THE DETERMINANTS OF ECONOMIC GROWTH IN THE EU NUTS2 REGIONS

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Abstract

We employ Bayesian Model Averaging (BMA) framework to study economic growth determinants of the 276 European regions during 2006-2015 period. This framework allows us to address model uncertainty problem, which is a famous issue in growth econometrics. Moreover, we use post-crisis data to study the economic growth. We find that quality of education is one of the significant determinants of economic growth. Also, our model proves that higher education level, higher share of ICT patents, higher prime age population share as well as higher manufacturing share are positively associated with subsequent economic growth; whereas, capital city regions tend to develop faster. We also find a positive spillover effect from the neighbouring regions. Finally, our findings confirm conditional convergence process among European regions – regions with higher initial income tend to develop slower.

Keywords: Economic growth, Spatial Autoregressive (SAR) model, Bayesian Model Averaging (BMA), conditional convergence, European regions

I Introduction

Starting from the middle of the 20th century, econometricians were using Standard Ordinary Least Squares to investigate which factors influence the economic growth. Extensive research was performed to explore new determinants, allowing regulators to correctly identify directions of reforms needed to be implemented to boost economic growth. Solow (1956) and Swan (1956) are pioneers who studied economic growth and conditional convergence, also known as catch-up effect theory[1]. This gave birth to a new stream of research called "Growth Econometrics". Solow and Swan invented neoclassical growth model showing that GDP per capita tends to converge over time and productivity of labor and capital is positively related to economic growth. Subsequent authors identified that the study can be improved by determining what influences the productivity of labor and capital accumulation. Thus, such research papers as Barro (1991), Levine and Renelt (1992), Magrini (1998), Henderson and Russel (2004) added education attainment, the degree of macroeconomic stability, human capital, research activities, literacy rate, fertility rate, mortality rate, spillovers of technological knowledge and many other determinants to explain productivity of previously discussed factors.

Despite being exhaustively studied on a cross-country level, the economic growth in regions has been remaining an open question for several decades, because of data-sensitive results. Researchers found it essential to analyse regional growth since regulators generally implement structural reforms that affect regions and consequently by their means influence macroeconomic condition of the countries. Regional level studies allowed to identify more potential GDP per capita growth determinants, thus, allowed making better strategic decisions for regulators. Authors of regional studies analysed regional economic growth of a wide variety of countries: analysis of American regions by Deller S. C., Lledo V., Marcouiller D. W. (2008), study by Ding S., Knight J. (2008) of Chinese provinces, and paper of Gonzalez & Montolio (2004), who investigated growth determinants of Spanish regions. In turn, being insipid by Cuaresma, J. C., Doppelhofer, G., & Feldkircher, M. (2014) research, we focus on NUTS2 regions in Europe. The justification of potentially different effect on conditional convergence in Europe also lies behind the following arguments: for several years, ECB has tried to boost the European economic growth by implementing the quantitative easing program. Due to the free-trade agreement, countries in

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[1] The theory states that regions with lower level of per capita income, controlling all the other factors, tend to grow at faster rates than richer regions.

European Union can trade without any barriers. Additionally, citizens of European countries can travel across the region without barriers. This might enhance the labor mobility across the countries and, consequently, might speed up the conditional convergence. A key difference between Europe and other world regions is a quite rapid change in the list of member countries. This can have an ambiguous effect on the conditional convergence. On the one hand, the geographic expansion of the EU might have a positive effect on conditional convergence due to additional funds received from the EU. On the other hand, additional costs to meet the requirements of European Union for joining the union and inefficient policies of EU might destroy the economic value. The effect is unclear and economic theory has poor evidence that would explain this. Moreover, the previous studies (for example, Cuaresma et al, 2009; Cuaresma et al., 2014) use pre-crisis data to find economic growth determinants. Importantly, pre-crisis economy was peaking, which might bias the impact of macroeconomic indicators on economic growth. For example, Latvian GDP per capita in 2008 was 11 110 EUR, however, in 2009, it was already 8 704 EUR; total investments as % of GDP have declined by 37.35% in 2009; etc. (IMF, 2018).

Finally, the novelty of paper lies behind the explanation of the GDP growth per capita by the quality of education in a region. We measure the quality of education in a region by adding a variable that represents the number of universities in a region conditional upon inclusion in top 500 Shanghai Jiao Tong University Ranking in 2005. We believe that the better the quality of education that was recognized internationally the larger should be the GDP growth per capita of a region.

Up until now, numerous factors that explain economic growth have been identified, and researchers constantly continue to look for new determinants that are related to economic growth.

The determinants can be classified into three broad groups:

- Macroeconomic variables (Investments, initial income[2], industry structure, etc.)
- Demographic and human capital variables (Population, population growthfertility, percentage of male population, level of educational attainment, etc.)
- Geolocation variables (Area, coastal,[3] pentagon[4], capital city[5], etc.)

