Higher education effects on regional growth in Poland: panel data estimates

Victor Shevchuk and Joanna Zyra

Abstract In this paper, we have estimated determinants of real regional per capita growth, with the focus on higher education effects, using a balanced panel data set consisting of 16 Polish voivodships for the period from 2000 to 2015. Our results confirm a strong stimulating impact of the number of students on regional growth, but there is evidence (though rather weak) of a negative effect of the educational variable in changes. Such an outcome provides evidence in favor of the Nelson-Phelps approach, which stipulates positive growth effects of the human capital stock. We also find that higher employment accelerates regional growth, while evidence is rather ambiguous for investments in physical capital. Finally, our results offer evidence to support the convergence hypothesis in Poland.

Victor Shevchuk
Institute of Economics, Philosophy and Sociology, Cracow University of Technology, 24 Warszawska Street, 31-155 Cracow, Poland,
✉ vshevchuk@pk.edu.pl

Joanna Zyra
Institute of Economics, Philosophy and Sociology, Cracow University of Technology, 24 Warszawska Street, 31-155 Cracow, Poland
✉ jzyra@pk.edu.pl

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1 Introduction

Higher education enrolment growth is one of the most distinctive features of modern economies, with Poland being one of the most prominent cases. The number of students had increased from as low as 11 per 1000 people in 1990 to 48 at the peak in 2005, and then was gradually decreasing to 31 per 1000 people, as of 2016. According to human capital theory, which is the foundation of modern endogenous growth models and labour market theories, education at any level should contribute to income and wage growth through human capital accumulation. Favourable effects of education at different levels upon economic growth are well documented in national panel data studies (Barro, 2002; Bassanini and Scarpetta, 2002; Mankiw et al, 1992; Sianesi and van Reenen, 2003). Using regional data, positive growth effects of higher education have been found for European regions (Crespo Cuaresma et al, 2014; Sterlacchini, 2008), and in regional studies for Germany (Brunow and Hirte, 2009), Portugal (Cardoso and Pentecost, 2011), Spain (De la Fuente, 2002), Sweden (Wixe and Andersson, 2013), and Switzerland (Polasek et al, 2010). However, negative educational effects on economic growth have been found by Benhabib and Spiegel (1994), Islam (1995) and Pritchett (2001), as well as for Italy (Oppedisano, 2010) and Croatia (Mikulić and Nagyszombaty, 2015).

It is quite natural to explain different higher education growth effects not only by human capital accumulation and favourable labour market effects, but with a variety of externalities, too (Klenow and Rodriguez-Clare, 2005). Besides positive externalities, such as a higher level of education in the society, better achievements of children or better family planning, other educational spillover effects also need to be mentioned. Although education investments used to be viewed as a factor behind capital and labour-enhancing technological innovation, the effects could be negative for less advanced regions (Aghion et al, 2009). Disappointing growth effects of higher education could be explained by the absence of industrial infrastructure able to properly integrate highly educated individuals into the productive system (Teixeira and Queirós, 2016).

The objective of this study is an empirical assessment of the higher education effects upon regional growth in Poland, using fixed effects (FE), instrumental variables (IV), ordinary least square (OLS) and general method of moments (GMM) estimators. Our estimation results demonstrate that a higher number of students is positively correlated with regional growth, while this educational variable in first differences does not bring about any positive growth effects.

2 Theoretical framework

There are two alternative approaches in studying the role of education as a component of human capital in economic growth: (i) education is one among a few production factors (factor-accumulation channel) and (ii) education is important for an increase in the total factor of productivity (TFP) (productivity channel). The former approach is based on the logic of early endogenous growth models, for example Lucas (1988), and treats education in the same way as physical capital. As a consequence, the rate of economic growth is affected by *changes* in the educational variable. The latter approach is based upon the assumption that R&D activities are stimulated by accumulation of intangible assets, such as ideas or knowledge. As argued by Nelson and Phelps (1966) in the mid-1960s, it is not innovations *per se*, but their implementation that plays the most important role in economic growth. In this interpretation, it is the *level* of human capital that stimulates growth (Benhabib and Spiegel, 1994). Following Lucas (1988), the aggregate production function is as follows:

$$y = Ak^{\alpha}(uh)^{1-\alpha}(h_a)^{\gamma}, \tag{1}$$

where y is output, k is physical capital (α denotes its share in the production function), u is the amount of time a typical worker devotes to production, h is the human capital of the representative agent, and h_a is the average human capital in the economy. If $\gamma > 0$, there are positive externalities to human capital. As human capital is a factor of production, output growth rate is determined by the rate in which human capital is accumulated.

