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THE REGIONAL GROWTH AND UNEMPLOYMENT EFFECTS OF ENGINEERING & TECHNOLOGY AND ECONOMICS EDUCATION IN POLAND

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Abstract: Using annual time series for the period 2000-2019, this article analyses educational effects of the Engineering & Technology and Economics fields of study for Poland. It was found that the long-term education effects (in levels) are in favour of the former, both in terms of regional output growth and reduction in the number of unemployed. The short-term effects (in the first indicated differences) on both regional growth and unemployment are negative, regardless of the field of study. As both fields of study have unfavourable growth effects in the first differences, it indicates insufficient quality of investments in the human capital.

Keywords: higher education, fields of study, regional growth, unemployment rate, Poland.

1. Introduction

Similarly to other countries (Dobson, 2012), there was an increase in the number of students in the field of Engineering & Technology (E&T) in Poland during the 2000s, but the recent declining enrolment raised some concerns (Figure 1). The same downward trend is observed in the number of students studying Economics since the beginning of the last decade, whilst the number of students studying E&T reached its peak at 405 thousand in 2012 and has been fallinh since then. At the same

time the number of students in the field of Economics declined from 516 to 252 thousand in 2019. As most of the theoretical arguments, for example Nelson and Phelps (1966) and Lucas (1988), as well as the empirical findings, are in favour of the positive growth effects of higher educational attainment at universities (Benos and Karagiannis, 2010; Krueger and Lindahl, 2001), including Poland (Shevchuk and Zyra, 2018; Żyra, 2020), such a decrease in the number of students does raise serious concerns regarding the prospects of future economic development. On the other hand, there are studies which show no relation between higher education attainment and economic growth (Islam, 2001; Nedić, Turanjanin, and Cvetanović, 2020). It implies that such specific aspects of higher education as the structure across fields of study, the mismatch between the level of education and job place requirements, and quality considerations, can play a role. If the educational attainment is neutral (or even inversely related) in respect to economic growth, any changes in the number of students become of marginal importance.

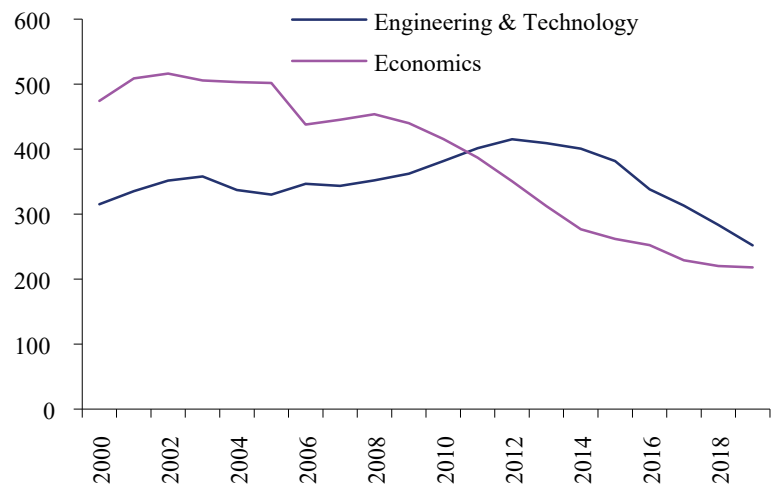

Fig. 1. Number of students in the Engineering & Technology and Economics fields of study in Poland (in thousands), 2000-2019

Source: (GUS, b.d.).

Another research question is the relation between higher education and unemployment. Although there has been a significant decrease in the unemployment rate from 12% to 5% over the last decade (see Figure 2), patterns of employability and unemployment rates of E&T graduates versus degree holders in other professions, for example Economics, are still of interest, especially against the backdrop of a lower educational attainment. While it is natural to assume that a higher number of students is associated with a higher demand for innovations and, consequently, contributes to lower unemployment, it cannot be ruled out that educational skill

mismatches or an insufficient quality of educational services may result in higher unemployment among university graduates which has a proportional effect on the unemployment rate nationwide. In such a context, it is possible that a lower number of students is positively linked to a significant drop in the unemployment rate.