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[2] Here and after we consider the GDP per capita PPP in 2005 as the initial income

However, more determinants also caused limitations for researchers and increased the uncertainty of the model. Linear regressions are sensitive to overfitting. When the model includes too many parameters, compared to the number of observations, the output of regression erodes because it starts to incorporate random error, i.e. noise; rather than just investigating the causal effect between the variables. Another problem that arises is the lack of methods through which computers would be able to aggregate the whole set of variables and provide reliable estimates of the marginal effects. One of the ways to mitigate the uncertainty of the model is to aggregate all the possible outcomes and average their probabilities of being included into the regression, thus, Bayesian Model Averaging (BMA) method was created. Using BMA, it is possible to address not only a single model but millions of models which could potentially be constructed in order to estimate the effect of a particular bundle of factors on economic growth. BMA allows combining the output of millions of linear regressions. BMA allowed to account for more factors, mitigate the model uncertainty problem, and find previously unobserved factors (Raftery, 1995).

The process of determining the appropriate factors of economic growth is still an open question. Since regions individual growth rates contribute to the overall growth of the economy in a country, there is a need for regulators to understand what policies and structural reforms should be implemented to boost the regional growth. Researchers continue to find alternative determinants of GDP growth using various techniques, statistical models, and unique datasets. Consequently, despite a huge pool of factors being already discovered, there are many more that still are unknown. Therefore, we formulate the following research question: **What are the determinants of economic growth of European Union NUTS2 regions?**

The paper is structured in the following way: section II reviews the existing literature regarding the economic growth and analyses the advantages of a wide variety of methodologies applied in growth econometrics. Section III describes the BMA methodology employed in this paper. Section IV describes the data, and Section V provides empirical results. Section VI discusses the determinants of economic growth. Section VII finalizes with the concluding remarks and the potential improvements of the research.

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[3] Coastal – dummy variable that is equal to one if the region is located near the sea.
[4] Pentagon – dummy variable that is equal to one if the region is in pentagon area. Pentagon is shaped by London, Paris, Munich, Milan, and Hamburg
[5] Capital city – dummy variable that is equal to one if the region includes a capital city.

II Literature review

The economic growth has been one of the most researched topics since the middle of the 20th century. Countries strive to boost the economic development; however, after every year with a positive economic growth, it becomes harder to achieve high growth rates. Larger economies are challenged to achieve high growth rates per capita by their increasing income level per capita. The graph below explicitly depicts the absolute convergence, the effect when regions with higher GDP per inhabitant have lower economic growth. (Figure 1).
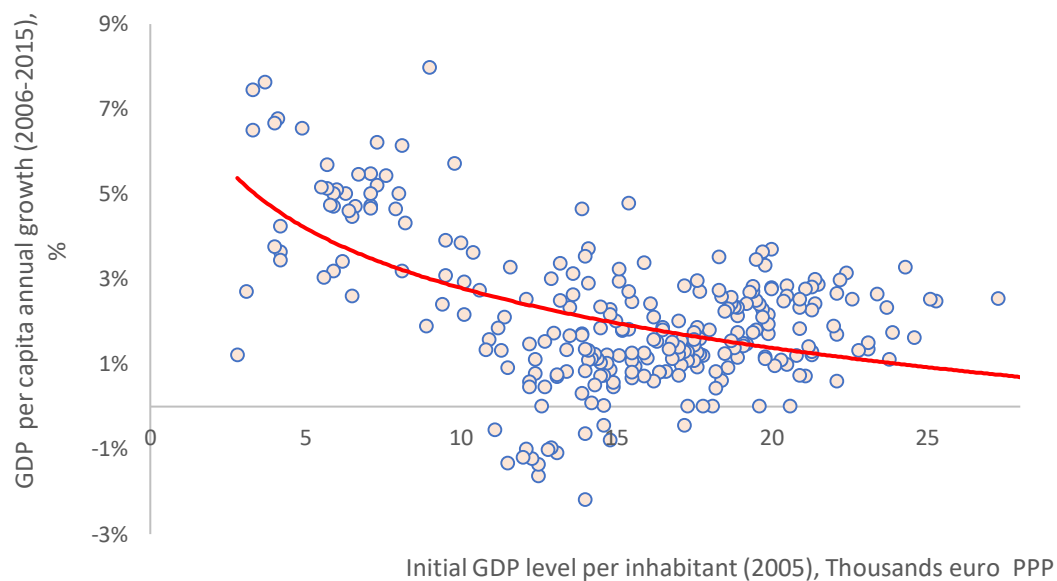
Figure 1. Absolute Convergence in EU NUTS2 regions during 2006-2015.

