Human Capital and Growth of ICT-Intensive Industries:

Empirical Evidence from Open Economies

GAVIN MURPHY[a,b] and IULIA SIEDSCHLAG[a,b]

[a] *Economic and Social Research Institute Dublin, Whitaker Square, Sir John Rogerson's Quay, Dublin 2, Ireland.*
Emails: gavin.murphy@esri.ie; iulia.siedschlag@esri.ie
[b]*Department of Economics, Trinity College Dublin*

ABSTRACT

This paper examines the effect of human capital on the growth of ICT-intensive industries using data from a sample of open economies over the period 1980-1999. Our econometric analysis suggest that value added and employment in ICT-intensive industries grew relatively faster in countries with a higher *ex-ante* human capital stock and in countries with a fast improvement in human capital. Further, in countries with fast human capital accumulation, labour productivity in ICT-intensive industries grew faster. Our results are robust to controls for other determinants of industry growth and country characteristics affecting industry specialisation and to using alternative human capital measures.

Key words: Human capital, ICT industries, Economic growth

JEL classification: E62, F43, O33

INTRODUCTION

This paper examines the relationship between human capital and the growth of Information and Communication Technologies (ICT)-intensive industries using data from a sample of open economies over the period 1980-1999.

The question whether human capital fosters economic growth, in particular the growth of ICT-intensive industries is interesting and relevant for both research and policy. First, notwithstanding a well-established theoretical literature showing positive effects of human capital on economic growth, existing empirical evidence is mixed. Second, ICT are at the core of the knowledge-driven economy and there is growing evidence suggesting that ICT-linked knowledge, innovation and technological changes are strong determinants of growth differentials and the ability of countries to benefit from globalisation. While earlier studies have found little evidence of a link between ICT and growth, more recent studies point to a positive effect of ICT investment on growth (Oliner and Sichel 2000; OECD 2000; Timmer and van Ark 2005; van Ark, O'Mahony and Timmer 2008). The role of ICT-intensive industries on growth is threefold. First, to the extent that ICT industries grow faster than the other industries, their contribution to output growth can be significant (OECD 2000). Second, it has been shown that industries with higher shares of ICT in total capital experienced larger gains in productivity growth (Jorgenson and Stiroh 2000; Inklaar et al. 2008). Third, a growing literature points to positive spillovers generated by ICT use such as learning-by-doing effects, and accompanying organisational change as well as network effects (Katz and Shapiro 1994; Liebowitz and Margolis 1994). To the extent that such spillover effects and externalities exist they can raise overall total factor productivity (TFP). Carlsson (2004) and Hollestein (2004) find evidence suggesting that ICT had a positive effect on economic growth via new products and services and new organisation methods. Third, our research about the relationship between human capital and growth in ICT-intensive industries is relevant for education policy.

The theoretical literature[1] indicates several channels through which human capital affects economic growth. Nelson and Phelps (1966) show that high levels of human capital facilitate the adoption of new technologies. In contrast to this view, Lucas (1988) focuses on skill acquisition as an input in an aggregate production function. Romer (1990) allows for the possibility that both the stock as well as the growth of human capital generate ideas for new designs and goods which in turn endogenously drive physical capital investment and growth. Mankiw, Romer and Weil (1992) add human capital accumulation to the neoclassical Solow growth model and show that this augmented model explains better the cross-country differences in income per capita.

Most empirical analyses use educational attainment as a proxy for human capital and investigate the relationship between the level of education or education improvement and output growth at country level. The estimated output growth models are based on a standard Cobb-Douglas aggregate production function in which labour, human and physical capital enter as factors of production. The empirical results obtained with cross-country growth regressions are mixed. While Romer (1990) and Benhabib and Spiegel (1994) found a positive effect of the human capital level on output growth, Cohen and Soto (2007) found no significant effect. The same mixed evidence has been found in the case of the relationship between improvements in human capital and growth. In contrast to a significant positive correlation between improvements in human capital and growth found by Temple (1999), Cohen and Soto (2007), de la Fuente and Doménech (2006), no effect of human capital improvement on growth is found in other studies (Benhabib and Spiegel 1994; Barro and Sala-i-Martin 1995; Caselli, Esquivel and Lefort 1996). Furthermore, Topel (1999) and Krueger and Lindhal (2001) find a positive effect of the human capital level as well as human capital improvement on economic growth.

Cross-country growth regressions have several shortcomings (for example, no controls for unobserved heterogeneity, limited degrees of freedom, among others). Analysis at industry level across countries can correct for these limitations by exploiting the within country variation between industries. Rajan and Zingales (1998) use a cross-country cross-industry analysis to examine whether financial development fosters economic growth. They find that industries that are dependent on external finance grew faster in countries with more developed financial markets. Using a similar analysis at industry level in a large sample of countries, Ciccone and Papaioannou (2009) find that schooling-intensive industries grew relatively faster in countries that initially had higher levels of human capital and in countries with fast human capital improvement. Hirsch and Sulis (2008) provide additional empirical evidence on the positive effect of both the initial level of human capital and human capital improvement on the growth of value added and labour productivity across regions and industries in Italy. In contrast to findings of Ciccone and Papaioannou (2009) they find no significant effect of human capital on industry employment growth.

Following the seminal paper by Nelson and Phelps (1966), a large empirical literature has focused on the relationship between human capital and new technology adoption. Chun (2003) provide empirical evidence from the US over 1960-1996 showing that highly educated workers were more likely to implement new technologies such as information technology (IT). The adoption and use of IT accounted for a large proportion of the increase in the demand for educated workers over the period 1970-1996. Bartel and Sicherman (1999) find a positive correlation between the education premium of workers and technological change at industry level. Caselli and Coleman (2001) find that the educational attainment was an important determinant of the level of investment in computers in a sample of OECD countries over the period 1970-1990. Firm-level evidence suggests that firms using advanced technology employ more skilled workers. Doms et al. (1997) use plant-level data from the US and find a positive correlation between the education of workers and the use of new technology. Furthermore, they find that plants that invested relatively more in computing equipment had a higher increase in the share of non-production workers. Similar evidence supporting the hypothesis that the presence of highly skilled workers fosters innovation and facilitates ICT adoption and use at firm level was found in other studies (Arvanitis 2005; Bresnahan et al. 2002; Fabiani et al. 2005; Falk 2005; Bayo-Moriones and Lera-López 2007).

Our analysis builds on and extends the analysis by Ciccone and Papaioannou (2009). In particular, we investigate the effect of human capital on growth of ICT-intensive industries using measures for both the initial *stock* of human capital and the *accumulation* of human capital. We identify an independent effect of human capital on the growth of ICT-intensive industries over and above the effect of human capital on the growth of output and employment of schooling–intensive industries found by Ciccone and Papaioannou (2009). In addition, we extend our analysis to the effect of human capital on productivity growth.

The main finding of this paper is that in open developed countries, human capital is an important factor driving the growth of ICT-intensive industries. Specifically, on average, other things equal, in countries with an *ex-ante* high human capital stock and in countries with a rapid human capital accumulation, value added and employment in ICT-intensive industries grew relatively faster. Further, in countries with fast human capital accumulation, labour productivity in ICT-intensive industries grew faster. This effect of human capital on growth in ICT-intensive appears to be positive and significant over and above the effect of human capital on schooling-intensive industries. These results are robust to controls for other factors affecting industry growth, country characteristics affecting industry specialisation and alternative measures of human capital. In addition, while our results are stronger for a a data set of mainly manufacturing industries they hold when we estimate the model with a larger set of industries including services.

The remainder of this paper is organised as follows. Next Section outlines our empirical strategy, model specifications and explains how we account for potential econometric issues. Data that we use in our analysis is described next followed by a discussion of the results of our empirical analysis. The final Section concludes.

EMPIRICAL STRATEGY AND MODEL SPECIFICATION

This paper examines the relationship between human capital at country level and growth of ICT-intensive industries. To this purpose, we estimate an augmented aggregate production function model. Specifically, we focus on within country between industry variation building on the methodology used by Rajan and Zingales (1998) and Ciccone and Papaioannou (2009). On the basis of the theoretical and empirical background discussed above, we test the hypothesis that ICT-intensive industries grew faster in countries with an initial high stock of human capital and in countries with greater improvement in human capital. We first examine the link between human capital and value added growth and then extend the analysis to the effects of human capital on productivity and employment growth.

To identify the effect of human capital on industry growth we estimate the following benchmark model:

$$\Delta \ln y_{i,k,T} = \lambda_i + \mu_k + \alpha_1 (hc_{i,t_0} * ict_{k,t_0}) + \alpha_2 (\Delta hc_{i,T} * ict_{k,t_0}) + \alpha_3 (hc_{i,t_0} * hc_{k,t_0}) + \alpha_4 (\Delta hc_{i,T} * hc_{k,t_0}) + \\ + \alpha_5 (k_{i,t_0} * k_{k,t_0}) + \alpha_6 \ln y_{i,k,t_0} + \varepsilon_{i,k} \quad (1)$$

In the above model, the dependent variable ($\Delta \ln y_{i,k,T}$) is the average annual growth rate of real gross value added (or the average annual growth rate of labour productivity or average annual growth rate of employment) in industry k within country i over the analysed period T. The explanatory variables of interest are the country level initial human capital stock (hc_{i,t_0}) and human capital accumulation ($\Delta hc_{i,T}$) interacted with a measure of industry level ICT intensity (ict_{k,t_0}). Our theoretical prior is that $\alpha_1 > 0$ and $\alpha_2 > 0$.