This study was aimed at the empirical analysis of the education effects on regional growth and unemployment for the E&T and Economics fields of study. Such a comparative study allows for a better understanding of possible heterogeneity in educational effects across fields of study, thus setting the stage for more advanced research on human capital accumulation in Poland.

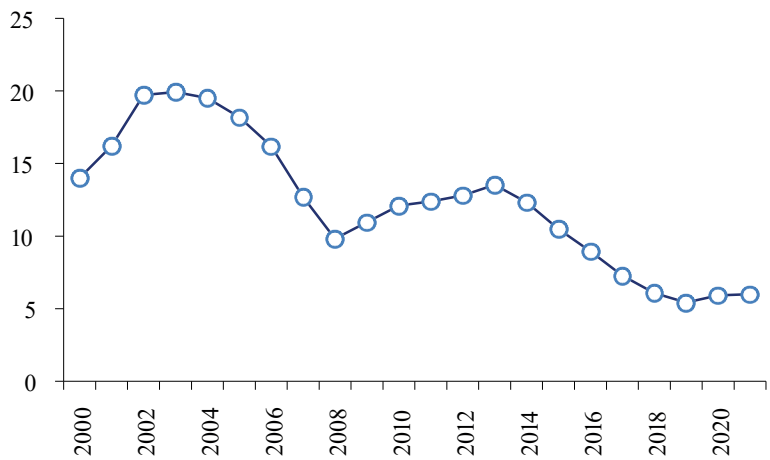

Fig. 2. The unemployment rate in Poland (%), 2000-2021

Source: (GUS, b.d.).

In the rest of the article, analytical considerations are presented in Section 2. Data and statistical model are outlined in Section 3. The empirical results are discussed in Section 4. The final section concludes.

2. Analytical considerations

It is a standard assumption of modern growth models that university education contributes to economic growth, either as one among several production inputs (factor-accumulation channel), or as a factor behind total productivity of production inputs (productivity channel). The former approach is based on the proposals by Nelson and Phelps (1966), namely that it is the level of education that matters, enabling the implementation of innovations and applied use of new technologies. The implementation of technological innovations per se is of ultimate importance, with human capital being necessary in order to make practical use of innovations and inventions. Consequently, the *stock* of human capital determines the ability to

improve productivity and accelerate economic growth. In the latter approach of endogenous growth models based on proposals made by Lucas (1988), education in general and higher education in particular are treated in the same way as physical capital meaning that only changes in the number of students contribute to economic growth. As a result, it is the *rate* of human capital accumulation that affects economic growth.

Most empirical studies provide evidence in favour of both approaches, for example Benos and Karagiannis (2010), Krueger and Lindahl (2001), but publications showing no relation between higher education attainment and economic growth are not lacking either (Islam, 2001; Nedić et al., 2020). It cannot be ruled out that the insufficient quality of the higher education and/or educational skill mismatches are responsible for counterintuitive negative growth effects (Pritchett, 2001). Empirical estimates for Poland's regional data demonstrate that the increase in the number of students (in levels) contributes to the regional growth per capita, as implied by the Nelson-Phelps approach, while estimates of education variable in the first differences suggest no growth effects (Shevchuk and Zyra, 2018; Żyra, 2020).

The growth effects across fields of study have attracted much less attention, despite their importance in detecting the source of educational skill mismatches and the lack of expected strong positive link between higher education and economic growth in empirical studies. Specifically, heterogeneous growth effects for different fields of study can be explained by substantially different labour market payoffs, even after accounting for institution and peer quality (Kirkeboen, Leuven, and Mogstad, 2016). Although both the Nelson-Phelps approach and endogenous growth models put stress on the advantages of higher education as a factor behind economic growth, the former is much closer to assuming a stronger role of the E&T field of study in productivity and growth developments, as compared, for instance, with the field of Economics. The explanation seems to be straightforward, as the E&T field of study has the closest connections to R&D activities. There is empirical support for such a relation in the latest study of 284 European regions (NUTS 2) over the period 2000-2017 (Agasisti and Bertoletti, 2022). It is established that the quality of research and a specialisation in science, technology, engineering, and mathematics (STEM) subjects are the most important factors behind regions' economic growth.

