SHALLOW DETERMINANTS OF GROWTH OF POLISH REGIONS. EMPIRICAL ANALYSIS WITH PANEL DATA METHODS

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Tomasz Brodzicki *

Abstract

We derive and then estimate an augmented growth model to identify major shallow determinants of development of Polish regions at NUTS-2 level of spatial disaggregation. Of particular interest to us is an attempt to assess the impact of investment in transport infrastructure and investment in human capital related to a large influx of Structural Funds after the accession in 2004 to European Union.

We utilize various panel data techniques in order to reach the major conclusion. Most of results are in line with theoretical predictions. The obtained results are however sensitive to the introduction of spatial effects and their particular specifications. At regional level agglomeration effects are clear with metropolitan status of a region playing a significant role in development. Polycentric core-periphery model seems to suit the Polish framework conditions.

Key words: regional development, economic growth, panel data analysis
JEL code: O41, R10, R11, C23

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1 Introduction

Economic development of regions is a complex, sequential and non-linear process affected by a number of shallow and deep-rooted determinants such as geography or quality of institutions (Rodrik 2002). Growth literature traditionally focuses on shallow determinants of growth. According to Crescezni and Rodriguez-Pose (2008) backward European regions should follow balanced strategies in which infrastructure development is coordinated with policies aimed at developing human capital and the innovative potential of regions. In order to assess their postulates we extended the analysis of Carstensen et al. (2009) further augmenting the neoclassical model of Solow (1956, 1957) and Swan (1957) to incorporate Mincerian schooling externalities and infrastructure externalities in a single theoretical framework (Brodzicki 2012). Infrastructure was introduced into the model in a manner similar to exogenous Hicks-neutral technological change – raising the overall efficiency of an economy and tested for a panel of European economies in the period 1999-2010. Econometric results were promising and robust in line with basic expectations. The model could be applied to a regional level as well taking into account spatial interactions between regions within single states.

The purpose of this paper is to identify the major shallow determinants of development of Polish NUTS – 2 regions and attempt to determine their impact on the level and diversity of development. In order to identify the major shallow determinants of development we construct and solve a neoclassical model of economic growth in an augmented formula. Of particular interest to us in this context is an attempt to assess the impact of investment in transport infrastructure and investment in human capital, due to the large inflow of EU funds after an accession in 2004. Other studies utilizing more general approaches found an important impact of infrastructure development on growth of Polish regions (e.g. Cieślik and Rokicki 2010). We then develop an empirical model and apply it in the panel setting to a group of Polish NUTS-2 regions over the period 1999-2009.

The structure of this paper is as follows. In section 1 we develop an augmented neoclassical growth model including infrastructure and human capital obtaining the structural equation. In section 2 we demonstrate the empirical model to be estimated. Section 3 presents and discusses the principal results. The last section concludes, discusses the limitations as well as gives guidelines for future empirical research.
2 Augmented neoclassical growth model

Following Brodzicki (2012) we assume that at an aggregated level the regional production function takes the Cobb–Douglas form with physical capital K and labor L as the two basic inputs. The labor input is conditioned for the average level of education\(^1\). The general production function is thus given by:

\[
Y = I^{\gamma} K^\alpha (B L)^{1-\alpha},
\]

where \(Y\) is the aggregate output of a region, \(B\) an exogenous index of the level of technology and \(I\) is an index of the quality of infrastructure that is also exogenous to individual firms. \(K\) represents the stock of aggregate physical capital and \(L\) the labor force. We do not set any a priori restrictions on parameter \(\gamma\). The general production function shows constant returns to scale as long as we treat infrastructure as an exogenous efficiency-adjusting parameter having the impact on overall productivity of the regional economic system.

Accumulation of human capital (through education system\(^2\)) generates an externality given by:

\[
B = Ah^{\lambda},
\]

where \(h\) the average level of education and \(\lambda\) represents educational externality.

A is a region-specific technology that grows exponentially over time at an exogenous and positive rate \(g\) common to all the regions.

\[
A = A(0) e^{gt},
\]

Technological progress is labor-augmenting or Harrod-neutral. We take into account heterogeneity of regions along technological dimension by allowing the initial level of technology as given by \(A(0)\) to vary. We have to note however, that at the level of NUTS-2 regions of Poland, the observed differences in the level of technology should not be significant probably varying between metropolitan and not-metropolitan regions.

\(^1\) In order to simplify notation we drop the notation \(i\) for regions.