Source: Graph created by the authors using Eurostat

In our case, the absolute convergence can be reflected on the regional level as well. The regions with GDP level per inhabitant higher than 10'000 EUR PPP per capita experience an average growth of 1.57%; however, regions with lower income (<10'000 EUR PPP) experience the average growth of 4.67%. In turn, the idea of conditional convergence is that poor countries tend to grow faster than rich countries if they have similar equilibrium income level. In other words, Germany would require much larger effort to achieve growth of 4% than Latvia, because it already has a higher income level per capita.

Consequently, the instruments of economic growth have been actively researched using various econometric models and statistical techniques starting from simple OLS up to Bayesian Econometrics. The models were tested on cross-country and cross-region levels.

We will discuss the studies of economic growth using various methods and different levels of aggregation in detail.

Main approaches to study the determinants of economic growth

The neoclassical growth model, introduced by Solow (1956) and Swan (1956), shows that GDP per capita converges over time. The original theory postulates that there is a negative relationship between the income level and income growth. Notably, this does not imply absolute convergence yet, because countries may strive for their individual steady-state growth rates.

One of the most important contributions using variables outside the original theory to explain economic growth was done by Barro (1991). He tried to explain growth by adding 16 different variables to original theory to describe the productivity growth. However, the main problems he faced using standard OLS model was the heterogeneity problem and simultaneous causality. The direction of causality between economic growth and some possible growth determinants (institutions and macroeconomic factors, for instance) is not clear. Since the findings are subject to bias they have to be analysed cautiously. As an alternative, Sirimaneetham & Temple (2009) compare results of OLS and 2SLS models. Although 2SLS has an undebatable advantage over simple OLS in mitigating causality issues, it is weakly robust in practice. The reason is that it is challenging to find proper instrumental variables that would describe a determinant and at the same time have a 0 correlation with the dependent variable, GDP growth. 2SLS approach has not found enough support due to its limited applicability.

Another way to determine productivity growth is to apply nonparametric production frontier approach instead of using a common Cobb-Douglas function (Henderson and Russel, 2004). Traditional parametric tests always assume a normal distribution of the data, similarly, if we take GDP growth, it might follow a normal distribution. However, the normal distribution is often overused in academia and even GDP growth with a large data set might be skewed to one of the sides. In this case, nonparametric tests allow the researchers to relax the assumption of normal distribution of the data and get closer to the real data distribution. Importantly, if any of the parametric tests are valid then non-parametric tests will provide spurious results. The drawback of the model is that it gives too much weight on data distribution which might be quite arguable.

However, employing different factors of economic growth in the model raise another econometric problem - model uncertainty. In a simple Ordinary Least Squares estimation, by adding an additional variable to the model there is some probability of receiving a significant determinant just by chance. Statistically, we might expect 1 out of 10 determinants to be significant at 10% significance level. This raises the ambiguity of any results. One of the examples is excluding fundamental Solow-predicted variables such as technological change has led to controversial results that growth is boosted by indefinite investments in human capital so that countries with higher initial income might have higher economic growth (Romer, 1986; Lucas, 1988). The absence of conditional convergence has to be cautiously taken into account. There are three problems that might appear when empirically modeling conditional convergence process. (1) Due to model specifics, the absence of initial income in a model can lead to uncertain results since initial income has proven to have a strong correlation with GDP per capita growth (Temple, 1999). (2) There is a certain initial income threshold below which conditional convergence may not take place (Azariadis & Drazen, 1990). (3) There are certain issues with endogeneity. Hence, we include initial income in the regression, and, luckily, are not exposed to the second issue since none of the European regions live under the growth threshold. To deal with the third issue we use lagged values of given variables. We include independent variables as close as possible to the beginning of the period under consideration. Also, another alternative approach is to use 2SLS, however, it is quite challenging to find proper instrumental variables for the model. Finally, once describing economic growth all the above-mentioned issues have to be taken into account.

There are several methods to mitigate model uncertainty – extreme bound analysis, BACE, and BMA. Under extreme bound analysis, if the factors change the sign over different models they are not regarded as robust determinants; however, if the factors retain the sign in different model sets, the determinant is considered robust (Levine & Renelt, 1992). Contrary, Hoover and Perez (2004) argue that extreme bound analysis makes some of the important variables weak determinants, but some independent variables spuriously appear to be significant.

The computational power of PCs before did not allow using more sophisticated techniques. Researchers have developed advanced methodologies to deal with model uncertainty but received ambiguous results. Luckily enough, in hand with technological development, the academia come up with new frameworks to analyse the economic growth.