It is quite natural to assume that higher education growth effects are inversely related to their impact on unemployment. As higher education leads to the accumulation of human capital, which is linked with higher productivity, it should contribute to either stronger economic growth or the better employability of university graduates. As established for 21 EU countries, male graduates from E&T are less at risk of unemployment in a clear majority of countries (Boll, Rossen, and Wolf, 2018).

The effects of education could be heterogeneous across different fields of study. If graduates of the E&T field dominate in the job market due to their higher productivity, it is possible to increase unemployment, despite the low unemployment

rate among engineers per se. On the other hand, graduates from the fields of study with presumed lower productivity, for example Humanities & Art or Education, can find jobs easier, especially in the earlier stages of their career, just after graduation, as they are better trained in the so-called soft skills, which are important factors behind labour market flexibility (Calmand, Frontini, and Rostan, 2011). Based on the data from the European Social Survey (ESS), it was found that graduates from the E&T field of study face a lower risk of unemployment in the middle term, but no significant correlations were found in the case of long-term unemployment (Tarvid, 2011). Additionally, the empirical results for the CEE countries are much more optimistic in respect of the graduates from technical fields of higher education – is the case for the Czech Republic where technical disciplines offer the best employment opportunities in comparison to those of economic disciplines and natural sciences (Stojanova and Blašková, 2014, pp. 636-643).

3. Data and statistical model

The analysis focused on two fields of study. Enrolment in the E&T field of education was gradually increasing since the beginning of the 2000s, but this trend has reversed recently (Figure 1). It should be noted that from 2008 to 2012, the Ministry of Science and Higher Education in Poland conducted a programme involving the special funding of higher education for courses classified as strategic for development.

The data period selected for analysis was 2002 to 2018 due to the availability of regional time series on student enrolment in the fields of E&T and Economics per 1000 of population, $SENG_{it}$ and $SECON_{it}$ respectively. Among other variables used in the study, Y_{it} is the regional product per capita (in zlotys), U_{it} and L_{it} are the numbers of unemployed and employed persons, respectively, I_{it} are investment expenditures in physical capital per capita (in zlotys), W_{it} is the nominal wage. All time series are obtained from Poland's office for national statistics (GUS) online database. In order to control for external factors, the gross domestic product of the Eurozone, $YEURO_{it}$, was used, as provided by Eurostat. To stabilise the variances and to normalise their distributions, all variables were transformed into their natural logarithms. A dummy $CRISIS_{it}$ was aimed at control of the crisis developments of 2008-2009.

The author tested the stationarity of the panel data by the Levin-Lin-Chu test and Fisher-PP test which assume common and individual unit root processes, respectively. Table 1 reports the findings of both unit root tests. The stationarity in levels is not detected for regional output, investment, employment and nominal wage variables. As first differences of $\ln Y_{it}$, $\ln I_{it}$, $\ln L_{it}$ and $\ln W_{it}$ were stationary, it meant that all these variables have unit root I(1). On the other hand, the time series for both education variables seemed to be stationary. For the unemployment variable, the results of the unit root tests are ambiguous but it cannot to be denied that the first differences of $\ln U_{it}$ are stationary.