Further, we control for other determinants of industry growth suggested by the recent relevant theoretical and empirical literature (Rajan and Zingales, 1998; Ciccone and Papaioannou 2009). To this purpose, the following two interactions capture the effect of country level initial human capital stock and human capital accumulation on the growth of human capital intensive industries. hc_{k,t_0} denotes human capital intensity in industry k in the base year. We control for the role of physical capital on growth by adding an interaction between the country level initial capital-output ratio (k_{i,t_0}) and industry level capital intensity (k_{k,t_0}). The initial level of gross value added, $\ln y_{i,k,t_0}$ (or the initial level of employment) account for differences in industry size.

In addition, we control for country-specific (λ_i) and industry-specific (μ_k) growth effects. Country-specific growth effects include unobserved factors affecting economic growth at country level. Industry-specific growth effects include unobserved industry characteristics such as industry-specific technological progress. Thus, our model specification explains the within country between industries variation of growth. We thus isolate the effect that human capital at country level has on growth of ICT-intensive industries relative to country and industry means.

Detailed definitions of variables and data sources are given in Table A1 in the Appendix. We estimate the equation (1) by ordinary least squares (OLS) and instrumental variables (IV) to account for the possibility that the accumulation of human capital could be endogenous as countries with a high income level or fast growing economies are able to allocate a higher proportion of their resources to education (Gemmel 1996). In addition, decisions to invest in education might be affected by industry growth in human capital intensive industries (Ciccone and Papaioannou, 2009). We do not treat the level of human capital in 1980 as endogeneous since it is less likely that this was affected by expected growth in human capital-intensive industries[2].

Further, we carry out a sensitivity analysis to check the robustness of our results to additional control variables, an alternative measure of human capital, and a larger set of industries. In particular, we consider country characteristics which affect industry specialisation such as income per capita, physical capital, financial development, and the quality of institutions.

DATA

Country-industry data

The country-industry data used in this paper is taken from the EU KLEMS database[3]. From this database we obtain data on nominal gross value added, number of employees, total number of hours worked by employees and total and ICT real fixed capital stock for both manufacturing and non-manufacturing industries for a mix of one and two digit ISIC Rev. 3 classification over the period 1970-2005. The database contains information for the EU countries[4] along with the United States (US), Canada, Switzerland, Australia, Japan and Korea. However, time coverage of the data series varies across countries: for EU countries before the EU enlargement of 2004 (EU-15) and US, Australia and Japan data is broadly available over the period 1970-2005, while for the new EU member countries (EU-10) coverage begins from 1995 onwards. Due to a limited number of observations we exclude countries from our sample for which data are only available post 1995. Thus, our sample includes 17 countries[5] which are all open economies. We deflate the nominal gross value added using country-industry specific gross value added price indices provided in the dataset to obtain real gross value added. The dependent variables in our model specifications are average annual changes of real gross value added, of labour productivity and of employment over the period 1980 to 1999.

The country level human capital measure is average years of schooling taken from the Barro and Lee (2001) human capital dataset which provides average years of schooling data at five year intervals for the period 1960-1999. The country level initial stock of human capital (hc_{i,t_0}) is measured as the average years of schooling in 1980. Human capital accumulation ($\Delta hc_{i,T}$) is measured as the change in the average years of schooling between 1980 and 1999. We construct our cross country-industry sample based on data covering the period 1980 to 1999[6]. We use information on ICT capital stock for 29 non-overlapping one and two digit industries[7].

Industry-level data

To investigate the effect of human capital on growth in ICT-intensive industries we adopt the difference-in-difference approach taken by Rajan and Zingales (1998) and contend that the effect of human capital on growth should vary depending on industry level ICT intensity. Similar to other papers which use this approach, we use industry data for US as a benchmark for industry characteristics (see for example Rajan and Zingales 1998; Raddatz 2006; Ciccone and Papaioannou 2009; Bassanini et al. 2009). Analogously, the key assumption underlying our benchmark approach is that for technological and economic reasons some industries require more ICT capital than others, and these differences persist across countries. The US is one of the most flexible market economies and thereby enables firms to adjust their capital stock mix closer to their desired level as they face lower barriers compared to firms in other countries. We therefore contend that the ICT intensity of US industries is an appropriate proxy for the underlying industry level ICT intensities. We compute the ICT intensity of industries in the US as the share of industry fixed ICT capital in total industry fixed capital stock.

The validity of using the US industry ICT intensity as our benchmark can be called into question on the grounds that institutional factors specific to the US may impact on the ICT intensity rates in particular sectors and thereby cast doubt on whether the US industry ICT intensity rates are a good measure of the cross-industry differences in ICT intensities in other countries[8]. Before we proceed with our analysis, it is therefore necessary to show that the US industry ICT intensity is an appropriate benchmark and that the underlying assumption of the benchmark approach is valid. To this purpose, we compare the distribution of ICT intensity of US and UK industries in 1980 using the Spearman rank correlation index. We compare the US with the UK as the UK is also one of the most flexible market economies in the world. The Spearman correlation index between the US and UK industry ICT intensity rates is high (0.54)[9] suggesting that US industry's ICT intensities are not driven by institutional characteristics specific to the US.

Further, we check that the distribution of ICT intensity across industries remains stable over time. To this purpose, we compare the Spearman rank correlation between the distributions of industry ICT intensity at five year intervals from 1980 to 2005. As shown in Table A2 in the Appendix, the distribution of ICT intensity across industries in the US has remained relatively stable over time. The Spearman correlation index between the intensity rates between 1980 and 1999 is quite high (0.72).

Table A3 in the Appendix reports values of industry ICT intensity, human capital intensity and physical capital intensity for all 29 industries. Industry human capital intensity is defined as the share of hours worked by medium and high skilled workers in total hours worked in an industry. Industry physical capital intensity is computed as the share of fixed capital stock in total gross value added.

In our analysis we focus on a smaller sample of mainly manufacturing industries. The reasoning for doing so is motivated by research which has highlighted that mismeasurement of gross value added and productivity can be quite large in some non-tradable sectors as well as in public sectors (see for example Nordhaus 2008; Inklaar et al. 2008). The excluded industries are the following: Agriculture, hunting, forestry and fishing; Real estate, renting and business activities; Mining and quarrying; Sale, maintenance and repair of motor vehicles and motorcycles, retail sale of fuel; Public administration and defence, compulsory social security; Coke, refined petroleum products and nuclear fuel; Education; Health and social work; Other community, social and personal services; Financial intermediation. In addition, given its very large ICT intensity we exclude Post and telecommunication, to ensure that our results are not driven by this outlier. In this restricted sample of 17 industries, “Electrical and optical equipment” has the highest ICT intensity while “Construction”, has the lowest ICT intensity.

Country level data

Our country-level measure of human capital is taken from the Barro and Lee (2001) dataset. Our initial human capital measure is the average years of schooling in 1980. The average years of schooling attained across the sample in 1980 was 7.5 years. Table A4 shows the values for the country level initial human capital stock and for human capital improvement used in our analysis. In 1980, Australia had the highest level of human capital (10 years) while Portugal had the lowest (3.3 years). The average change in the years of schooling across the sample of countries over the period was 1.5 years. Korea experienced the greatest increase in the average years of schooling (3.7 years) while Austria saw the lowest increase (0.4 years). As an alternative measure of human capital we use the share of the population who have completed secondary level education or have attained third level education. The average share of the population with this level of education was 28% in 1980 with Portugal exhibiting the lowest share, 8.1% and Sweden the greatest share, 51%.

Table A5 reports summary statistics for other country level variables used in our analysis. The country level controls used in our analysis are taken from a number of sources. Physical capital to GDP ratio is constructed using the real fixed capital stock for total industries taken from EU KLEMS and is expressed as a share of real GDP which is obtained from the World Economic Outlook Database. GDP per capita is obtained from the World Development Indicators dataset of the World Bank. We use two measures to control for financial development: domestic private credit as a share of GDP (measuring the size of financial markets), obtained from the World Development Indicators dataset of the World Bank and the stock market turnover ratio (measuring the liquidity of stock markets relative to their size), taken from the World Bank Financial Development and Structure Database (Beck et al. 2010). The stock market turnover data is available from the late 1980s onwards and we therefore use the value of stock market turnover ratio in 1990 in our analysis. Indices of the rule of law and of regulatory quality are taken from the World Bank Governance Indicators dataset (Kauffman et al 2009). We use the values of the indices in 1996 as this is the first year for which data is available.

EMPIRICAL RESULTS

Table 1 reports the benchmark estimates of the relationship between human capital and industry real gross value added growth. OLS estimates are shown in odd columns and IV estimates are given in even columns. In the IV model specifications we instrument human capital improvement over the period 1980-1999 with human capital accumulation over the period 1970-1980. The exogeneity of the interactions with human capital accumulation is rejected in all models. We focus our discussion on the IV estimates.