The most recent development in models of economic growth includes Bayesian approaches to estimate the posterior probabilities[6]. The beauty of Bayesian econometrics is model uncertainty mitigation. Since previous models are compatible, the Bayesian approach allows to put all the models in one place and estimate the average coefficient out of all models. Sala-i-Martin (1997) suggests estimating the robustness of findings by applying Bayesian Averaging Classical Estimates (BACE). He proposes giving a weight to each model that sum of all the weights is equal to 1. The weights should represent the likelihood of each model. Nevertheless, the equal weighting is applied. This model allows testing many determinants at one time, but the choice of a prior[7] remains a subjective judgment. Also, BACE gives an equal weighting to each of the models whereas some models are superior to other based on historical prove or correlational analysis (Sala-I-Martin, Gernot and Miller, 2004)

The further research applies model averaging techniques, or Bayesian Model Averaging technique to correctly evaluate the robustness of findings. In contrast to BACE, BMA does not assign an equal weight to each model but chooses the best model out of all. In fact, BMA does $2^K - 1$ regressions (K stands for a number of explanatory factors). For illustrative purposes, if we apply 30 different factors to explain GDP growth, BMA would run more than 1 billion models. In such a large pool of models, each theory is tested and provides an aggregate outcome (Sala-i-Martin, 1997; Eris, & Ulasan, 2013; Danquah M., Moral-Benito E., Ouattara B., 2014; Zeugner & Feldkircher, 2015).

Eicher et al. (2007) adjust BMA to Iterative Bayesian Model Averaging (IBMA) "because the simultaneous consideration of model uncertainty and parameter heterogeneity in standard growth regressions increases the number of candidate regressors beyond the processing capacity of BMA" (Eicher et al., 2007). The adjustments allow making a conclusion that a long list of regressors that most of the authors applied in cross-country data does not explain economic growth determinants in OECD. This is to say that economic growth yet remains a puzzle even on the cross-country level as well as on the region-specific level.

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[6] Posterior Inclusion Probability (PIP) – is a ranking measure based on the inclusion of a regressor into the model
[7] Prior – initial model's prediction about probability distribution of the variables.

Exploring economic growth determinants on a country-specific level

Not to mention more than 150 variables tested to see the effect on GDP growth we suggest get acquainted with a great survey made by Durlauf et al. (2005) where all the possible determinants have been collected in one place until 2005 (Durlauf et al. 2005, Appendix B, p. 652-659). We rather mention the most influential works and the development of GDP growth findings.

The findings of conditional convergence go down to Solow (1956) and Swan (1956) starting with neoclassical growth model described above. Solow and Swan (1956) define GDP as a function of investments (I), total factor productivity level (A) and labor endowment (L). Mankiw, Romer, and Weil (1992) argue that productivity parameter, A, should not only account for fixed productivity level and technology, but also for country-specific effects on growth. Many cross-country studies have tried to build up on the previous research by extending the variable set determining A. Although Solow and Swan assumed total factor productivity (TFP) being the same over the long run, this is hardly realizable since TFP is constantly growing and additional factors help to explain the growth (Temple, 1999). Hence, further research of economic factors determining the convergence is split between the two groups: Solow growth model and growth determinants outside original theory (Durlauf, 2005).

One of the most popular contributions using alternative variables to explain economic growth was done by Barro (1991). He was one of the first who applied a large set of variables to determine the GDP growth. Barro tried to explain economic growth with such variables as primary schooling, GDP levels at different periods of time, literacy rate, fertility rate, mortality rate, secondary-school enrollment rate and many others. He states that poor countries will catch-up if they have high human capital per capita; growth per capita and investment rate negatively relate to government consumption, because government distorts the growth with high taxes; economic instability has an inverse relation to economic growth. Indeed, economic stability plays a significant role in economic growth. Although when enough economic stability is in place institutions do not contribute to economic growth (Sirimaneetham & Temple, 2009). Likewise, the authors reflect to a finding of Azariadis and Drazen (1990) that there should be a certain amount of initial income and degree of stability for conditional convergence.

Since the middle of the 20th century, the debate about determinants outside original Solow theory was widely discussable. For instance, several authors are claiming that by applying various determinants the effect of economic convergence can be confirmed only with initial income and investments (Levine, R., Renelt, D., 1992). Contrary, other researchers prove that there are plenty of other variables that can explain economic growth. As such political institutions (Acemoglu & Robinson, 2001), real exchange rate (Easterly and Levine, 1997) or specifically capital accumulation should have had economic effect on the economic convergence. Indeed, capital accumulation takes a significant stake in the process of determining the labor productivity. It does include both physical and human capital which account for 90% increase in output, while an increase in TFP accounts for the remaining 10% (Henderson and Russel, 2004).

While technology develops the authors discover new determinants with an accumulation of statistics and data analysis. This implies using various techniques to explain the economic growth. Hence, one of the influential studies by Fernandez (2001) already provided 25 variables in 140 countries throughout 1960-1992 and proved the significance of initial GDP in 1960, ethnical homogeneity, life expectancy, equipment investment, regions-specific dummy variable, and legislation for economic convergence. In turn, Sala-I-Martin, Gernot and Miller (2004) extended the explanatory variables by finding the strongest evidence in effect of primary schooling enrollment, and the relative price of investment goods constituting to the economic convergence. Interestingly, public consumption and public investment share were negatively related to growth (Sala-I-Martin, Gernot and Miller, 2004). While discovering the hidden determinants of economic convergence, Eicher et al. (2007) add capitalism, primary export share and black-market premium to factors determining GDP growth.