Table 1. Panel unit root test results

Variables	Fisher PP test		Levin-Lin-Chu test	
	Level	Δ	Level	Δ
$\ln Y_{it}$	0.98	−4.88***	0.54	−8.24***
$\ln U_{it}$	1.43	−1.34*	−5.98***	−9.74***
$\ln SENG_{it}$	−2.09**	−10.15***	−6.44***	−17.03***
$\ln SECON_{it}$	−5.12***	−6.93***	−7.91***	−28.51***
$\ln I_{it}$	0.41	−8.78***	−0.66	−9.59***
$\ln L_{it}$	0.45	−8.50***	−1.29*	−12.62***
$\ln W_{it}$	0.01	−3.30***	−1.18	−6.02***

Note: ***, ** and * mean rejection of null hypotheses at 1%, 5% and 10% level, Δ is the operator of first differences.

Source: own elaboration.

As most data series are not stationary in levels, but stationary after the first difference at the 1% significance level according to the unit root tests (Table 1), this implies the estimation of the panel regression model in first differences. However, it is suggested by Krueger and Lindahl (2001) to account for the Nelson-Phelps effect by using the education variable in levels as a proxy for the stock of human capital, while changes in the education variable are relevant for the estimation of the investment effect of higher education, as assumed in the endogenous growth models.

Following Krueger and Lindahl (2001), the baseline dynamic panel model for the determinants of regional growth and unemployment incorporates education variable in both level and first differences are as follows:

$$\Delta \ln X_{it} = a_1 \Delta \ln X_{it-1} + a_2 \Delta \ln SENG_{it} + a_3 \ln SENG_{it} + a_4 \Delta \ln SECON_{it} + a_5 \ln SECON_{it} + \eta_i + \tau_t + \varepsilon_{it},$$

where X_{it} refers to regional output and the number of unemployed persons, respectively, $SENG_{it}$ and $SECON_{it}$ are education variables, η_i and τ_t are controls for regional and time effects, respectively, ε_{it} is a stochastic factor, capturing all other omitted factors, *i* stands for a region (*voivodeship*), and Δ is the operator of first differences.

It can be hypothesised that a positive effect of education variables on regional growth was combined with a negative correlation with unemployment. If the Nelson-Phelps approach does hold, not only parameters a_3 and a_5 on the education variables in levels are expected to be of higher statistical significance compared with parameters a_2 and a_4 on both variables in first differences, but the effect of study in the field of E&T should be stronger, i.e. $a_3 > a_5$.

The relation is expected to be reversed regarding the effects of education variables on the number of unemployed. However, this causal link seems to be less straightforward. For example, graduates from the field of E&T with a higher contribution to productivity and growth can dominate employment in less productive

segments of the labour market. It is also not ruled out that the lack of employability skills or other labour market imperfections could prevent young engineers from finding a job for quite a long period of time after graduation.

The lagged value of dependent variable is included on the right-hand side to capture persistence in regional growth and/or unemployment.

In the extended regression model, the effects of education variables on regional output and unemployment are controlled by investments in physical capital and employment. Such a specification of the regression growth model reflects the observation that the estimation of education effects critically depends on controlling for investments in physical capital (Krueger and Lindahl, 2001). There are theoretical arguments that more effective regions with higher level of innovativeness and greater demand for higher education attract the immigration of skilled workers thus increasing the stock of human capital (Aghion, Boustan, Hoxby, and Vandenbusschem, 2009). Although less effective regions also benefit from education, the potential gains are smaller due to the emigration of graduates with higher qualifications.

In both regional growth and unemployment regression models, a control for the GDP growth in the Eurozone allows for an assessment of the demand for goods and services, as well as for the labour force. It is likely that favourable economic conditions in the Eurozone not only stimulate regional growth and employment through exports but set incentives for labour migration and thus contribute to a further decrease in unemployment. Finally, control for nominal wages in the unemployment regression model aimed at additional checking of the robustness of the higher educational, investment and employment effects on regional unemployment.