\(^2\) To simplify the analysis omitted other processes affecting human capital accumulation, eg. through improvements in the health care system.
In accordance with Mincerian tradition the average level of education may be specified as a function of average years of schooling (AYS) and average years of experience (AYS) (Bils & Klenow 2000). Accordingly:

\[ h = \mu e^{\beta_{AYS+\chi AYE}} \]

where \( \mu \) – constant and positive parameter, \( \beta \) i \( \chi \) – microeconomic – individual private returns from additional year of schooling and additional year of experience respectively.

In the analysis of the empirical model it would be advisable to take into account the diversity of the quality of education between regions.

The overall production function in the intensive form with income per efficient unit of labor and capital per efficient unit of labor \( \bar{y} \equiv \frac{Y}{AL} \) and \( \bar{k} \equiv \frac{K}{AL} \) takes the following form:

\[ \bar{y} = I^{\gamma} \tilde{k}^{\alpha} (h^\lambda)^{1-\alpha} = I^{\gamma} \tilde{k}^{\alpha} (\mu e^{\beta_{AYS+\chi AYE}})^{1-\alpha} \lambda \]

Adopting the neoclassical rule of physical capital accumulation proposed by Solow (the so-called perpetual inventory method) as well as assuming that a constant fraction of output \( s \) is saved and invested (\( s>0 \)) and a constant fraction of physical capital \( \delta \) decays every period (\( \delta>0 \)), it follows that an increase in the stock of physical capital is given by

\[ \dot{K} = sY - \delta K \]

Furthermore, from the chain rule of differentiation we can show that evolution of capital per effective unit of labor over time is governed by:

\[ \dot{k} = s\bar{y} - \bar{k} (g + n + \delta), \]

where \( n \) is the exogenous rate of population growth assumed to be constant.

A series of transformations allows us to derive the key equation for the level of income per unit of effective work in the steady state and thanks to the definition of effective unit of labor to determine the level of real income per capita in the long-term. Its level is shown by the following equation:

\[ \bar{y} = I^{\gamma} \tilde{k}^{\alpha} (h^\lambda)^{1-\alpha} = I^{\gamma} \tilde{k}^{\alpha} (\mu e^{\beta_{AYS+\chi AYE}})^{1-\alpha} \lambda \]

\[ [4] \]

\[ [5] \]

\[ [6] \]

\[ [7] \]

\[ 3 \] For simplicity we omit the potential non-linear impact of experience as discussed in the literature.
\[ y^* = AI^{\frac{\gamma}{1-\alpha}} \left( \mu e^{\beta YS + \chi AYE} \right)^{\frac{\alpha}{1-\alpha}} \] \[ \text{[8]} \]

Real income per capita in the steady state is a function of exogenous structural parameters of the model. It is worth noting that in the steady state, all the key parameters of the model such as income, consumption and capital in per capita terms grow at exogenously determined and constant rate of technological progress \( g \). It is a characteristic for neoclassical growth models.

Taking logs of both sides allows us to obtain the crucial structural equation of the model:

\[ \ln y^* = \ln A + \frac{\gamma}{1-\alpha} \ln I + \lambda \ln \mu + \lambda \left( \beta YS + \chi AYE \right) + \frac{\alpha}{1-\alpha} \ln \left( \frac{s}{g + n + \delta} \right) \] \[ \text{[9]} \]

The level of real income per capita in the steady state is a positive function of the rate of saving (investment), a negative function of the population growth rate and depreciation of capital. Technological progress has generally a positive impact on the level of GDP per capita as shown by A. The direction of impact of infrastructure and human capital depends on the structural parameters whose values should not be assumed a priori. \( \lambda \) and \( \gamma \) equal to 0 would indicate their neutrality.

4 The empirical model and its components

In order to estimate an empirical panel model version of the above theoretical model with individual effects for voivodeships to capture the unobservable, region-specific characteristics and to eliminate the potential bias we make a relatively strong simplifying assumption that the observed real GDP per capita is similar to the level in the steady state.

Starting from the structural equation (9) assuming that \( \lambda \ln \mu = \text{const.} \) and allowing for differences in technology to be given by \( A_i \) and knowing the average investment rate \( \bar{s}_i \) and average population growth rate \( \bar{n}_i \) we can construct our empirical equation containing the stochastic component:

\[ \ln y_i = \text{const} + \ln A_i + \frac{\gamma}{1-\alpha} \ln I_i + \lambda \left( \beta YS_i + \chi AYE_i \right) + \frac{\alpha}{1-\alpha} \ln \left( \frac{\bar{s}_i}{g + \bar{n}_i + \delta} \right) + \epsilon_i, \ i = 1,...,N \] \[ \text{[10]} \]
Equation (10) predicts that the coefficient on the investment share equals in absolute value the coefficient on labor force growth (conditioned by $g$ and $\delta$). For a typical capital share in income $\alpha$ of one-third as suggested by proponents of neoclassical growth theory, the size of this coefficient is predicted to be exactly 0.5. We are however not going to impose any restrictions on its size.