It is important to note that the finding may differ from region to region. In other words, different countries might have different growth determinants. For instance, when Eicher et. al. (2007) analysing developed OECD counties does not find any effect of industry structure on economic growth, however, Masanjala and Papageorgiou (2008) analysing African region find mining sector significantly contributing to economic development. This might be one of the reasons the variables outside original theory may differ from region to region.

A purely new approach to economic growth is the analysis of a spatial effect (the neighboring countries positively affect the GDP growth). For instance, fast developing

countries may positively affect the neighboring country. LeSage et al. (2008) take a new approach to the effect by applying Spatial Durbin Model (SDM), Spatial growth regression and compare the results to the BMA using region-specific data. They found that long-run steady-state regional income depends on own region, neighboring region characteristics, the spatial connectivity structure of the regions and the strength of spatial dependence. Their finding was that the spatial spillover impact on neighbors is negative, while own regions positively affect the economic growth; consequently, the overall effect is ambiguous (LeSage et al. 2008).

Finally, M. Danquah (2013) combined non-parametric DEA approach with BMA approach to find the effect of geographic, institutional, macroeconomic variables, trade openness, factor supply variables, and institutional variables on the economic growth. Danquah et al. (2014) postulates that the key determinant of TFP growth is trade openness, initial GDP, and unobserved heterogeneity during the estimation period 1960-2000.

Exploring economic growth determinants on a regional level

The researchers apply similar to cross-country growth factors, but regional level allows the use of additional explanatory variables that are different across the regions within a country, and as a consequence, new discoveries and approaches to economic growth.

According to Lall & Yilmaz (2001), public capital and human capital do not contribute to the speed of convergence, because temporal economic behavior and regional differences have much larger effect on economic convergence. In contrast, Gonzalez & Montolio (2004) support the idea that public investments would increase the economic growth; while Cuaresma et al. (2014) and Kaldewei, C. & Walz, U. (2001) argue that human capital matters on a regional level. Cuaresma runs a BMA model proving that increase in 10% population share of workers with higher education is associated with 0.6 pp higher annual growth rates of GDP per capita in European regions.

Interestingly, the spatial effect of human capital has positive effect on economic growth (Lall, S., & Yilmaz, S., 2001; Magrini, 1998). The free movement within the EU allows people to migrate with no problem. Policies against the barriers for factor mobility might be critical for the fast economic convergence. Contrary, Polasek and Berrer (2006) claim that migration is no always good. Due to free movement, countries are not able to stop the migration in critical cases. They claim that almost a half of the observed regions in the sample is not able to avoid decreasing demographic trend and will shrink. Also, Kaldewei, C.

& Walz, U. (2001) find no significant effect from migration of human capital on economic growth.

Furthermore, the presence of universities in the regions positively affects the economic growth (Magrini, 1998). Universities affect the growth both directly and indirectly. Either universities are a research producer, or they provide human capital, both types of contribution positively increase the economic growth.

Another important economic growth determinants on a regional level coinciding with original theory are investments, and initial income (Ledyaeva S. & Linden M., 2008; Błażejowski et al., 2016). However, investments being one of the main growth determinants in Solow growth model reduce its significance on the regional level (Kaldewei, C. & Walz, U., 2001). Alternatively, larger investments in the industrial sector share proven to contribute more to economic growth than diversified investments in different industries (Magrini, 1998). The specialisation in one segment brings more benefits rather than spreading the investment portfolio among different industries. Nevertheless, investments in the manufacturing sector do not contribute to economic growth (Polasek and Sellner (2013).

Another way to explain economic growth is by adding fixed effects (Ding & Knight, 2011; Cuaresma, et al., 2009; Cuaresma et al., 2014). The researchers have proven that capital cities tend to grow faster on average as well as country specific effects are significant for some regions. They also provide the significant effects from regions located near the sea and within the pentagon area. There should be some other growth determinants within the area of fixed effect determinants that would explain the economic growth in the region. In fact, fixed effects are good control variables but have almost no explanatory power. Additionally, the coastal effect has been proven to be insignificant in the latest research by Ding & Knight (2011).

Also, income convergence can be explained with natural resource endowments and amenities by constructing a matrix of amenities that covers five general amenity measures and includes 34 variables (Deller et al., 2008). For example, cold weather significantly contributes to the measure of the amenity. They find that regional economic growth of American counties is not explained by high levels of natural amenities. Instead, there should be recreational sites established in order to access the use of resources at any time. In addition to previous findings, they suggest that income convergence requires camping grounds and amusement attractions to be in place. Interestingly, the paper challenges standard economic

growth determinants, and provide a new set of variables that might potentially affect the GDP growth. This proves that there is no one unique set of determinants that can explain the GDP growth but there is a wide range of approaches to the well-established problem.