4. Empirical results

As the lagged dependent variable X_{it-1} might be correlated with the error term ε_{it}, the generalised method-of-moments estimator (GMM) was used, which is one of the most widely applied econometric techniques in economic growth studies. In the context of regional studies, the use of panel data allows the analysis of a greater number of observations containing more information, with such additional advantages as support of a greater number of variables, the reduction of multi-collinearity between explanatory variables and tackling the omitted variable bias problem. In the panel data framework, individual effects or heterogeneity can be tackled by allowing the constant term to vary across individuals. As proposed by Arellano and Bover (1995), the GMM estimation of dynamic panel data in differences is aimed at a control for unobservable effects. For the GMM estimator, it is not required that the regression model to be serially independent and homoscedastic (Blundell and Bover, 1999). By controlling the heterogeneous characteristics of the sample, the GMM method estimates the actual influence of choice variables on response variables more accurately.

Tables 2 and 3 show the estimation results for $\Delta \ln Y_{it}$ and $\Delta \ln U_{it}$ as dependent variables, with four specifications of the regression model used in each case. Independent variables were used as instruments. In addition, local population and the share of employed persons in total population (in percent) were employed as instruments in growth regressions. It was assumed that both variables account for the hidden (unobserved) correlation between the explanatory variables and regional growth. For unemployment regressions, nominal wage was also added to the instruments. The Hansen J test indicated that the overidentifying restrictions implied by this GMM procedure were not rejected in 7 cases out of 8, justifying the confidence that the instrument set was appropriate.

Table 2. Determinants of regional growth

Independent variables	Dependent variable $\Delta \ln Y_{it}$			
	I	II	III	IV
$\Delta \ln Y_{it-1}$	0.190 (9.80***)	0.090 (1.65*)	0.056 (1.03)	0.001 (0.01)
$\Delta \ln SENG_{it}$	−0.062 (−2.83***)	−0.079 (−6.76***)	−0.079 (−6.52***)	−0.079 (−5.49***)
$\ln SENG_{it}$	0.033 (3.17***)	0.029 (2.27**)	0.028 (2.35**)	0.030 (2.75***)
$\Delta \ln SECON_{it}$	−0.062 (−4.03***)	−0.026 (−2.47**)	−0.025 (−2.47**)	−0.027 (−2.48**)
$\ln SECON_{it}$	−0.003 (−0.30)	−0.004 (−0.76)	−0.003 (−0.57)	−0.003 (−0.61)
$\Delta \ln I_{it}$	–	0.078 (6.92***)	0.073 (7.05***)	0.068 (8.73***)
$\Delta \ln L_{it}$	–	–	0.074 (2.46**)	0.049 (1.57)
$\Delta \ln YEURO_{t-1}$	–	–	–	0.186 (2.05**)
$CRISIS_{it}$	–	−0.035 (−6.75***)	−0.035 (−5.95***)	−0.029 (−4.86***)
Hansen J test (prob)	0.57	0.10	0.11	0.11
Observations	256	246	228	230

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% significance level respectively.

Source: own elaboration.

The results are in favour of the Nelson-Phelps approach that implies the impact of the education variable in levels. However, a positive effect was observed only in the field of E&T (a positive coefficient of $\ln SENG_{it}$ on regional growth was statistically significant at the 1% level in all the specifications). On the other hand, the results indicate that an increase in the number of students in the field of Economics did not contribute to regional growth in Poland. It is natural to explain a positive growth contribution of technical education by its close connection to innovations and productivity. Unfortunately, both fields of study have unfavourable growth effects in first differences (the coefficients of $\Delta \ln SENG_{it}$ and $\Delta \ln SECON_{it}$ are significantly negative in all specifications), which might indicate the inferior quality of investments in the human capital at regional level.

It is worth noting that education effects stay intact in the presence of a control for investments in physical capital, as highlighted by Krueger and Lindahl (2001), but also in the extended regression models with employment and output of the Eurozone. At the same time, persistence in regional growth, as captured by the coefficient on the lagged term $\Delta \ln Y_{it-1}$, is lost in the extended regression models.