Nelson and Phelps (1966) established that human capital is the factor standing behind the ability to innovate and/or adapt new technologies thus leading to technological progress and sustained growth. Assuming a production function in the form of $y = A(h)K^{\alpha}L^{1-\alpha-\gamma}$, human capital affects production via the productivity term:

$$\frac{\dot{A}(t)}{A(t)} = \Phi(h)\left[\frac{T(t) - A(t)}{A(t)}\right], \qquad \Phi(0) = 0, \qquad \Phi'(h) > 0, \tag{2}$$

where $T(t)$ is the theoretical level of technology. The growth rate of technology level, $A(t)$, is dependent upon the human capital stock and the technology ”gap” measured by $[T(t) - A(t)]/A(t)$. Consequently, output growth is affected by the level of human capital. The Nelson-Phelps approach implies that returns on education are increasingly a function of technological progress, while complemented by higher R&D expenditures in both private and public sectors. Romer (1990) incorporated human capital into the Cobb-Douglas production function in the fashion of the Nelson-Phelps approach, and it may be presented as follows:

$$Y_t = [(1 - a_K)K_t]^{\alpha} \, [A_t(1 - a_L)L_t]^{1-\alpha}\,, \tag{3}$$

where a_K and a_L represent the share of capital and labor force used in the research sector, respectively. Although the endogenous growth model enables increasing returns on technology, they may diminish if resources are exhausted in the research sector because of poor collaboration between universities or because of any other reason of inefficiency.

Both mechanisms are important in the regional context, with externalities and labour market effects playing an instrumental role. Spillovers of knowledge across producers and human capital accumulation can offset the diminishing tendencies of returns. Human capital increases its absorption capacity of new ideas and technologies, thus encouraging greater investment in physical capital (Benhabib and Spiegel, 1994). On the other hand, there are also indirect effects generated by interaction with the productive structure of economies (Teixeira and Queirós, 2016). Regional growth is likely to slow down by shifting away from sectors with higher productivity, such as manufacturing, toward less advanced sectors, such as public services or construction. As human capital improves the quality of labour and its ability to absorb new technologies, skills and information, as well as its ability to seize business opportunities, it creates a basis for faster convergence of national and regional economies (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994).

While it is difficult to undermine the role of higher education on a theoretical basis, it is possible to question empirical results on several grounds. First of all, there is the issue of choosing the ‘correct’ educational variable. As argued by Hanushek and Kimko (2000), quality of education is better measured by international school test scores, with better results translating into higher growth rates. Appleton et al (2008) confirm a positive schooling quality effect on economic growth, but claim that it is substantially smaller than in the previous studies. Second institutional factors are also important. Higher level of education promotes political stability, social cohesion and civic participation. It tends to improve health and environmental conditions (Sianesi and van Reenen, 2003). Returns on skills are lower in countries with higher union membership, stricter employment protection and a larger public sector (Hanushek et al, 2015). For 15 EU countries, it has been found that technology adoption depends on the workforce skill level and on the capacity of firms to adjust employment to technology changes (Conti and Sulis, 2016). Third, the statistical model specifications and measurement problems could matter as well. The relationship between education and economic growth could be weakened by the two-way causality between both variables (Bils and Klenow, 1998), possible deficiencies in data or inadequacies of the economic specification (Bassanini and Scarpetta, 2002), or by collinearity between physical and human capital stocks and possible endogeneity in panel data (Soto, 2006).

Finally, it may not be ruled out that there is a non-linear relationship between education and economic growth, as education is positively associated with growth only in countries with the lowest level of education while the relationship turns negative for countries with a high level of education (Krueger and Lindahl, 2001). Besides the above-mentioned arguments related to the inverse relationship between education benefits and regional development (Aghion et al, 2009) or industrial structures (Teixeira and Queirós, 2016), it is likely that the growing popularity of higher education is followed by rising inequality and temporarily lower wages for low-skilled workers, with a reverse recovery in income to follow with a considerable time lag (Böhm et al, 2015).