In turn, higher level of trust and active associationism lead to more intense economic growth (Forte et al., 2015). Contrary to previous findings, social norms are not anymore a relevant predictor of growth, which may be caused by the recent social developments and digitalization.

The interest of this paper is to find the uncovered explanatory variables and justify the statistical significance with economic reasoning. Although various studies applying BMA approach have been consistent in some growth determinants (Initial GDP, investments), they have also found additional determinants that are specific to each country or region. The idea of applying BMA to region-specific level allows realizing alternative growth determinants that have not been considered before. Hence, the goal of the paper is to understand why some growth determinants appear to be significant; explain why some regions tend to grow faster than others; and discover new growth determinants.

III Methodology

BMA is a standard approach to both account for model uncertainty and handle large datasets. In order to evaluate potential growth determinants, we use two different approaches: the cross-section of regions, the cross-section of regions with a spatial autoregressive (SAR) structure suggested by Cuaresma, Doppelhofer and Feldkircher (2009). Applying it together with the methods proposed by Levine and Renelt (1992) and Sala-i-Martin (1997), we run the following linear regression with $K+F$ variables in an N x $K+F$ -dimensional matrix X:

$$y = \alpha i_N + \beta_F X_F + \beta_K X_K + \rho SY + \varepsilon \tag{1}$$

where an N-dimensional column vector y is economic growth for N European Union regions (NUTS2), α is the intercept term, i_N is an N-dimensional column vector of regions. We divide variables into two groups: factor accumulation/convergence variables (X_F) used by Solow-Swan and the rest variables (X_k) that can explain total factor productivity (TFP) differences between the regions, which are represented as β - a $K+F$ -dimensional vector of regression coefficients, being equal 0 if no regressors added. Additionally, we include in the regression spatial dependence structure and denote it with the variable S, which is an N x $(N-1)$ matrix and ρ being a degree of spatial autocorrelation, which is also represented as N x $(N-1)$ matrix. Non-zero ρ indicates the presence of spatial effect among the regions. Two approaches could be used to measure degree of spatial autocorrelation: (1) distance metrics, where distances might be calculated on the basis of the centroid of the regions or (2) equal weight for all region's neighbours (LeSage & Parent, 2007). Finally, ε, an N-dimensional shock follows a normal distribution with zero mean and identity variance-covariance matrix.

Contrary to Levine and Renelt (1992) and Sala-i-Martin (1997), we use Fernandez, Ley and Steel (2001) approach and allow any number of regressors from vector X to be included into the model. This is done to avoid the limitation of the model, since fixing the number of regressors influences the size of the predicted coefficients.

To overcome the abovementioned issue, we apply Bayesian Model Averaging (BMA) approach and add prior distribution for the parameters. Our focus is to compare the models with a diverse set of explanatory variables. According to Kass and Raftery (1995), the choice of the prior has a significant impact on posterior inclusion probabilities of the model. Fernandez, Ley and Steel (2001) proposed uniform prior $\rho = 2^{-K}$ on α and variance of the error term, which means that probability of adding a variable into regression is equal 0.5 exclusive of how many regressors are in the model, and g-prior on β. These priors are

supported by LeSage and Parent (2006) and called "benchmark" prior distribution since these priors have a minor influence on the posterior distribution and overall results. Thus, we apply the uniform and g-prior combined for sampling distribution and state that the probability that one variable appears in the model is independent of other variables.

Model uncertainty given the data (D), if β is the coefficient of interest, can be assessed by weighing the uncertainty of all individual models. Models M_1, M_2, ... , M_K are mutually exclusive and exhaustive.

$$p(\beta_i|D) = \sum_{k=1}^{2^K} p(\beta_i|D, M_k)p(M_k|D) \tag{2}$$

Equation (2) allows analysing the posterior distribution of regressors which approved future prediction. The probability of the data (D) can be expressed as:

$$p(Y) = \sum_{k=1}^{2^K} p(D|M_k)p(M_k) \tag{3}$$

We use posterior inclusion probabilities (PIP) to determine variable's significance in determining the regional growth level. Posterior inclusion probability, denoted as *p(Mi/D)*, is calculated using equation (4) and Bayes rule as a sum of probabilities variable X_K being included in the regression. Therefore, the posterior probability of the model M_i is given by the following equation:

$$p(M_i|D) = \frac{p(D|M_i)p(M_i)}{\sum_{k=1}^{2^K} p(D|M_k)p(M_k)} \tag{4}$$

where *p(Mi)* is a probability of the *Mi*, which belongs to the sample of all the 2K models; *p(D/Mi)* is a probability of D given the model i *(Mi)* and a probability of the data (D) given the model M_i equals:

$$p(D|M_i) = \int p(D|\beta_x, M_i)p(\beta_x, M_i)\Delta\beta_x, \tag{5}$$

where $p(D|\beta_x, M_i)$ is the observed likelihood, whereas $p(\beta_x, M_i)$ is prior density.