[Table 1 about here]

Models 1-3 show the effects of human capital on industry growth conditioned only on the initial level of gross value added. While in column 1 the coefficient of the initial country human capital interacted with industry ICT intensity is not statistically significant, it appears that human capital accumulation was associated with faster growth of ICT intensive industries. As shown in column 3, the effect of the initial human capital stock on the growth of ICT-intensive industries becomes significant when we add to the model the interaction between human capital accumulation and industry ICT intensity. This result is in line with findings by Krueger and Lindhal (2001) and Aghion et al (2010). Models 4-7 include additional interactions to control for other industry growth determinants. The positive and significant effects of both the human capital stock and human capital accumulation on the growth of ICT-intensive industries are robust to the inclusion of other determinants of industry growth. In particular, the effect of human capital on ICT-intensive industries appears independent of the effect of human capital on the growth of human capital-intensive industries and the role of physical capital. The coefficient of the initial conditions is negative and significant at 1 % level[10].

To interpret the economic significance of the above mentioned estimates we consider the growth differential between the industry at the 75th percentile of ICT intensity (Transport equipment) and the industry at the 25th percentile of ICT intensity (Wood and products of wood and cork) in a country with initial human capital stock at the 75th percentile (Austria with 8.4 years) in comparison with a country with an initial human capital stock at the 25th percentile (France with 6.8 years). The positive and highly significant coefficient of the initial human capital interaction shown in column 7 suggests that the annual growth differential between Transport equipment and Wood and products of wood and cork was 0.6% in Austria in comparison with France. The economic size of the effect of human capital improvement on growth in ICT-intensive industries is larger. Thus, the implied annual growth differential between the above mentioned industries is 0.9% in a country with human capital accumulation at the 75th percentile (Finland with a human capital improvement of 1.8 years over the period) in comparison with a country with human capital improvement at the 25th percentile (Denmark with a human capital improvement of 0.9 years). Given that the countries analysed here are developed countries, differentials in human capital stocks and human capital improvement are not sizable. It is therefore worthwhile to look at growth differentials between the 90th percentile and the 10th percentiles. In this latter case the implied annual growth differential between the industry at the 90th percentile of ICT intensity (Machinery, not classified elsewhere) and the industry at the 10th percentile (Rubber and plastic products) is 3.3% in a country with human capital stock at the 90th percentile (Denmark with 9.2 years) compared to the country with an initial human capital stock at the 10th percentile (Italy with 5.3 years) and 4.1% in a country with human capital improvement at the 90th percentile (Spain with 2.1 years) in comparison with a country with human capital improvement at the 10th percentile (Australia with 0.6 years).

[Table 2 about here]

Table 2 shows the sensitivity of our benchmark estimates to additional country-specific determinants of industry specialisation such as per capita income, physical capital, financial development (we consider two measures of financial development: the ratio of private credit to GDP - a measure of the size of financial markets and the stock market turnover ratio - a measure of the stock market liquidity relative to its size[11]), and the quality of institutions (the rule of law and regulatory quality). Again odd columns show the OLS estimates and even columns show the IV estimates. The exogeneity of the human capital variables is rejected in all models with the exception of the model controlling for the interaction between country stock market turnover ratio and industry ICT intensity. The positive and highly significant effect of human capital accumulation on the growth of ICT-intensive industries appears robust to all additional country characteristics interacted with industry ICT intensity. The effect of the initial human capital stock is positive and significant in all models with the exception of model 5 which includes an interaction of an index of the country level rule of law and industry ICT intensity. In this latter case, the human capital stock interaction with ICT intensity is positive but not significant. This finding together with the positive and highly significant coefficient of the rule of law interaction suggests that in countries with strong law contract enforcement, ICT-intensive industries grew faster and the effect of the initial human capital stock on the growth of ICT-intensive industries was not statistically significant over and above this effect. It is also worth noting that in countries with a high initial human capital stock, and in countries with a rapid human capital accumulation, human capital-intensive industries grew relatively faster. The statistical significance of the coefficients of the interactions between human capital accumulation and industry human capital intensity is lower in comparison to the initial human capital stock interactions. The estimates shown in Table 2 imply an annual growth differential between the 75th percentile industry and the 25th percentile industry of 0.5% to 0.7% in Austria in comparison to France. In the case of human capital improvement, the respective annual growth differential ranges from 0.9% to 1.9% in Finland in comparison to Denmark.

Further, we check the sensitivity of our results to an alternative measure of human capital, namely the share of the population over 25 years who have completed secondary level education or have attained third level education. The OLS and IV estimates of equation (1) and the sensitivity analysis to additional country characteristics interacted with industry ICT intensity are shown in Table 3.

[Table 3 about here]

The exogeneity of the interactions with human capital accumulation variables is not rejected when using this alternative measure of human capital. The OLS estimates are qualitatively similar to those obtained with the previous measure of human capital. The effect of the initial human capital stock on the growth of ICT-intensive industries is positive and significant in all models with the exception of the model controlling for the role of the stock market liquidity. The effect of human capital accumulation remains positive and significant in all model specifications. The coefficients of the interactions of human capital variables with industry level human capital intensity are positive but no longer statistically significant.

Next, we extend our analysis to the effects of human capital on the growth of productivity and employment.

[Table 4 about here]

Table 4 shows the OLS and IV estimates of the effect of human capital on the real gross value added per hour worked by employees[12]. The exogeneity of the human capital variables is not rejected. The OLS estimates suggest that in countries with fast human capital accumulation, labour productivity in ICT-intensive industries grew relatively faster. This result is robust to the inclusion of controls for other country characteristics interacted with the industry ICT intensity. The OLS estimates of the effect of the country initial human capital stock are positive but not statistically significant. Furthermore, the OLS estimates of the effect of human capital on the labour productivity in human capital-intensive industries are not statistically significant. The OLS estimates suggest that labour productivity growth differential between the 75th percentile industry and the 25th percentile industry was from 0.3% to 0.7 % per annum in Finland in comparison to Denmark.

[Table 5 about here]

Table 5 shows the OLS and IV estimates of the effect of human capital on employment growth. In this case, the exogeneity of the human capital variables is rejected. The IV estimates indicate that in countries with fast human capital accumulation, employment grew faster in ICT-intensive industries. The implied annual employment growth differential between the 75th percentile industry and the 25th percentile industry was from 0.4% to 0.9% in Finland in comparison to Denmark. This effect is statistically significant over and above the positive and statistically significant effect of the initial human capital stock and human capital accumulation on employment growth in human capital-intensive industries. The effect of the initial human capital level on employment growth in ICT-intensive industries is also positive but not significant in all models.

We finally re-estimate all regressions using a larger sample of industries. Table 6 shows the OLS and IV estimates of equation (1)[13] using a data set of 28 industries, all shown in Table A3 with the exception of Post and telecommunications, a major outlier.

[Table 6 about here]

The results are broadly qualitatively similar to the results obtained with the smaller number of industries. While the effect of human capital accumulation on labour productivity growth in ICT-intensive industries appears positive and statistically significant it is negative and statistically significant in the case of human capital-intensive industries[14].

SUMMARY AND CONCLUSIONS

This paper provides novel empirical evidence showing that the adoption of new technology and human capital are complementary. In particular, we investigate the effects of human capital on the growth of ICT-intensive industries using data from a sample of open economies over the period 1980-1999. We focus on within country between industry differences and control for country- and industry-specific effects and a set of interactions between country and industry characteristics. In our model specifications we account for the endogeneity of human capital improvement over the analysed period.

Our econometric analysis suggest that value added and employment in ICT-intensive industries grew faster in countries with a higher *ex-ante* human capital stock and in countries with a fast improvement in human capital. Further, in countries with fast human capital accumulation, labour productivity in ICT-intensive industries grew faster. Our results are robust to controls for other determinants of industry growth and factors affecting industry specialisation such as per capita income, physical capital, financial development, and quality of institutions as well as to using alternative human capital measures. The positive and statistically significant effect of human capital on growth in ICT-intensive industries appears independent of the effect of human capital on the growth of human capital-intensive industries documented by Ciccone and Papaioannou (2009) and Hirsch and Sulis (2008). The effect of human capital on the growth of ICT-intensive industries appears stronger in a data set of mainly manufacturing industries in comparison to a larger number of industries including services.

ACKNOWLEDGEMENTS

Financial support from the European Union's RTD 6th Framework Programme (Contract No. CIT5-028818) is gratefully acknowledged. We are grateful to Mary O'Mahony and her colleagues in Spain and France for kindly providing additional data from the EU KLEMS project. We thank John Fitz Gerald, Christian Volpe Martincus, Roberta Capello, participants in research seminars and conferences at the Economic and Social Research Institute in Dublin, Tinbergen Institute in Amsterdam, European Economic Association Congress in Budapest, Irish Economic Association in Bunclody, ESSHRA International Conference in Bern, European Association for Research in Industrial Economics Conference in Valencia, and three anonymous referees for helpful comments and suggestions.