The panel data version of the empirical model with individual effects for countries takes the following form:

$$
\ln y_{i,t} = \text{const} + \ln A_{i,t} + \frac{\gamma}{1 - \alpha} \ln I_{i,t} + \lambda(\beta AS_{i,t} + \chi AYE_{i,t}) + \\
+ \frac{\alpha}{1 - \alpha} \ln \left( \frac{\bar{s}_{i,t}}{g + \bar{n}_{i,t} + \delta} \right) + \eta_i + u_{i,t}, \ i = 1,...,N, \ t = 1,...,T
$$

[11]

As can be seen from the empirical equation above, fixed individual effects seem to be our preferred choice. However, in the estimation we are not going to assume fixed effects a priori, but we will perform a standard Hausman test which gives a generally accepted way of choosing between fixed (FE) and random effects (RE). The null hypothesis of the test states that the RE estimator is consistent and thus outperforms FE estimator. GDP per capita ($y$) is the explained variable of key interest to us.

From the estimates of the coefficient on $\ln(s/(g+n+\delta))$ we will be able to calculate the implied value of $\alpha$. We expect it to be close to one-third. Knowing $\alpha$ and the coefficient on the infrastructure index will allow us to calculate the implied value of $\gamma$. We expect it to be positive and in the range of 0 to 10 per cent. We will obtain implied macroeconomic return on education $\lambda$ directly from the coefficient on the fourth term on the right hand side of the estimated empirical equation. We expect $\lambda$ to be positive and statistically significant.

In line with the related empirical growth literature, we assume a constant rate of labor-augmenting technological progress $g=0.02$ and a constant decay of physical capital $\delta=0.03$. Thus $g+\delta=0.05$. In accordance with the theoretical model we allow for variation in the level of technological sophistication of regions. A large number of variables have been utilized in the literature as proxies for international differences in technology including simple dummy-

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*The fixed effect estimation assumes to some extent that human capital and infrastructure stock are exogenous while they might in fact be endogenous. In other words, advanced countries could have better education systems, better institutions in general, and superior infrastructure than less developed economies. The use of more sophisticated estimation methods such as system GMM could take out potential bias.*
variables for heterogeneous samples. Since in this case we are dealing with regions of one country constituting a single national innovation system in the model we introduced variables approximating variation in scientific potential of regional innovation systems (RIS).

Sticking to the initial theoretical assumptions we adjust average schooling years for differences in education quality (edrq). In order to obtain an implied macroeconomic return for human capital accumulation (λ) similarly to Carstesen et al. (2009) we impose restrictions on private returns to schooling, thus setting β=0.1 and private return on experience χ=0.03. The assumed values are based on the results of microeconometric research. We will independently analyze the consequences of abandoning the adoption of constant parameters and their separate estimation.

In order to obtain average years of experience (AYE) we follow Mincer and calculate it as an average age of the cohort (ages 15 to 65) minus the average years of schooling and further deduce 6 years (presumed age of entry into education system). The data on population come from GUS (Baza Danych Lokalnych).

Construction of the crucial index measuring overall quality of infrastructure is based on the methodology proposed by Careijo et al. (2006). The index of corrected infrastructure quality CIIQ relativizes the infrastructure endowment by taking into account both population size and land area and compares it to a benchmark. In the case of the present study we take the average for Poland as the respective benchmark. CIIQ is calculated according to the following formula:

\[
CIIQ_r = \left( \frac{X_r}{N_r} \right)^{0.5} \left( \frac{X_r}{S_r} \right)^{0.5} \left( \frac{X_{PL}}{N_{PL}} \right)^{0.5} \left( \frac{X_{PL}}{S_{PL}} \right)^{0.5},
\]

where \(X_r\) i \(X_{PL}\) gives the infrastructure endowment of a given region and Poland, whereas \(N\) and \(S\) represents respectively population (in thousands) and land area (in square kilometers).