We repeat the same analysis for spatial autoregressive (SAR) structure by running the regression with an inclusion of country fixed effects. After determining which variables are important in explaining economic growth at the regional level, we calculate the posterior mean (PM), the mean of the distribution of coefficients before the explanatory variables - β_k,

$$E(\beta_K|D) = \sum_{k=1}^{2^K} p(M_i|D)E(\beta_K|D, M_i) \tag{6}$$

To characterize the dispersion and uncertainty of the parameters we use posterior standard deviation (PSD).

$$PSD = \sqrt{var(\beta_x|D)} \tag{7}$$

The variance of the posterior density or posterior variance is determined as a sum of all conditional variances weighted across all the visited models with the estimated model uncertainties from the equation (6). Thus, equation (7) of posterior standard deviation can be rewritten as:

$$PSD = \sqrt{\sum_{i=1}^{2^K} p(M_i|D)var(\beta_K|D, M_i) + \sum_{i=1}^{2^K} p(M_i|D)[E(\beta_K|D, M_i) - E(\beta_K|D)]^2} \tag{8}$$

Given that a sample with 42 potentially significant determinants is observed (see more in the Data section), we follow the approach of Xin Fang et al (2016). The results are analysed using Bayesian credible interval equal to 95%. This implies that with a large number of models observed, with 95% probability the true value will be within a given interval.

Lastly, we ensure that the results obtained using two different specifications are robust. An econometric theory does not provide the specific methodology for finding spillover weights in matrix S, we do a sensitivity analysis and adjust weights based on regions GDP per capita PPP.

IV Data

The data include statistics on 276 European regions at second-level of Nomenclature of Territorial Units for Statistics (NUTS) classification valid from 1 January 2015 in the time period 2006 – 2015 (Appendix A). We take a NUTS2 regions instead broader set of NUTS3 regions (1347), because of data availability.

In order to collect yearly data for possible determinants, we use ESPON (European Spatial Planning Observation Network) database for:

- Infrastructure variables, such as density of transportation network (e.g. rail density, road density), network connectivity and accessibility;
- Variables such number of nights spend by tourists, different types of emissions of carbon dioxide, and number of airports and seaports;
- Geolocation variables (Area, pentagon, coastal, capital city, etc.)

And EUROSTAT database to gather statistics on:

- Macroeconomic variables (Investments, initial GDP, industry structure, etc.)
- Demographic and human capital variables (Population growth, population, fertility, percentage of male population, level of educational attainment, etc.)

Moreover, we use an additional newly created variable – university_top500 which is an index receiving value from 1 to 213 depending on the place in Shanghai Jiao Tong University Ranking 2005. The higher is the place in the ranking the bigger is the index value. 213 stands for the number of universities in Europe included in top 500 best universities ranking based on academic performance of the students – Nobel Prize and Field Medals winners, and bibliometric data. In case there are two or more universities within the area the sum of the respective indices is taken. This is a proxy for the quality of tertiary education in a region, since Shanghai Jiao Tong University Ranking 2005 is one of the top ranking matrix used to evaluate a university performance.

As a dependent variable, we take the average GDP per capita growth rate of the region from the year 2006 to 2015. The distribution of the dependent variable looks similar to a normal distribution.
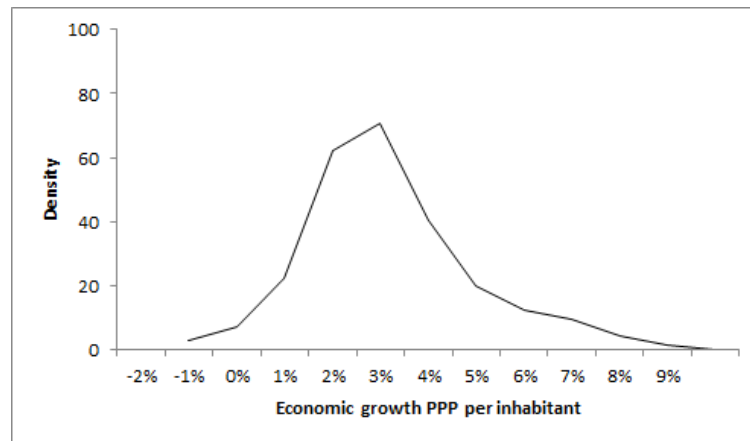
Figure 2. Distribution of average GDP per capita growth PPP of EU regions in the period from 2006 to 2015.

Source: Graph created by the authors using the data described in the Data section.

Despite Barro and Lee's (1994) finding that endogeneity had minor effect on coefficient estimates, we share Caselli F., Esquivel G., Lefort F. (1996) opinion that endogeneity plays a significant role in driving standard results in growth empirics. In order to mitigate the problem of endogeneity, the explanatory variables enter the model as close as possible to the beginning of the observed period.