APPENDIX

[Table A1 here]

[Table A2 here]

[Table A3 here]

[Table A4 here]

[Table A5 here]

NOTES

[1] See Aghion and Howitt (1998) for a discussion of the theoretical literature on economic growth

[2] Results obtained with regressions where both the human capital stock and human capital accumulation are instrumented are qualitatively similar. These results are available from the authors upon request.

[3] The March 2008 release available at: http://www.euklems.net/euk08i.shtml. O'Mahony and Timmer (2009) present a detailed description of the EU KLEMS database.

[4] All EU countries without Bulgaria and Romania (EU-25): Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal Slovakia, Slovenia, Spain, Sweden, United Kingdom.

[5] Australia, Austria, Belgium, Denmark, Spain, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, the Netherlands, Portugal, Sweden, United Kingdom.

[6] The period of over which we conduct our analysis ensures our results are comparable with Ciccone and Papaioannou (2009).

[7] Real gross value added data is not available for Belgium's "Coke, refined petroleum and nuclear fuel" industry in 1980.

[8] Bassanini et al. (2009) undertake a similar exercise to show that US industry layoff rates are an appropriate benchmark for the underlying layoff propensity in an industry.

[9] A Spearman rank-order correlation test gives a significance level rejecting the null hypothesis of no correlation between the two series (p-value = 0.0026).

[10] Our results are robust to the exclusion of this variable from regressions. We thank one anonymous referee for suggesting this sensitivity check. These results are available upon request from the authors.

[11] Existing empirical evidence suggests that economic growth is driven by the stock market liquidity rather than its size (see for example Levine and Zervos 1998; Beck and Levine 2004).

[12] We also estimated regressions using as dependent variable the real gross value added per employee. The results are broadly similar to those obtained with the gross value added per hour worked by employees as dependent variable. These results are available on request from the authors.

[13] We also performed a sensitivity analysis to the inclusion of additional country characteristics interacted with industry ICT intensity. The results are qualitatively similar to those obtained with the

restricted number of industries. The size of the effects of the human capital on the growth of ICT-intensive industries is smaller in comparison with those obtained with the smaller number of industries. These results are available upon request from the authors.

[14] The positive effect of human capital accumulation on labour productivity in ICT-intensive industries and a negative effect of human capital accumulation on labour productivity in human capital intensive industries are also obtained when we include the Post and Telecommunications industry in the sample. These results are available from the authors upon request.

REFERENCES

AGHION P. and HOWITT P. (1998) *Endogenous Growth Theory*. MIT Press, Cambridge, MA.

AGHION P., HOWITT P. and MURTIN F. (2010) Le bénéfice de la santé. Un apport des théories de la croissance endogène, *Revue de l'OFCE* 112, 87-108.

ARVANITIS S. (2005) Computerization, workplace organization, skilled labour and firm productivity: Evidence for the Swiss business sector, *Economics of Innovation and New Technology* 14(4), 225-249.

BARRO R. J. and SALA-I-MARTIN X. (1995) *Economic Growth*. McGraw-Hill, New York, NY.

BARRO R. J. and LEE J-W. (2001) International data on educational attainment: Updates and implications, *Oxford Economic Papers*. 53, 541-63.

BARTEL A. and SICHERMAN N. (1999) Technological change and wages: an interindustry analysis, *Journal of Political Economy* 107, 285-325.

BASSANINI A., NUNZIATA L. and VENN D. (2009) Job protection legislation and productivity growth in OECD countries, *Economic Policy* 24(58), 349-402.

BAYO-MORIONES A. and LERA-LÓPEZ F. (2007) A firm level analysis of determinants of ICT adoption in Spain, *Technovation* 27 (6-7), 352-366.

BECK T. and LEVINE R. (2004) Stock markets, banks, and growth: Panel evidence. *Journal of Banking and Finance* 28(3), 423-442.

BECK T., DEMIRGÜÇ-KUNT A. and LEVINE R. (2010) A new database on financial development and structure, *The World Bank Economic Review* 24(1), 77-92.

BENHABIB J. and SPIEGEL M. (1994) The role of human capital in economic development: Evidence from aggregate cross-country data, *Journal of Monetary Economics* 43, 143-174.

BRESNAHAN T., BRYNJOLFSSON E. and HITT L. M. (2002) Information technology, workplace organization, and the demand for skilled labour: Firm level evidence, *Quarterly Journal of Economics* 117(1), 339-376.

CARLSON B. (2004) The digital economy: what is new and what is not?, *Structural Change and Economic Dynamics* 15(3), 245-264.

CASELLI F., ESQUIVEL G. and LEFORT F. (1996) Reopening the convergence debate: A new look at cross-country growth empirics, *Journal of Economic Growth* 1(3), 363–389.

CASELLI F. and COLEMAN W. (2001) Cross-country technology diffusion: The case of computers, *American Economic Review* 91(2), 328-335.

CHUN H. (2003) Information technology and the demand for educated workers: Disentangling the impacts of adoption versus use, *Review of Economics and Statistics* 85, 1-8.

CICCONE A. and PAPAIOANNOU E. (2009) Human capital, the structure of production and growth, *Review of Economics and Statistics* 91(1), 66-82.

COHEN D. and SOTO M. (2007) Growth and human capital: Good data, good results, *Journal of Economic Growth* 12**,** 51-76.

de la FUENTE Á. and DOMÉNECH R. (2006) Human capital in growth regressions: How much difference does data quality make?, *Journal of European Economic Association* 4 (1), 1-36.

DOMS M., DUNNE T. and TROSKE K. (1997) Workers, wages and technology, *Quarterly Journal of Economics* 112(1), 253-290.

FABIANI S., SCHIVARDI F. and TRENTO S. (2005) ICT adoption in Italian manufacturing: Firm level evidence, *Industrial and Corporate Change* 14(2), 225-249.

FALK M. (2005) ICT-linked firm reorganisation and productivity gains, *Technovation* 25(11), 1229-1250.

GEMMELL N. (1996) Evaluating the impacts of human capital stocks and accumulation on economic growth: Some new evidence, *Oxford Bulletin of Economics and Statistics* 58(1), 9-28.

HIRSCH C. and SULIS G. (2008) *Schooling, Production Structure and Growth: An Empirical Analysis on Italian Regions*, CRENOS Working Paper No. 21, University of Cagliari and University of Sassari.

HOLLENSTEIN H. (2004) Determinants of the adoption of information and ICT. An empirical analysis based on firm-level data for the Swiss business sector, *Structural Change and Economic Dynamics* 15(3), 315-342.

INKLAAR R., TIMMER M. P. and VAN ARK B. (2008) Market services, productivity across Europe and the US, *Economic Policy* 23(1), 139-194.

JORGENSON D. W. and STIROH K. (2000) Raising the speed limit: US economic growth in the information age, *Brookings Papers on Economic Activity* 1, 125-211.

KATZ M. L. and SHAPIRO C. (1994) Systems competition and network effects, *Journal of Economic Perspectives* 8(2), 93-115.

KRUEGER A. and LINDHAL M. (2001) Education for growth, *Journal of Economic Literature* Vol. XXXIX, 1101-1136.

KAUFMAN D., KRAAY A. and MASTRUZZI M. (2009) *Governance Matters VIII: Aggregate and Individual Governance Indicators, 1996-2008*. World Bank Policy Research Working Paper No. 4978.

LEVINE R. and ZERVOS S. (1998) Stock markets, banks and economic growth, *American Economic Review* 88(3), 537-558.

LIEBOWITZ S. J. and MARGOLIS S. E. (1994) Network externality: An uncommon tragedy, *Journal of Economic Perspectives* 8(2), 133-50.

LUCAS R. E. (1988) On the mechanics of economic development, *Journal of Monetary Economics* 22(1), 3-42.

MANKIW G., ROMER D. and WEIL D. (1992) A contribution to the empirics of economic growth, *Quarterly Journal of Economics* 107, 407–437.

NORDHAUS W. D. (2008): Baumol's diseases: A macroeconomic perspective, *The B.E Journal of Macroeconomics* 8(1).

NELSON R. and PHELPS E. (1966) Investment in humans, technological diffusion and economic growth, *American Economic Review* 56, 69-75.

OECD. (2000) *A New Economy? The Changing Role of Innovation and Information Technology in Growth,* OECD, Paris.

OLINER S. D. and SICHEL D. E. (2000) The resurgence of growth in the late 1990s: Is information technology the story?, *Journal of Economic Perspectives* 14(4), 3-22.

O'MAHONY M. and TIMMER M. (2009) Output, input and productivity measures at the industry level; the EU KLEMS Database, *The Economic Journal* 119(538), 374-403.

RADDATZ C. (2006) Liquidity needs and vulnerability to financial underdevelopment, *Journal of Financial Economics* 80(3), 677-722.

RAJAN R. G. and ZINGALES L. (1998) Financial dependence and growth, *American Economic Review* 88(3), 559-86.

ROMER P. M. (1990) Human capital and growth: Theory and evidence, *Carnegie-Rochester Conference Series on Public Policy* 32, 251-86.