Regarding the earlier empirical findings by Shevchuk and Zyra (2018) and Żyra (2020), it was confirmed that it is an increase in the total number of students, not upward changes in the educational attainment, that had a positive regional growth effect. However, the study's estimates of educational output effects in the first differences are more pessimistic, as instead of neutrality there is a clear inverse relation between the dynamics of students and regional growth. Yet, these results are in line with the findings by Agasisti and Bertoletti (2022), that a specialisation in STEM subjects is crucial for regional economic growth in European countries.

With regard to other variables, investments in physical capital have a clear positive impact on regional growth (Model II), being in full accordance with the standard predictions of neoclassical growth models. A higher employment is also a pro-growth factor (Model III), but a positive coefficient on $\Delta \ln L_{it}$ becomes insignificant if the lagged GDP growth in the Eurozone is accounted for (Model IV). As expected, there are positive spillovers of economic growth abroad and the negative effects of the crisis of 2008-2009. After including additional variables, no changes to the established relation between education variables and regional growth were observed, while regional growth has become less persistent.

Consistent with the educational effects on regional growth, a higher number of students in the field of E&T (in levels) contributes to a decrease in the number of unemployed, while more students studying Economics is a factor behind higher unemployment. This corresponds with the findings of several studies for European countries that the risk of unemployment is lower for E&T graduates (Boll et al., 2018; Tarvid, 2010; Stojanova and Blašková, 2014). However, the dynamics of student attainment (in the first differences) in both fields of study was unfavourable, as the coefficients of $\Delta \ln SENG_{it}$ and $\Delta \ln SECON_{it}$ were positive and statistically significant. Similar to regional growth estimates (Table 2), the causal links between education variables and unemployment were quite robust to changes in the specification of the regression models.

Table 3. Determinants of regional unemployment

Independent variables	Dependent variable $\Delta \ln U_{it}$			
	V	VI	VII	VIII
$\Delta \ln U_{it-1}$	0.350 (4.17***)	0.315 (4.74***)	0.161 (1.49)	0.123 (1.70*)
$\Delta \ln SENG_{it}$	0.215 (2.50**)	0.267 (2.05**)	0.315 (2.28**)	0.103 (1.67*)
$\ln SENG_{it}$	−0.169 (−1.80*)	−0.271 (−4.14***)	−0.389 (−3.22***)	−0.148 (−3.67***)
$\Delta \ln SECON_{it}$	0.449 (3.69***)	0.373 (4.43***)	0.419 (3.97***)	0.157 (2.02**)
$\ln SECON_{it}$	0.152 (1.66*)	0.220 (1.89*)	0.308 (2.52**)	0.117 (4.57***)

$\Delta\ln I_{it-1}$	–	−0.407 (−2.97***)	−0.390 (−2.94***)	−0.351 (−6.57***)
$\Delta\ln L_{it-1}$	–	–	−1.049 (−1.65*)	−0.562 (−2.19**)
$\Delta\ln W_{it-1}$	–	–	–	1.253 (2.53**)
$\Delta\ln YEURO_{t-1}$	–	–	–	−4.245 (−9.46***)
Hansen J test (prob)	0.18	0.14	0.17	0.11
Observations	246	256	246	230

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% significance level respectively.

Source: own elaboration.

Regardless of specification, lagged investments in physical capital contribute to a decrease in the number of unemployed persons. The same favourable effect of higher lagged employment becomes statistically significant only in the extended specification of Model VIII. Higher lagged wages seem to cause unemployment, reflecting a decrease in the demand for labour. On the contrary, another demand--driven factor as a stronger output growth in the Eurozone clearly reduces unemployment.

These results seem to confirm the international evidence that the relation between the number of students and economic growth is not uniform and positive in all cases. In such a context, it is quite natural to assume that educational skill mismatches can be responsible for counterintuitive negative growth effects, as argued by Pritchett (2001). Important differences in the field of study effects for output and unemployment can be explained not as much by differences in productivity, as with different labour market flexibility or sectoral disequilibrium when a surplus of students in one field of study is combined with a shortage of students in another. However, the lack of the much sought inverse relation between the education variables (in first differences) and unemployment that used to be interpreted as an indicator of causality in the short term, could be explained by problems with employment mobility in their early career in the first place.