3 Data and statistical model

All the data on the number of students, regional domestic product, investments, employment and nominal wages in 16 voivodships for the 2000–2015 period have been obtained from the General Statistical Office of Poland (online resource). The panel data sample is balanced. Our baseline growth-accounting regression is as follows:

$$\begin{aligned}\Delta \ln Y_{it} = {} & \alpha_1 \ln Y_{it-1} + \beta_1 \Delta \ln S_{it} + \beta_2 \ln S_{it} + \gamma_1 I_{it} + \gamma_2 \Delta L_{it} \\ & + \delta_1 SIND_{it} + \delta_2 CRISIS_t + \eta_i + \tau_t + \varepsilon_{it},\end{aligned} \tag{4}$$

where Y_{it} is the real regional domestic product per capita for voivodship i in period t (in thousands of *zlotys*), S_{it} is the number of students per 1000 people, L_{it} is the labour force (in thousands of persons), I_{it} is investments (in millions of *zlotys*), $SIND_{it}$ is the share of industrial production in the regional domestic product, $CRISIS_t$ is the dummy for crisis developments of 2009, η_i represents the unobservable country-specific effect, τ_t is the time dummy, ε_{it} is the error term, and Δ signifies the change in the variable from $t-1$ to t.

The lagged value of the output level logarithm is included in order to control the effect of convergence. If there is conditional convergence, the coefficient of $\ln Y_{it-1}$ is expected to be negative ($\alpha_1 < 1$). If higher education affects regional growth through a factor-accumulating channel, the estimated coefficient of $\Delta \ln S_{it}$ should be positive and significant ($\beta_1 > 0$). On the other hand, the importance of the productivity channel implies that a one-time increase in the number of students has a lasting growth effect, with the estimated coefficient of S_{it} also being positive and significant ($\beta_2 > 0$).

Control over the level of industry specialization allows accounting for the effects of regional industrial specialization in Poland. As argued by Teixeira and Queirós (2016), by using variables from both the supply and demand sides, it is possible to assess the direct and indirect effects of human capital on economic growth.

In methodological terms, we apply panel data fixed effects (FE) and instrumental variables (IV) estimators, pooled data (OLS) estimator, as well as dynamic panel data techniques based on the generalized method of moments (GMM). In the IV estimates, the lagged output is instrumented with the unemployment rate. The choice of the GMM estimator is motivated by the risk of endogeneity between regional growth and higher education and structural change variables, as well as by possible interaction between explanatory variables. The unemployment rate (in percent) and the nominal wage (in logs) are chosen as instrumental variables. Such a choice is motivated by proximity of both variables to the labour supply in the first place. Educational decisions are likely to be affected by the situation on the labour market either.

4 Empirical results

Our results for the baseline model with an educational variable in logarithms are presented in Table 1, along with an alternative specification with nominal wages. The inclusion of wages is important because it has long been recognized in theory that both labour supply and demand for labour are dependent upon real wages.

It is universally believed that an increase in the number of students (in *levels*) has a significant positive impact upon regional growth, regardless of the estimator used. It provides support to the productivity channel of educational growth effects. However, the estimated coefficient of *change* in student enrolment is negative and significant at least at the 10% level in three models, while the coefficient of $\Delta \ln S_{it}$ is negative but insignificant in the other two regression models. Educational growth effects are somewhat stronger in specification with changes in nominal wages. As suggested by the positive coefficient $\Delta \ln W_{it}$, labour supply factors dominate, but the wage effect is statistically significant only in the OLS regression. If we consider a specification with employment, an increase in $\Delta \log L_{it}$ contributes to regional growth and the result is quite robust across estimators. However, the positive link between employment and regional growth becomes weaker if nominal wages are used as an instrument in the IV estimate.

As regards the effects of physical capital accumulation viewed as another component of the production function, the estimates are highly sensitive to the chosen estimator. As the FE estimator indicates a standard direct relationship between investments and regional growth, the effect is exactly the opposite if we use the OLS estimator, with the coefficients on $\Delta \log K_{it}$ being statistically significant at the level of 1% in both cases.

In Poland, more industrialized regions experience higher economic growth. The coefficient of $SIND_{it}$ is positive and significant at the level of 1%. As expected, crisis developments of 2009 hampered regional growth. Consistently with standard growth models, the lagged output level is negatively correlated with regional growth rates, but the coefficient of $\ln Y_{i,t-1}$ is statistically significant only in the FE estimates.