TEMPLE J. (1999) The new growth evidence, *Journal of Economic Literature* 37(1), 112-156.

TIMMER M. P. and VAN ARK B. (2005) Does information and communication technology drive EU-US productivity growth differentials?, *Oxford Economic Papers* 57(4), 693-716.

TOPEL R. (1999) Labor markets and economic growth, in Ashenfelter O. C. and Card D. (eds.) *Handbook of Labor Economics*, vol. 3C, 2943-2984, Elsevier, Amsterdam.

VAN ARK B., O'MAHONY M., AND TIMMER M.P. (2008) The productivity gap between Europe and the United States: Trends and causes, *Journal of Economic Perspectives* 22(1), 25-44.

Table 1. Human capital and industry value added growth: Benchmark estimates

	(1)	(2)		(3)		(4)		(5)		(6)	
	OLS	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
hc*ict intensity	0.101			0.233***	0.325***	0.189**	0.281***	0.164**	0.249***	0.218*	0.358***
	(0.079)			(0.075)	(0.081)	(0.078)	(0.083)	(0.078)	(0.082)	(0.116)	(0.118)
Δhc *ict intensity		0.510***	0.913***	0.735***	1.253***	0.732***	1.243***	0.596***	1.069***	0.716***	1.120***
		(0.172)	(0.278)	(0.162)	(0.322)	(0.161)	(0.319)	(0.154)	(0.314)	(0.139)	(0.301)
hc*hc intensity						0.015**	0.015**	0.023***	0.025***	0.028***	0.032***
						(0.007)	(0.007)	(0.009)	(0.008)	(0.011)	(0.012)
Δhc*hc intensity								0.044**	0.057*	0.047*	0.059*
								(0.021	(0.03)	(0.027)	(0.032)
k/y*k intensity										0.000	-0.000
										(0.001)	(0.001)
initial gva	-0.015***	-0.014***	-0.013***	-0.015***	-0.014***	-0.016***	-0.015***	-0.015***	-0.015***	-0.021***	-0.020***
	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.005)	(0.004)
Adjusted R^2	0.608	0.620	0.611	0.633	0.620	0.637	0.624	0.642	0.628	0.747	0.735
Observations	306	306	306	306	306	306	306	306	306	198	198
Countries	17	17	17	17	17	17	17	17	17	11	11
Industries	18	18	18	18	18	18	18	18	18	18	18
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Test for joint significance of country and industry fixed effects	F(34,270) =12.234 p = 0.000	F(34,270) =10.910 p = 0.000	χ^2 (34) =398.669 p = 0.000	F(34,269) =11.031 p = 0.000	χ^2 (34) =400.815 p = 0.000	F(34,268) =8.979 p = 0.000	χ^2 (28) =276.721 p = 0.000	F(28,267) =8.749 p = 0.000	χ^2 (28) =251.099 p =0.000	F(28,164) =9.481 p = 0.000	χ^2 (28) =266.364 p = 0.000
Wooldridge's robust score test of endogeneity			χ^2 (1) = 4.047 p = 0.044		χ^2 (1) = 5.818 p = 0.016		χ^2 (1) = 5.804 p = 0.016		χ^2 (2) = 6.296 p = 0.043		χ^2 (2) = 7.271 p = 0.026

Notes: The dependent variable is the average annual growth of real gross value added at the country-industry level over the period 1980-1999. The initial country-level human capital (hc) is measured as the average years of schooling in 1980 and it is interacted with industry-level ICT intensity (ict intensity) and industry-level human capital intensity (hc intensity). The human capital accumulation (Δhc) is the change in the average years of schooling at country level over the period 1980-1999 and it is interacted with industry ICT intensity and with industry human capital intensity. The physical capital interaction is obtained as the product between physical capital to GDP ratio at country level in 1980 (k/l) and industry physical capital intensity in 1980 (k intensity) measured as the ratio of industry fixed capital stock in total gross value added. Industry factor intensities are computed using data for the US. All models include the log of the gross value added (gva) in 1980 at the country-industry level. In the IV models human capital accumulation over the period 1980-1999 at country level is instrumented with the change in average years of schooling in each country for the period 1970-1980. Robust standard errors are shown in parentheses. Detailed definitions of variables and data sources are given in Table A1 in the Appendix.

Table 2. Human capital and industry value added growth: Controls for other country characteristics

	GDP per Capita (1)		Physical Capital (2)		Domestic Credit to GDP (3)		Stock Market Turnover (4)		Rule of Law (5)		Regulatory Quality (6)	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
hc*ict intensity	0.234**	0.392***	0.265*	0.475***	0.238**	0.376***	0.221*	0.298**	0.153	0.149	0.238*	0.353***
	(0.095)	(0.098)	(0.136)	(0.120)	(0.112)	(0.114)	(0.113)	(0.125)	(0.156)	(0.139)	(0.128)	(0.122)
Δhc*ict intensity	1.273***	2.270***	0.886***	1.534***	0.724***	1.118***	0.759***	0.988***	0.876***	1.475***	0.626***	1.172***
	(0.352)	(0.407)	(0.236)	(0.341)	(0.141)	(0.284)	(0.139)	(0.278)	(0.311)	(0.317)	(0.212)	(0.386)
hc*hc intensity	0.028***	0.031***	0.028***	0.032***	0.027**	0.031***	0.028***	0.032***	0.028***	0.031***	0.028***	0.032***
	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)
Δhc*hc intensity	0.047*	0.055*	0.047*	0.059*	0.048*	0.059*	0.048*	0.059*	0.047*	0.057*	0.047*	0.059*
	(0.027)	(0.031)	(0.027)	(0.032)	(0.026)	(0.032)	(0.027)	(0.032)	(0.027)	(0.031)	(0.027)	(0.032)
k/l*k intensity	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.000	-0.000	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
initial gva	-0.022***	-0.022***	-0.021***	-0.019***	-0.020***	-0.020***	-0.021***	-0.020***	-0.021***	-0.021***	-0.020***	-0.020***
	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
gdpc*ict intensity	1.129**	2.322***										
	(0.518)	(0.540)										
k/y*ict intensity			-0.214	-0.460***								
			(0.169)	(0.168)								
dcgdp*ict intensity					0.002	0.002						
					(0.002)	(0.001)						
smt*ict intensity							0.420	0.509**				
							(0.265)	(0.233)				
rlaw*ict intensity									0.647	1.783**		
									(0.980)	(0.801)		
regq*ict intensity											-0.462	0.211
											(0.687)	(0.773)
Adjusted R^2	0.758	0.732	0.749	0.729	0.748	0.737	0.748	0.744	0.747	0.734	0.747	0.731
Observations	198	198	198	198	198	198	198	198	198	198	198	198
Countries	11	11	11	11	11	11	11	11	11	11	11	11
Industries	18	18	18	18	18	18	18	18	18	18	18	18
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Test joint significance of country and industry fixed effects	F(28,163) =8.907 p = 0.000	χ^2 (28) =226.601 p = 0.000	F(28,163) =8.933 p = 0.000	χ^2 (28) =252.770 p = 0.000	F(28,163) =9.540 p = 0.000	χ^2 (28) =284.536 p = 0.000	F(28,163) =7.473 p = 0.000	χ^2 (28) =246.557 p = 0.000	F(28,163) =8.514 p = 0.000	χ^2 (28) =263.337 p = 0.000	F(28,163) =8.947 p = 0.000	χ^2 (28) =248.695 p = 0.000
Wooldridge's robust score test of endogeneity		χ^2 (2) = 6.181, p = 0.045		χ^2 (2) = 7.158, p = 0.028		χ^2 (2) = 6.984, p = 0.030		χ^2 (2) = 3.115, p = 0.211		χ^2 (2) = 8.449, p = 0.015		χ^2 (2) = 5.712, p = 0.058

Notes: The dependent variable is the average annual growth of real gross value added at the country-industry level over the period 1980-1999. The initial country-level human capital (hc) is measured as the average years of schooling in 1980 and it is interacted with industry-level ICT intensity (ict intensity) and industry-level human capital intensity (hc intensity). The human capital accumulation (Δhc) is the change in the average years of schooling at country level over the period 1980-1999 and it is interacted with industry ICT intensity and with industry human capital intensity. The physical capital interaction is obtained as the product between physical capital to GDP ratio at country level in 1980 (k/l) and industry physical capital intensity in 1980 (k intensity) measured as the ratio of industry fixed capital stock in total gross value added. Industry factor intensities are computed using data for the US. All models include the log of the gross value added (gva) in 1980 at the country-industry level. Controls for country characteristics include interactions of industry ICT intensity in 1980 with country level values in 1980 for the following indicators: per capita GDP (gdpc), physical capital to GDP ratio (k/l), domestic credit to GDP ratio (dcgdp), stock market turnover ratio (smt), the rule of law (rlaw), and regulatory quality (regq). In the IV models human capital accumulation over the period 1980-1999 at country level is instrumented with the change in average years of schooling in each country for the period 1970-1980. Robust standard errors are shown in parentheses. Detailed definitions of variables and data sources are given in Table A1 in the Appendix.

