between growth, innovation, and the number of SSH researchers as a proxy variable for human capital is not preferable in this analysis.

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APPENDIX A

The country sample (27)
The EU-15 states are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.
The NEU-12 countries are: Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovenia, Slovakia,

TABLE 1: **Variables description and sources.**[13]
The main data sources are EUROSTAT, International Monetary Found, OECD, UNESCO, and World Bank (WDI).

[13] Variables description and sources may be obtained from the author by request.

APPENDIX B

The choice of variables presented in equation (1)-(4) is based on the following considerations.

The level of initial GDP introduced in first and second equations controls for the feedback effect of economic activity on infrastructure, education, and innovation capacity. Following Akcomak and ter Weel (2009), this study measure innovation with the number of patent applications filed to the European Patent Organization, and education with the share of SSH students to all tertiary students, as primary and secondary education measures are not expected to matter significantly for innovation capacity. This analysis use a measure of access to telecommunications as measure of infrastructure, as it has been found to be the main contributive infrastructure category to economic growth (as it was confirmed by Bougheas et al. (2000), Egert et al. (2009), Esfahani and Ramirez (2003), Kellenberg (2009), Röller and Waverman (2001).

Variables $\left(X_{k,it}\right)_{k=1}^{m}$ represent a set of conditioning variables that have been identified in growth studies to explain a substantial variation in the data. They include the rates of fertility and inflation, and trade openness. $\left(Z_{l,it}\right)_{l=1}^{n-1}$ represents the set of fiscal variables in levels, measured as fractions of GDP. According to theoretical suppositions, the government budget identity in levels, $\sum_{l=1}^{n} Z_l = 0$, requires the exclusion of one fiscal factor Z_0 so that the coefficient $\lambda_l = z_l - z_0$, where z_i is the coefficient of variable Z_i, with z_0 unobserved, measures the marginal impact of the included factor Z_l, net of the marginal impact of the excluded factor Z_0. The set $\left(Z_{l,it}\right)_{l=1}^{n-1}$ comprises public spending on infrastructure, education, R&D, the remaining component of government spending, the budget deficit, and non-tax revenue; for consistency with the theoretical model, the excluded fiscal factor Z_0 is thus tax revenue. At a later stage, we also test for the composition effects of public spending where, on top of the level effects, we control for the set $\left(N_{p,it}\right)_{p=1}^{w}$. This is defined to include public spending on infrastructure, education, R&D, and the remaining component of government spending, all as shares of total public expenditure. By excluding one of these spending elements, say N_0, then given the budget identity $\sum_{p=1}^{w} N_p = 1$, the coefficient of each remaining component is understood to measure the marginal impact on growth of the included spending factor N_p, net of the marginal impact of the excluded factor N_0. In that case, however, it is necessary to control for the level effect of total government expenditure–independently of the composition effects. As in Devarajan et al. (1996), we do this by taking the ratio of that variable to GDP.

The set $\left(W_{j,it}\right)_{j=2}^{q}$ includes a group of controls typically associated with educational attainment (life expectancy, population, and the rate of urbanization), while *popdens*$_{it}$ stands for the rate of population density. Finally, μ_i captures time-invariant country-specific effects, whereas ε_{it}, u_{it}, v_{it}, and z_{iz} are the error terms. The term μ_i is incorporated in our panel specification as a means of allowing the fixed-country effects to capture certain observed patterns in the key variables, such as the country-specific propensity to apply for patents (see Bottazi and Peri (2005)).

APPENDIX C

Researchers by field of science and sector of employment
- Business enterprise - Social sciences
- Business enterprise - Humanities
- Government - Social sciences
- Government - Humanities
- Higher education - Social sciences
- Higher education - Humanities
- Private non-profit - Social sciences
- Private non-profit - Humanities
- Non-specificities – Social Sciences
- Non-specificities – Humanities

Source: The UNESCO Institute for Statistics disentangled data.