The main results regarding education effects on regional growth hold if not include physical capital and labour simultaneously into a regression model. As demonstrated by Krueger and Lindahl (2001), there is a statistically significant and positive effect of a change in schooling on GDP growth in a model specification with no physical capital, while the impact of change in schooling upon growth becomes insignificant in a model specification with physical capital. The above work confirms the findings of an earlier study by Benhabib and Spiegel (1994).

Table 1: Determinants of regional product per capita growth ($\Delta \ln Y_{i,t}$).

Variables	FE-1	FE-2	IV(FE)	OLS-1	OLS-2
$\ln Y_{i,t-1}$	-0.136 (-4.24***)	-0.144 (-4.34***)	-0.132 (-3.89***)	-0.021 (-1.25)	-0.024 (-1.39)
$\Delta \ln S_{it}$	-0.094 (-1.59)	-0.180 (-3.03***)	-0.183 (-3.10**)	-0.038 (-0.75)	-0.092 (-1.77*)
$\ln S_{it}$	0.030 (2.16**)	0.075 (5.26***)	0.092 (5.36***)	0.034 (3.04***)	0.052 (4.27***)
$\Delta \ln K_{it}$	0.039 (2.98***)	0.036 (2.68***)	0.032 (2.41**)	-0.031 (-3.52***)	-0.034 (-3.97***)
$\Delta \ln L_{it}$	0.107 (2.97***)	—	0.067 (2.01**)	0.113 (3.34***)	—
$\Delta \ln W_{it}$	—	0.102 (1.33)	—	—	0.200 (2.58**)
$SIND_{it}$	0.187 (4.90***)	0.238 (6.39***)	0.243 (6.37***)	0.086 (3.42***)	0.109 (4.27***)
$CRISIS_t$	-0.013 (-1.68*)	-0.010 (-1.47)	-0.013 (-1.79*)	-0.014 (-1.84*)	-0.012 (-1.74*)
Observations	240	224	200	240	224

Note: t-values in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2: Determinants of regional product per capita growth ($\Delta \ln Y_{it}$).

Variables	FE-1	FE-2	IV(FE)	OLS-1	OLS-2
$\ln Y_{i,t-1}$	-0.123	-0.139	-0.125	-0.020	-0.024
	(-3.61***)	(-3.95***)	(-3.43***)	(-1.24)	(-1.40)
ΔS_{it}	-0.001	-0.003	-0.003	-0.001	-0.001
	(-0.80)	(-2.21**)	(-2.28**)	(-0.02)	(-1.10)
S_{it}	0.001	0.002	0.002	0.001	0.001
	(3.11***)	(5.05***)	(4.82***)	(3.47***)	(4.42***)
$\Delta \ln K_{it}$	0.040	0.040	0.033	-0.030	-0.033
	(3.12***)	(3.00***)	(2.46**)	(-3.76***)	(-3.96***)
$\Delta \ln L_{it}$	0.104	—	0.068	0.114	—
	(2.90***)		(2.02**)	(3.35***)	
$\Delta \ln W_{it}$	—	0.079	—	—	0.195
		(1.03)			(2.52**)
$SIND_{it}$	0.180	0.228	0.240	0.084	0.106
	(4.73***)	(6.09***)	(6.18***)	(3.35***)	(4.18***)
$CRISIS_t$	-0.015	-0.013	-0.014	-0.014	-0.013
	(-2.01**)	(-1.83*)	(-1.94*)	(-2.01**)	(-1.88*)
Observations	240	224	200	240	224

Note: t-values in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Determinants of regional product per capita growth ($\Delta \ln Y_{it}$).