Table 3. Human capital and industry value added growth: Alternative measure of human capital

			GDP per Capita		Physical Capital		Domestic Credit to GDP		Stock Market Turnover		Rule of Law		Regulatory Quality	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
hc*ict intensity	2.287*	7.090***	2.301*	5.865**	3.897**	7.595***	2.468*	7.079***	1.790	5.336**	2.739**	4.348*	2.470*	6.765***
	(1.294)	(2.329)	(1.312)	(2.369)	(1.595)	(2.180)	(1.274)	(2.320)	(1.610)	(2.590)	(1.234)	(2.336)	(1.341)	(2.269)
Δhc*ict intensity	5.071***	20.459***	5.877**	23.479***	8.869***	19.089***	4.998***	19.971***	5.924***	22.747***	4.328**	20.895***	3.940**	22.038***
	(1.589)	(5.558)	(2.504)	(5.263)	(2.788)	(6.056)	(1.680)	(5.541)	(1.352)	(8.116)	(2.152)	(5.215)	(1.926)	(5.801)
hc*hc intensity	0.154	-0.030	0.154	0.011	0.153	-0.012	0.150	-0.031	0.155	0.017	0.155	-0.058	0.155	-0.076
	(0.121)	(0.201)	(0.122)	(0.210)	(0.121)	(0.209)	(0.120)	(0.200)	(0.120)	(0.190)	(0.122)	(0.209)	(0.122)	(0.206)
Δhc*hc intensity	0.344	-0.239	0.343	-0.102	0.342	-0.176	0.349	-0.231	0.346	-0.095	0.345	-0.324	0.346	-0.381
	(0.226)	(0.511)	(0.227)	(0.520)	(0.227)	(0.526)	(0.224)	(0.507)	(0.227)	(0.490)	(0.227)	(0.529)	(0.226)	(0.522)
k/l*k intensity	-0.000	0.000	-0.000	0.000	0.000	0.001	0.000	0.001	-0.000	0.000	-0.000	0.001	-0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
initial gva	-0.021***	-0.020***	-0.021***	-0.022***	-0.021***	-0.020***	-0.021***	-0.019***	-0.021***	-0.019***	-0.021***	-0.021***	-0.020***	-0.021***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
gdpc*ict intensity			0.209	1.907***										
			(0.497)	(0.591)										
k/y*ict intensity					-0.410*	-0.895***								
					(0.236)	(0.309)								
dcgdp*ict intensity							0.002	0.001						
							(0.002)	(0.002)						
smt*ict intensity									0.558	1.802**				
									(0.463)	(0.809)				
rlaw*ict intensity											-0.384	1.620*		
											(0.590)	(0.890)		
regq*ict intensity													-0.686	1.051
													(0.628)	(1.018)
Adjusted R^2	0.729	0.572	0.728	0.598	0.737	0.697	0.729	0.580	0.731	0.562	0.728	0.588	0.731	0.548
Observations	198	198	198	198	198	198	198	198	198	198	198	198	198	198
Countries	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Industries	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Test joint significance of country and industry fixed effects	F(28,164) =11.925 p = 0.000	χ^2 (28) =197.833 p = 0.000	F(28,163) =11.595 p = 0.000	χ^2 (28) =227.043 p = 0.000	F(28,163) =11.441 p = 0.000	X^2 (28) =309.246 p = 0.000	F(28,163) =12.027 p = 0.000	χ^2 (28) =209.014 p = 0.000	F(28,163) =8.387 p = 0.000	χ^2 (28) =207.67 p = 0.000	F(28,163) =11.811 p = 0.000	χ^2 (28) =216.184 p = 0.000	F(28,163) =12.24 p = 0.000	χ^2 (28) =198.288 p = 0.000
Wooldridge's robust score test of endogeneity		χ^2 (2) = 3.924 p = 0.141		χ^2 (2) = 4.271 p = 0.118		X^2 (2) = 3.193 p = 0.203		χ^2 (2) = 3.973 p = 0.137		χ^2 (2) = 3.376 p = 0.185		χ^2 (2) = 4.058 p = 0.131		χ^2 (2) = 3.397 p = 0.183

Notes: The dependent variable is the average annual growth of real gross value added at the country-industry level over the period 1980-1999. The initial country-level human capital (hc) is measured as the country level share of the population over 25 years with completed secondary or attained tertiary education in 1980 and it is interacted with industry-level ICT intensity (ict intensity) and industry-level human capital intensity (hc intensity). The human capital accumulation (Δhc) is the country level change in the share of population of over 25 years with completed secondary or attained tertiary education over the period 1980-1999 and it is interacted with industry ICT intensity and with industry human capital intensity. The physical capital interaction is obtained as the product between physical capital to GDP ratio at country level in 1980 (k/l) and industry physical capital intensity in 1980 (k intensity) measured as the ratio of industry fixed capital stock in total gross value added. Industry factor intensities are computed using data for the US. All models include the log of the gross value added (gva) in 1980 at the country-industry level. Controls for country characteristics include interactions of industry ICT intensity in 1980 with country level values in 1980 for the following indicators: per capita GDP (gdpc), physical capital to GDP ratio (k/l), domestic credit to GDP ratio (dcgdp), stock market turnover ratio (smt), the rule of law (rlaw), and regulatory quality (regq). In the IV models human capital accumulation over the period 1980-1999 at country level is instrumented with the change in average years of schooling in each country for the period 1970-1980. Robust standard errors are shown in parentheses. Detailed definitions of variables and data sources are given in Table A1 in the Appendix.

Table 4. Human capital and industry labour productivity growth

			GDP per capita		Physical capital		Domestic Credit		Stock Market Turnover		Rule of Law		Regulatory Quality	
	(1) OLS	(2) IV	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV	(7) OLS	(8) IV	(9) OLS	(10) IV	(11) OLS	(12) IV
hc*ict intensity	0.135	0.200**	0.146	0.217**	0.173	0.264***	0.159	0.220**	0.136	0.180**	0.168	0.191	0.157	0.208**
	(0.103)	(0.091)	(0.093)	(0.086)	(0.114)	(0.102)	(0.098)	(0.087)	(0.101)	(0.090)	(0.147)	(0.128)	(0.113)	(0.093)
Δ hc* ict intensity	0.473***	0.662***	0.877***	1.238***	0.612***	0.889***	0.484***	0.660***	0.488***	0.620***	0.392*	0.677***	0.374**	0.575**
	(0.154)	(0.187)	(0.259)	(0.335)	(0.197)	(0.249)	(0.167)	(0.188)	(0.155)	(0.168)	(0.215)	(0.262)	(0.181)	(0.251)
hc*hc intensity	0.011	0.004	0.011	0.004	0.011	0.004	0.010	0.003	0.011	0.004	0.011	0.004	0.011	0.004
	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Δ hc*hc intensity	-0.017	-0.038	-0.018	-0.040	-0.017	-0.038	-0.017	-0.038	-0.017	-0.038	-0.017	-0.038	-0.017	-0.037
	(0.022)	(0.028)	(0.022)	(0.028)	(0.022)	(0.028)	(0.022)	(0.028)	(0.022)	(0.028)	(0.022)	(0.028)	(0.022)	(0.028)
k/y* k intensity	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
initial gva	-0.018***	-0.018***	-0.018***	-0.019***	-0.018***	-0.017***	-0.017***	-0.017***	-0.018***	-0.018***	-0.018***	-0.018***	-0.017***	-0.018***
	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
gdpc*ict intensity			0.818*	1.162**										
			(0.430)	(0.451)										
k/y*ict intensity					-0.174	-0.252**								
					(0.129)	(0.128)								
dcgdp*ict intensity							0.003*	0.003*						
							(0.001)	(0.001)						
smt*ict intensity									0.144	0.166				
									(0.183)	(0.163)				
rlaw*ict intensity											-0.329	0.074		
											(0.665)	(0.617)		
regq*ict intensity													-0.512	-0.350
													(0.569)	(0.576)
Adjusted R^2	0.646	0.642	0.653	0.648	0.647	0.642	0.649	0.646	0.644	0.641	0.644	0.639	0.646	0.643
Observations	198	198	198	198	198	198	198	198	198	198	198	198	198	198
Countries	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Industries	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Test joint significance of country and industry fixed effects	F(28,164) =9.422 p = 0.000	χ^2 (28) =328.997 p = 0.000	F(28,163) =9.325 p = 0.000	$\chi^2$28) =311.031 p = 0.000	F(28,163) =9.303, p = 0.000	χ^2 (28) =321.127 p = 0.000	F(28,163) =9.835 p = 0.000	χ^2 (28) =339.962 p = 0.000	F(28,163) =8.612 p = 0.000	χ^2 (28) =290.506 p = 0.000	F(28,163) =9.045 p = 0.000	χ^2 (28) =316.015 p = 0.000	F(28,163) =9.351 p = 0.000	χ^2 (28) =327.392 p = 0.000
Wooldridge's robust score test of endogeneity		χ^2 (2) = 2.895 p = 0.235		χ^2 (2) = 2.748 p = 0.253		χ^2 (2) = 3.139 p = 0.208		χ^2 (2) = 2.732 p = 0.255		χ^2 (2) = 2.268 p = 0.322		χ^2 (2) = 3.407 p = 0.182		χ^2 (2) = 2.219 p = 0.330