We consider two types of infrastructure stock as key determinants of an overall accessibility and competitiveness of regions and states: motorway system and railway network\(^5\). These are key elements shaping interregional and international accessibility of regions. Indices have been calculated separately for both types of infrastructure (iqm and iqr respectively) as well as

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\(^5\) In accordance with the growing NEG literature, if the analysis was conducted at the regional level, it would be necessary to discriminate between intraregional and interregional infrastructure (eg. Ottaviano 2008). Furthermore, potential spatial autocorrelation should be taken into account.
an overall index CIIQ (a simple geometric mean of two aforementioned indices).\textsuperscript{6} The quality of the proposed index could obviously be questioned by economic geographers or spatial planners who utilize much more elaborate spatial techniques in order to construct regional accessibility indices. The ones calculated by IGiPZ PAN are however calculated in 5 year intervals which obviously is unsatisfactory for our purposes\textsuperscript{7}.

In addition to the variables described above, we used a set of conditioning set of variables as postulated by the literature on growth. These include among other the log of openness ratio (lnopen) as well as agglomeration index (a1).

Agglomeration index shows the strength of agglomeration processes taking place in the region. It is calculated as a ratio of population of the largest city in the region to its overall population. As some of provinces have polycentric metropolitan regions we also test the impact of taking into account 3 and 5 largest urban centers of individual provinces (a3 and a5 respectively).

\textsuperscript{6} The raw data for infrastructure endowment was taken from the EUROSTAT and supplemented in the case of missing data by information provided by national Ministries of Infrastructure.

\textsuperscript{7} Problems with access to comparable panel data prevented the decomposition of the index into sub-indices of the quality of intra-regional and inter-regional infrastructure suggested by the new economic geography theories.
5 Results and discussion

The empirical analysis is carried out for a group of 16 Polish NUTS-2 regions within the period 1999 to 2009. We utilize several data sources. The majority of data comes from Baza Danych Lokalnych and HERMIN database provided by Główny Urząd Statystyczny. EUROSTAT data bases have been utilized in construction of several infrastructure-related variables.

The results are presented in table 1. In the choice of the preferred specification of the model we have used the Hasuman and Bresuch-Pagan test. The null hypothesis of the Hausman test was rejected, leading to the choice of the model with fixed effects (FE). The analysis showed the legitimacy of the use of one-way model considering only region-specific effects and not taking into account the model of temporal effects (two-way approach).

Analyses were performed for a number of different specifications of the model with varying selection of explanatory variables. Due to the use of the approach with fixed effects for individual regions, we consider the effect of variation in the initial level of technology to be included in these effects.

We consider that potential spatial correlation between regions can be included in the model through introduction of the agglomeration effects or the introduction of spatial weighting matrixes in a more sophisticated spatial econometric approach.

The augmented neoclassical model, taking into account the impact of human capital and the quality of transport infrastructure, seems to suit well the specific nature of the development of Polish regions. Our base model explains approximately 88% of the variation in real GDP per capita Polish regions.

The impact of lnz on income per capita is statistically significant and positive in the base specification of the model (M1). The introduction of variable approximating the quality of infrastructure interferes with the result that is inconsistent with economic theory (M2). For this reason, in the next step (spec M3) we divide the lnz variable to its components: Inki which reflects the process of capital accumulation and the denominator ln(n + 0.05). Inki turns out to be significantly correlated with the quality of the infrastructure index CIIQ. In relation to the theoretical assumptions of the model, it was noted that it is not possible to separate the effect of the rate of investment (accumulation of fixed assets) from the impact of infrastructure quality. For this reason, in the following specifications (M4 and further) we
drop the lnki variable. Effect of ln (n + 0.05) on the dependent variable in these cases is negative and statistically significant – in accordance with theoretical postulates.

The impact of aysaye on the level of development of Polish regions in all specifications is positive and statistically significant. It signifies key impact of human capital on development of Polish regions. With the transition form extensive (based on a simple catching up process) to more intensive stage of growth of Poland its role is likely to increase even further. Separation of the overall impact on the education component (AYS) and experience (AYE) does not substantially change the situation. The influence of both elements is positive and statistically significant, the impact of the experience, however, seems to be stronger. It is worth noting that the results obtained are robust to the introduction of additional explanatory variables capturing the quality of the education system (eduq) and scientific research potential of regions - the natural logarithm of employment in R & D in the region (Irdeploy). The impact of these variables turns out to be statistically insignificant.

The impact of relative quality of infrastructure (CIIQ) on the dependent variable is positive but statistically insignificant (model M4). When we break it down in the following two specifications (M5 to M7) into subcomponents associated with the quality of roads (iqm) and railway (iqr), only the second term seems to have a statistically significant effect on the level of GDP per capita Polish regions.