Variables	I	II	III	IV
$\Delta \ln Y_{i,t-1}$	0.327 (8.76***)	0.332 (9.24***)	0.278 (3.71***)	0.314 (5.43***)
$\ln Y_{i,t-1}$	-0.029 (-0.99)	-0.036 (-2.62***)	-0.026 (-0.88)	-0.045 (-3.04***)
$\Delta \ln S_{it}$	0.007 (0.10)	0.031 (0.51)	-0.124 (-1.70*)	-0.083 (-1.35)
$\ln S_{it}$	0.034 (2.69***)	0.032 (2.83***)	0.052) (3.26***)	0.046 (3.29***)
$\Delta \ln K_{it}$	-0.007 (-0.52)	—	-0.013 (-0.84)	—
$\Delta \ln L_{it}$	0.124 (3.82***)	0.117 (4.37***)	—	—
$\Delta \ln W_{it}$	—	—	0.228 (5.02***)	0.192 (12.87***)
$SIND_{it}$	0.080 (1.42)	0.073 (2.03**)	0.143 (2.12**)	0.108 (2.24**)
$CRISIS_t$	-0.031 (-4.81***)	-0.034 (-6.43***)	-0.034 (-5.09***)	-0.038 (-6.53***)
Observations	184	184	184	184
Sargan test *p*-value	0.962	0.960	0.971	0.963
AR(1) *p*-value	0.027	0.017	0.674	0.076
AR(2) *p*-value	0.702	0.648	0.531	0.909

Note: *t*-values in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

Another point of discussion refers to the specification of the production function. While the log-log specification assumes that education enters the aggregate Cobb-Douglas production function linearly, there are arguments in favour of specifying human capital as an exponential function of education (Krueger and Lindahl, 2001). Taking into account the possibility of different growth effects due to the log or log-log specification of the educational variable, we then perform the same regressions by using a linear number of students in the growth equation (Table 2) instead of the logarithmic specification (Table 1). As our results suggest, estimating the linear education specification does not change much the conclusions referring to the educational effects on regional growth.

The results of dynamic estimates of the regional growth factors are presented in Table 3. Our specification uses changes in the unemployment rate as an additional instrumental variable. The two-step variant has been chosen as more efficient for small samples than the one-step variant (Li and Wang, 2018). The empirical performance of the system GMM estimation is reasonably satisfactory and robust. The Sargan test for over-identification indicates that the null of exogenous instruments is not rejected for all specifications. The test for the first-order serial correlation in residuals AR(1) shows that the null hypothesis of no first-order serial correlation is rejected in three out of four models. However, it is not possible to rule out in any of our results that error terms in differences do not follow the AR(2).

Dynamic estimates of the higher education growth effects are quite similar to their counterparts obtained with FE, IV and OLS estimators, but they are not identical. In particular, education growth effects (in levels) stay intact in specifications II and IV with no physical capital, but any modification of this kind restores statistical significance to the negative convergence coefficient of α_1. Although the estimates in Tables 1-2 tend to accept a negative relationship between changes in student enrolment and regional growth, dynamic estimates of the coefficient of β_1 do not reveal any consistent and significant impact on growth.

Following findings by Li and Wang (2018) for China that basic human capital matters in the factor-accumulation channel (in changes) whereas advanced human capital matters in the productivity channel (in levels), our results could be viewed as evidence in favour of further improvements in the quality of education in Poland. On the other hand, the lack of the expected positive relationship between changes in the number of students and regional growth could be the result of significant educational mismatches, either horizontal (the choice of a field of study) or vertical ones (over-education), which prevent capitalizing on gains from the accumulation of higher education.

The GMM estimates provide a middle ground in assessment of physical capital accumulation growth effects when compared with FE and OLS estimates, which propose the opposite sign of the coefficient of γ_1. At any rate, it is impossible to establish investment growth effects, as the estimates of γ_1 vary in sign and statistical significance across different regressions.

5 Conclusions

Our empirical results indicate a strong and statistically significant positive relationship between the number of students in Poland (in levels) and the regional growth rate (estimates are remarkably robust as to the choice of estimator and specification of regression models), while the changes in the number of students are at best neutral in respect to regional growth. Domination of the productivity channel, as opposed to simple growth of student enrolment, implies benefits for advanced human capital, and has clear policy implications in favour of quality improvements in the higher education institutions. Our results are largely robust with regard to dealing with the likely endogeneity of industrial structure, as well as the possible endogeneity of the educational variable and the lagged output level. On the other hand, we do not find any consistent evidence supporting the stimulating effect of investments in physical capital upon regional growth. However, regional growth is stimulated by rising levels of employment as well as by higher wages. There are robust and significant growth effects of industrial structure, which supports the standard arguments in favour of industry as regional growth driving force. Finally, it has been confirmed that the financial crisis of 2008-2009 contributed to the slowdown in regional growth.

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