Notes: The dependent variable is the average annual growth of real gross value added per hour worked by employees at the country-industry level over the period 1980-1999. The initial country-level human capital (hc) is measured as the average years of schooling in 1980 and it is interacted with industry-level ICT intensity (ict intensity) and industry-level human capital intensity (hc intensity). The human capital accumulation (Δhc) is the change in the average years of schooling at country level over the period 1980-1999 and it is interacted with industry ICT intensity and with industry human capital intensity. The physical capital interaction is obtained as the product between physical capital to GDP ratio at country level in 1980 (k/l) and industry physical capital intensity in 1980 (k intensity) measured as the ratio of industry fixed capital stock in total gross value added. Industry factor intensities are computed using data for the US. All models include the log of the gross value added (gva) in 1980 at the country-industry level. Controls for country characteristics include interactions of industry ICT intensity in 1980 with country level values in 1980 for the following indicators: per capita GDP (gdpc), physical capital to GDP ratio (k/l), domestic credit to GDP ratio (dcgdp), stock market turnover ratio (smt), the rule of law (rlaw), and regulatory quality (regq). In the IV models human capital accumulation over the period 1980-1999 at country level is instrumented with the change in average years of schooling in each country for the period 1970-1980. Robust standard errors are shown in parentheses. Detailed definitions of variables and data sources are given in Table A1 in the Appendix.

Table 5. Human capital and industry employment growth

			GDP per capita		Physical capital		Domestic Credit to GDP		Stock Market Turnover		Rule of Law		Regulatory Quality	
	(1)	(2)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
hc*ict intensity	0.067	0.151*	0.073	0.169**	0.076	0.203**	0.065	0.150*	0.069	0.110	-0.010	-0.029	0.068	0.140*
	(0.066)	(0.083)	(0.058)	(0.075)	(0.076)	(0.082)	(0.067)	(0.083)	(0.068)	(0.082)	(0.070)	(0.074)	(0.066)	(0.084)
Δhc*ict intensity	0.275**	0.514**	0.487**	1.157***	0.308*	0.701***	0.274**	0.514**	0.303**	0.425*	0.466**	0.818***	0.271*	0.636**
	(0.132)	(0.248)	(0.213)	(0.312)	(0.167)	(0.247)	(0.133)	(0.249)	(0.148)	(0.221)	(0.181)	(0.222)	(0.155)	(0.284)
hc*hc intensity	0.020**	0.028***	0.021**	0.028***	0.020**	0.028***	0.020**	0.028***	0.020**	0.027***	0.020**	0.027***	0.020**	0.028***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Δhc*hc intensity	0.051**	0.073***	0.050**	0.069***	0.051**	0.073***	0.051**	0.073***	0.051**	0.073***	0.051**	0.073***	0.051**	0.073***
	(0.021)	(0.023)	(0.021)	(0.024)	(0.021)	(0.023)	(0.021)	(0.023)	(0.021)	(0.023)	(0.021)	(0.023)	(0.021)	(0.023)
k/y*k intensity	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Initial employment	-0.010***	-0.009***	-0.010***	-0.011***	-0.010***	-0.009***	-0.010***	-0.009***	-0.010***	-0.009***	-0.009***	-0.009***	-0.010***	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
gdpc*ict intensity			0.424	1.277***										
			(0.283)	(0.418)										
k/y*ict intensity					-0.041	-0.208**								
					(0.098)	(0.106)								
dcgdp*ict intensity							-0.000	-0.000						
							(0.001)	(0.001)						
smt*ict intensity									0.277	0.342*				
									(0.188)	(0.183)				
rlaw*ict intensity											0.773	1.542***		
											(0.500)	(0.462)		
regq*ict intensity													-0.022	0.490
													(0.311)	(0.385)
Adjusted R^2	0.755	0.738	0.757	0.726	0.754	0.73	0.753	0.737	0.756	0.748	0.759	0.743	0.753	0.73
Observations	198	198	198	198	198	198	198	198	198	198	198	198	198	198
Countries	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Industries	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes
Test joint significance of country and industry fixed effects	F(28,164) =21.635 p = 0.000	χ^2 (28) =648.423 p = 34	F(28,163) =20.667, p = 0.000	χ^2 (28) =626.686 p = 34	F(28,163) =21.388 p = 0.000	χ^2 (28) =620.689 p = 34	F(28,163) =20.729 p = 0.000	χ^2 (28) =645.771 p = 34	F(28,163) =21.327 p = 0.000	χ^2 (28) =684.747 p = 34	F(28,163) =21.131 p = 0.000	χ^2 (28) =647.731 p = 34	F(28,163) =20.837 p = 0.000	χ^2 (28) =617.548 p = 34
Wooldridge's robust score test of endogeneity		χ^2 (2) = 11.313 p = 0.003		χ^2 (2) = 9.979 p = 0.007		χ^2 (2) = 10.800 p = 0.005		χ^2 (2) = 11.521 p = 0.003		χ^2 (2) = 6.025 p = 0.049		χ^2 (2) = 11.337 p = 0.003		χ^2 (2) = 10.667 p = 0.005

Notes: The dependent variable is the average annual growth of the number of employees at the country-industry level over the period 1980-1999. The initial country-level human capital (hc) is measured as the average years of schooling in 1980 and it is interacted with industry-level ICT intensity (ict intensity) and industry-level human capital intensity (hc intensity). The human capital accumulation (Δhc) is the change in the average years of schooling at country level over the period 1980-1999 and it is interacted with industry ICT intensity and with industry human capital intensity. The physical capital interaction is obtained as the product between physical capital to GDP ratio at country level in 1980 (k/l) and industry physical capital intensity in 1980 (k intensity) measured as the ratio of industry fixed capital stock in total gross value added. Industry factor intensities are computed using data for the US. All models include the log of the gross value added (gva) in 1980 at the country-industry level. Controls for country characteristics include interactions of industry ICT intensity in 1980 with country level values in 1980 for the following indicators: per capita GDP (gdpc), physical capital to GDP ratio (k/l), domestic credit to GDP ratio (dcgdp), stock market turnover ratio (smt), the rule of law (rlaw), and regulatory quality (regq). In the IV models human capital accumulation over the period 1980-1999 at country level is instrumented with the change in average years of schooling in each country for the period 1970-1980. Robust standard errors are shown in parentheses. Detailed definitions of variables and data sources are given in Table A1 in the Appendix.

Table 6. Human capital and industry growth: Benchmark estimates, extended industry data set (28 industries)

	Gross value added growth (1)		Labour productivity growth (2)		Employment growth (3)	
	OLS	IV	OLS	IV	OLS	IV
hc*ict intensity	0.180*	0.312***	0.145	0.209**	0.047	0.123*
	(0.106)	(0.097)	(0.093)	(0.082)	(0.063)	(0.067)
Δhc*ict intensity	0.607***	0.990***	0.497***	0.684***	0.207*	0.427***
	(0.184)	(0.256)	(0.190)	(0.214)	(0.111)	(0.165)
hc*hc intensity	0.015*	0.015	0.000	-0.005	0.016**	0.017**
	(0.009)	(0.009)	(0.010)	(0.010)	(0.007)	(0.007)
Δhc*hc intensity	0.007	0.007	-0.063***	-0.078***	0.044***	0.047***
	(0.020)	(0.024)	(0.021)	(0.025)	(0.016)	(0.018)
k/y*k intensity	0.000	0.001	0.001	0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Initial gross value added	-0.031***	-0.031***	-0.027***	-0.027***		
	(0.007)	(0.007)	(0.008)	(0.008)		
Initial employment					-0.015***	-0.015***
					(0.003)	(0.003)
Adjusted R^2	0.622	0.615	0.557	0.555	0.782	0.777
Observations	308	308	308	308	308	308
Countries	11	11	11	11	11	11
Industries	28	28	28	28	28	28
Country fixed effects	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes
Test joint significance of country and industry fixed effects	F(38,264) =7.908 p = 0.000	χ^2 (38) =357.398 p = 0.000	F(38,264) =11.888 p = 0.000	χ^2 (38) =537.421 p = 0.000	F(38,264) =25.638 p = 0.000	χ^2 (38) =1087.256 p = 0.000
Wooldridge's robust score test of endogeneity		χ^2 (2) = 7.339 p = 0.025		χ^2 (2) = 2.818 p = 0.244		χ^2 (2) = 6.96 p = 0.031

Notes: The dependent variables are defined as follows: model (1): the average annual growth of real gross value added at the country-industry level over the period 1980-1999; model (2): the average annual growth of real gross value added per hour worked by employees at the country-industry level over the period 1980-1999; model (3): the average annual growth of the number of employees at the country-industry level over the period 1980-1999. The initial country-level human capital (hc) is measured as the average years of schooling in 1980 and it is interacted with industry-level ICT intensity (ict intensity) and industry-level human capital intensity (hc intensity). The human capital accumulation (Δhc) is the change in the average years of schooling at country level over the period 1980-1999 and it is interacted with industry ICT intensity and with industry human capital intensity. The physical capital interaction is obtained as the product between physical capital to GDP ratio at country level in 1980 (k/l) and industry physical capital intensity in 1980 (k intensity) measured as the ratio of industry fixed capital stock in total gross value added. Industry factor intensities are computed using data for the US. All models control for initial conditions: as follows: in models (1) and (2): the log of the gross value added in at the country-industry level in 1980; in model (3) : the log of the number of employees at the country-industry level in 1980. In the IV models human capital accumulation over the period 1980-1999 at country level is instrumented with the change in average years of schooling in each country for the period 1970-1980. Robust standard errors are shown in parentheses. Detailed definitions of variables and data sources are given in Table A1 in the Appendix.