It is difficult to explain this result straightforward. It is worth noting that it does not disappear when we include the level of openness of regional economies and spatial interactions through the introduction of the agglomeration index (M7). In this context, it is worth noting that open regions achieve on average, a higher level of real GDP per capita. At the same time, at the 10% significance level, the positive impact of agglomeration forces on the dependent variable is clear. Regions with strong metropolitan areas attain ceteris paribus a higher the level of GDP per capita which could mean that core regions are the drivers of the overall growth of Poland. The role of peripheral regions is significantly lower. Growth seems to be spatially concentrated.

The obtained results are sensitive to the introduction of spatial effects and their particular specifications. We consider the introduction of models SEMs and SAR (model M9 and 10). We applied the most straightforward first neighbor spatial weight matrix. It turns out, however, that at NUTS2 the optimal solution is the introduction of spatial effects by including
a simple variable agglomeration (a1, specifications M7 and M8), and not by the effects of spatial autocorrelation of the endogenous variable or random factors.

6 Conclusions

The aim of the paper was to identify shallow determinants of growth of Polish regions as well the existence, the sign and magnitude of macroeconomic education and infrastructure-related externalities. In order to do so we developed an augmented neoclassical growth model incorporating a Mincerian approach to human capital accumulation, as well as assuming infrastructure to have a direct effect on overall productivity of an economic system. We derived a specific structural equation of the theoretical model which, after inclusion of stochastic element, became our empirical model. The panel version of the model was estimated with FE estimator.

Our simple panel model explains nearly 90 per cent of observed variation in GDP per capita. Overall, the return to accumulation of human capital through education and experience for Polish regions is statistically significant, robust and positive. The macroeconomic infrastructure externality is positive however statistically insignificant. When we separate the impact of quality of roads (iqm) and railway (iqr), only the second term seems to have a statistically significant effect on the level of GDP per capita Polish regions. Taken at face value, this result could have significant policy implications. Overriding priority should be given to fostering further accumulation of human capital over investments in the transport infrastructure.

Good quality of basic interregional infrastructure still seems to be fundamental determinant of growth. In order to boost economic growth further, when an economy goes from extensive (resource and efficiency-driven) to intensive (innovation-driven) growth (converges to world technology frontier) phase, requires accelerated accumulation of human capital as well as increasing gross expenditures on R&D. The central role of capital-deepening is replaced by human capital accumulation and knowledge creation (eg. Aghion and Howitt 2009).

We see several limitations of our analysis. Our theoretical model should preferably incorporate both direct and indirect effects of infrastructure on economic growth. We agree with Straube (2008) that modern NEG models could outperform economic growth models in this respect, as they allow for agglomeration effects, non-linear impact of infrastructure on development due to reduction in transport costs, and the role of sequencing and infrastructure
types (interregional and intraregional). The period analyzed is rather short while the impact of infrastructure and human capital is argued to have rather a long – run nature. Last but not least, there could be a measurement error in key variables which could potentially bias the estimates.

We see several potential extensions of our analysis. First of all, more effort has to be given to constructing better indices of infrastructure quality including various types of infrastructure (eg. ICT infrastructure said to be of prime importance for a knowledge-based economy, intraregional and interregional infrastructure). The use of more elaborate accessibility indices could bring interesting results, however, this is difficult due to the lack of data at yearly intervals. Secondly, the robustness of our results should be further tested at more disaggregated spatial level – powiats (LAD-4) where spatial interactions and externalities become crucial and cannot be empirically avoided. This would also require the use of more sophisticated spatial econometric approaches. The lack of GDP per capita estimates at the LAD-4 level has been solved recently by a new methodology of Ciołek (see Ciołek and Brodzicki 2015).

The analysis could be further broadened to include regions from other countries such as Visegrad group or EU28 as a whole (at least at NUTS-2 level). Last but not least, other potential theoretical frameworks could be utilized including more elaborated multi-sector growth models as well as dynamic NEG models. Polycentric core-periphery model seems to suit the Polish framework conditions. This is also stressed by economic geographers (eg. Tarkowski 2008).
References


Carejo i in., 2006, Indicadores de convergencia real para los países avanzados, Estudios de la Fundación, FUNCAS, Madrid.


Table 1 Estimation results

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Source: Estimation in the STATA 11 (command xtreg) and R (models with spatial effects). The table contains estimates of the parameters. In brackets () value of the Student's t-statistics. Result *** statistically significant at 1 per cent., ** - 5 percent. and * 10 percent level of significance. R2 - the value of the coefficient of determination; n - number of regions; N - the total number of observations in the data panel; F - test statistics for the combined effect of the explanatory variables; F-test - test statistic for the significance of the individual effects.
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