Regardless of the field of study, the author's findings on the direct relation between unemployment and both $\Delta\ln SENG_{it}$ and $\Delta\ln SECON_{it}$ argue for policies that would also improve the employability of university graduates as a prerequisite of lower unemployment and stronger regional growth effects. First of all, it requires teaching competences that match demand on the labour market. Second, the better identification of labour market trends across particular fields of study can be helpful in guiding the preferences of university study applicants. Third, the activities of job search agencies are of great importance. These agencies should focus on constant training and innovation, industry mapping and providing better consultation to graduates.

In a wider context, the favourable effects of higher student enrolment in the field of E&T provide arguments in favour of state-sponsored policies aimed at higher enrolment at the technical universities, similar to the government initiatives during the 2008-2012 period. Such a policy should contribute to either a higher rate of regional growth or lower unemployment.

5. Concluding remarks

These results suggest that technical education is more efficient in terms of regional growth and unemployment in comparison to other fields of study, for example Economics. Thus, the recent downward trend in the number of students in the E&T field of study has had unfavourable effects in terms of both lower regional output growth rate and higher unemployment. However, estimates of education variable in first differences signal that both fields of study, i.e. E&T and Economics, do not contribute to either regional growth or lower unemployment. Such findings imply that extra efforts are needed in order to improve employability among graduates.

Estimates of the causal links between education variables and both regional growth and unemployment are quite robust to changes in the specification of regression models. Moreover, the preliminary results allow to claim that this study's results hold in the case of using the number of graduates for consecutive four years as an education variable. However, modelling the stock of human capital, as indicated by the number of graduates over a long enough time span, requires a more sophisticated analysis which is reserved for future studies.

Several other directions for the continuation of this research seem to be promising as well. First, it is of interest to estimate the educational effects across several groups of regions, with a focus on the possible differences between the low and high-income regions. Second, it can be productive to expand the list of explanatory variables by indicators of infrastructure developments and technical progress. As argued in the literature (Aghion et al., 2009), regions with a higher level of innovativeness better accumulate human capital. Third, it is worthwhile to expand the number of fields of study in empirical analysis. It cannot be ruled out that the educational effects of E&T or Economics mask to some extent the impact of other fields of study. Fourth, a re-estimation of panel regression models using the number of university graduates instead of the number of students as the education variable, should be helpful in clarifying the mechanisms of educational effects on regional growth and unemployment. Finally, the educational effects can depend on the interaction with the demographic transition of the 1990s and 2000s. As longer time series become available, it will promising to study the relations between the demography curve, labour market conditions, human capital accumulation and economic growth in Poland. In this context, it is important to control for the determinants of the choice of fields of study.

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ODDZIAŁYWANIE EDUKACJI TECHNICZNEJ I EKONOMICZNEJ NA WZROST REGIONALNY I BEZROBOCIE W POLSCE

Streszczenie: Wykorzystując roczne dane z lat 2000-2019, poddano analizie efekty studiów na kierunkach technicznych i ekonomicznych dla Polski. Okazało się, że długookresowe efekty edukacyjne (w poziomie) są lepsze dla kierunków technicznych jako czynnik wzrostu regionalnego produktu oraz zmniejszenia liczby osób bezrobotnych. Oddziaływanie krótkookresowe (w pierwszych różnicach) na wzrost regionalny i bezrobocie jest negatywne, niezależnie od kierunku studiów. Ponieważ studiowanie na obu kierunkach ma niekorzystne efekty dla zmiennej edukacyjnej w pierwszych różnicach, to może świadczyć o niewystarczającej jakości inwestycji w zasoby kapitału ludzkiego.

Słowa kluczowe: edukacja wyższa, kierunki studiowania, wzrost regionalny, stopa bezrobocia, Polska.