Table A1. Variable definitions and data sources

Variables	Definition and Source
Country-Industry Specific	
$\Delta \ln y_{i,k,T}$	Average annual growth rate of real gross value added in industry k in country i over the period 1980-1999. Source: EU KLEMS.
$\Delta \ln emp_{i,k,T}$	Average annual growth rate of the number of employees in industry k in country i over the period 1980-1999. Source: EU KLEMS.
$\Delta \ln prod_{i,k,T}$	Average annual growth rate of labour productivity in industry k in country i over the period 1980-1999. Two measures of labour productivity are used: real gross value added per hour worked by employees and real gross value added per employee. Source: EU KLEMS.
$\ln y_{i,k,t_0}$	Natural logarithm of gross value added in industry k in country i in 1980. Source: EU KLEMS.
$\ln emp_{i,k,t_0}$	Natural logarithm of the number of employees in industry k in country i in 1980. Source: EU KLEMS.
$\ln prod_{i,k,t_0}$	Natural logarithm of labour productivity in industry k in country i in 1980. Source: EU KLEMS.
Industry Specific	
ict_{k,t_0}	ICT intensity computed as the share of ICT capital stock in total capital stock in industry k in the US in 1980. Source: EU KLEMS.
hc_{k,t_0}	Human capital intensity computed as the share of hours worked by high and medium skilled workers in total hours worked in industry k in the US in 1980. Source: EU KLEMS.
k_{k,t_0}	Physical capital intensity computed as the ratio of total fixed capital stock to total gross value added in industry k in the US in 1980. Source: EU KLEMS.
Country specific	
hc_{i,t_0}	Initial human capital stock. Average years of schooling in country i in 1980. Source: Barro and Lee (2001). We also use an alternative measure computed as the share of the population of over 25 years with completed secondary or attained tertiary education in 1980. Source: Barro and Lee (2001).
$\Delta hc_{i,T}$	Change in the average years of schooling in country i over the period 1980-1999. Source: Barro and Lee (2001). We also use an alternative measure computed as the change in the share of the population over 25 years with completed secondary or attained tertiary education over the period 1980-1999. Source: Barro and Lee (2001).
$gdpc_{i,t_0}$	GDP per capita in country i in 1980. Source: World Development Indicators Database, the World Bank.
k_{i,t_0}	Physical capital to GDP ratio in country i in 1980 computed as the ratio of fixed capital stock in total industries in country i to GDP in country i. Source: EU KLEMS and the World Bank, World Economic Outlook Database.
$dcgdp_{i,t_0}$	Domestic credit to private sector to GDP ratio in country i in 1980. Source: World Development Indicators Database, the World Bank.
smt_{i,t_0}	Ratio of the value of total shares traded to average real market capitalization in country i in 1990. Source: Beck et al. (2010).
$rlaw_{i,t_0}$	Rule of law in country i. An index which measures "the quality of contract enforcement, the police, and the courts, as well as the likelihood of crime and violence" in 1996. Source: Kaufman et al. (2009).
$regq_{i,t_0}$	Regulatory quality in country i. An index which measures "perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development" in 1996. Source: Kaufman et al. (2009).

Table A2. The Spearman rank correlation index of US industry ICT intensity at five year intervals

	1980	1985	1990	1995	1999
1980	1				
1985	0.9246	1			
1990	0.898	0.9739	1		
1995	0.764	0.8527	0.9025	1	
1999	0.7241	0.8192	0.8695	0.9916	1

Table A3. Industry characteristics

NACE Code	Industry Description	ict_{k,t_0}	hc_{k,t_0}	k_{k,t_0}
AtB	Agriculture, hunting, forestry and fishing	0.000	0.633	7.170
F	Construction	0.001	0.728	0.455
K	Real estate, renting and business activities	0.002	0.893	6.276
C	Mining and quarrying	0.002	0.733	9.993
25	Rubber and plastics products	0.003	0.748	1.750
17t19	Textiles, textile products, leather and footwear	0.003	0.566	1.147
H	Hotels and restaurants	0.003	0.722	1.500
20	Wood and products of wood and cork	0.004	0.594	1.647
E	Electricity, gas and water supply	0.004	0.903	7.209
36t37	Manufacturing nec; recycling	0.005	0.639	1.462
15t16	Food products, beverages and tobacco	0.005	0.697	1.304
24	Chemicals and chemical products	0.005	0.837	1.486
52	Retail trade, except of motor vehicles and motorcycles; repair of household goods	0.006	0.822	1.379
27t28	Basic metals and fabricated metal products	0.006	0.697	1.456
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	0.007	0.762	1.279
L	Public admin and defence; compulsory social security	0.008	0.868	1.479
23	Coke, refined petroleum products and nuclear fuel	0.008	0.868	7.401
M	Education	0.008	0.922	1.183
21t22	Pulp, paper, paper products, printing and publishing	0.009	0.821	0.899
N	Health and social work	0.011	0.890	0.818
60t63	Transport and storage	0.011	0.761	4.377
34t35	Transport equipment	0.013	0.812	1.060
26	Other non-metallic mineral products	0.015	0.669	1.858
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	0.017	0.849	0.814
O	Other community, social and personal services	0.023	0.813	1.226
29	Machinery, nec	0.026	0.784	0.642
J	Financial intermediation	0.038	0.961	0.491
30t33	Electrical and optical equipment	0.043	0.831	2.871
64	Post and telecommunications	0.306	0.959	2.051
	Mean	0.020	0.785	2.630
	Standard deviation	0.056	0.105	2.800
	Median	0.007	0.811	1.460
	75th percentile	0.013	0.864	2.050
	25th percentile	0.004	0.722	1.140

Table A3 reports values of industry characteristics in the US in 1980 that are used in our analysis. ict_{k,t_0} hc_{k,t_0}, k_{k,t_0} denote ICT intensity, human capital intensity, and physical capital intensity respectively in industry k in 1980; ICT intensity is computed as the share of ICT capital stock in total capital stock. Human capital intensity is the ratio of hours worked by high and medium skilled workers in total hours worked. Physical capital intensity is the share of physical capital in total gross value added.

Table A4. Country level human capital

Countries	Average years of schooling, 1980	Change in average years of schooling, 1980 -1999	Share of population over 25 years with completed secondary or attained tertiary education, 1980	Change in the share of population over 25 years with completed secondary or attained tertiary education, 1980-1999
Australia	10.02	0.56	0.42	0.07
Austria	8.42	0.37	0.51	-0.05
Belgium	7.85	0.88	0.19	0.10
Denmark	9.16	0.93	0.47	0.14
Spain	5.15	2.11	0.13	0.17
Finland	8.33	1.81	0.41	0.16
France	6.77	1.61	0.21	0.19
Germany	8.41	1.34	0.33	0.07
Greece	6.56	1.96	0.21	0.18
Ireland	7.61	1.41	0.25	0.14
Italy	5.32	1.68	0.15	0.11
Japan	8.23	1.49	0.30	0.12
Korea	6.81	3.65	0.28	0.33
Netherlands	7.99	1.25	0.23	0.13
Portugal	3.27	1.64	0.08	0.11
Sweden	9.45	1.89	0.51	0.15
United Kingdom	8.17	1.18	0.21	0.10
Mean	7.50	1.52	0.29	0.13
Standard Deviation	1.71	0.73	0.13	0.08
Median	7.99	1.49	0.25	0.13
Minimum	3.27	0.37	0.08	-0.05
Maximum	10.02	3.65	0.51	0.33

Table A5. Country level variables: Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Average years of schooling 1980	17	7.50	1.71	3.27	10.02
Change in average years of schooling,1980-1999	17	1.52	0.73	0.37	3.65
Share of population over 25 years with completed secondary or attained tertiary education, 1980	17	0.29	0.13	0.08	0.51
Change in the share of population over 25 years with completed secondary or attained tertiary education, 1980-1999	17	0.13	0.08	-0.05	0.33
GDP per capita, 1980 (billions US $)	17	14059	5114	3358	23982
Physical capital ratio to GDP, 1980	11	3.45	1.06	2.29	5.64
Domestic private credit to GDP ratio, 1980	17	0.62	0.29	0.28	1.33
Stock market turnover ratio, 1990	16	0.47	0.44	0.10	1.62
Rule of law, 1996	17	1.54	0.36	0.78	1.93
Regulatory quality, 1996	17	0.98	0.28	0.46	1.48