Some of the variables are adjusted to country's area or population. This allows obtaining determinants which can be compared across the regions. We also adjust other types of variables: we calculate the shares of different types of patent from total amount of patents in the region to assess the technological innovation of the region, as well as, compute the shares of the workers with tertiary, secondary and primary education as a measure of human capital in a region.

We observe the following complications with the obtained statistics. First of all, European Union regional NUTS2 classification has changed, resulting in increasing number of regions. Thus, data collected prior to changes in classification will miss observations for newly created regions. Secondly, some of the determinants have missing values on NUTS2 classification or are reported using NUTS3 classification. Therefore, we adjust the data from NUTS3 regions into NUTS2 regions by either taking average of the NUTS3 value that constitute to NUTS2 or taking a sum of all NUTS3 region values.

All things considering, the list of the variables sums up into 42 potential regional growth determinants in a regional level (See Appendix B)

V Results

Our empirical results imply that economic growth can be determined by the following factors: population share with primary education, initial income level, population aged 30-49, share of industry in gross value-added, share of patents in information and communication technologies (ICT), spatial effect, pentagon effect, CO_2 ground emission, coastal effect, population growth effect, capital city, and universities which are included in top 500 Shanghai Jiao Tong world university ranking. The results are analysed using Bayesian credible interval equal to 95%.

	PIP	Posterior Mean	Posterior SD	Conditional Sign
Primary education share	1.0000	-0.0516	0.0058	0
Initial income level	0.9999	-0.0000	0.0000	0
Population (30-49) share	0.9999	0.2311	0.0493	1
Industry share in GVA	0.9998	0.0454	0.0096	1
ICT patents share	0.9989	0.0152	0.0037	1
Spatial effect	0.9957	0.1286	0.0355	1
Pentagon	0.9953	0.0065	0.0018	1
CO_2 ground	0.9727	-0.0042	0.0014	0
Capital City	0.7943	0.0041	0.0029	1
University ranking	0.7117	0.0000	0.0000	1
Coastal	0.6726	-0.0018	0.0017	0
Population growth	0.4100	-0.0528	0.1060	0

Mean No. regressors 10.5515   **Prior Model Size** 6 (Random)   **% of models visited** 100%

Table 1. Cross-section BMA regression.

Note. Conditional sign represents in what percentage of the models the factor has positive sign. 1 shows that factor has a positive sign in 100% of the models, while 0 shows that factor always has a negative sign.

Source: created by the authors using the data described in the Data section and RStudio software.

Moreover, referencing to Ley and Steel (2009), we decide to use Beta-Binomial model prior, since we aimed to focus our distribution with prior model size (Figure 3). Due to primary sorting, we decreased uncertainty around the model size, thus, this prior reduces the risk "unintended consequences from imposing a particular prior model size" (Zeugner, 2011). We don't specify draws and burnins since the amount of the models can be assessed using our computational systems.
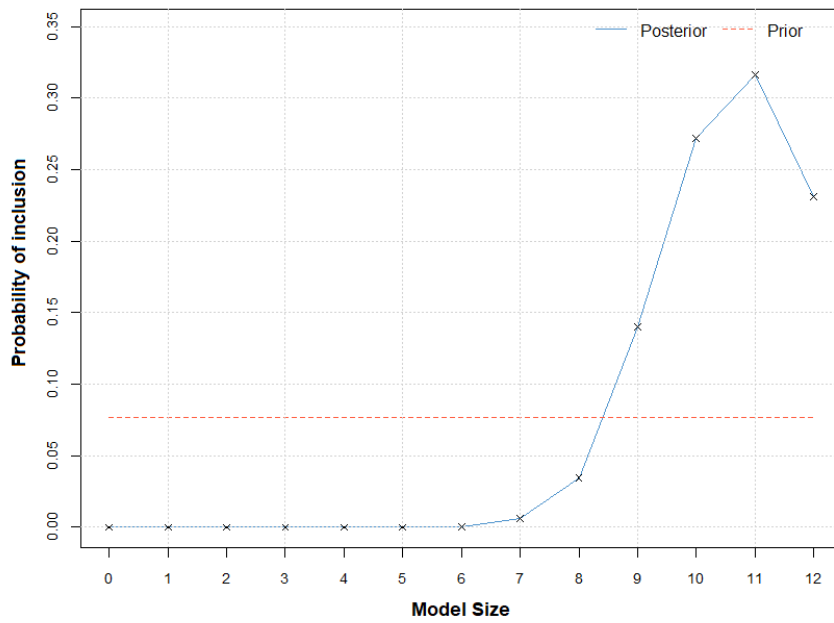
Figure 3. Posterior Model Size Distribution graph.

Source: Graph created by the authors using data discrubed in the Data section.
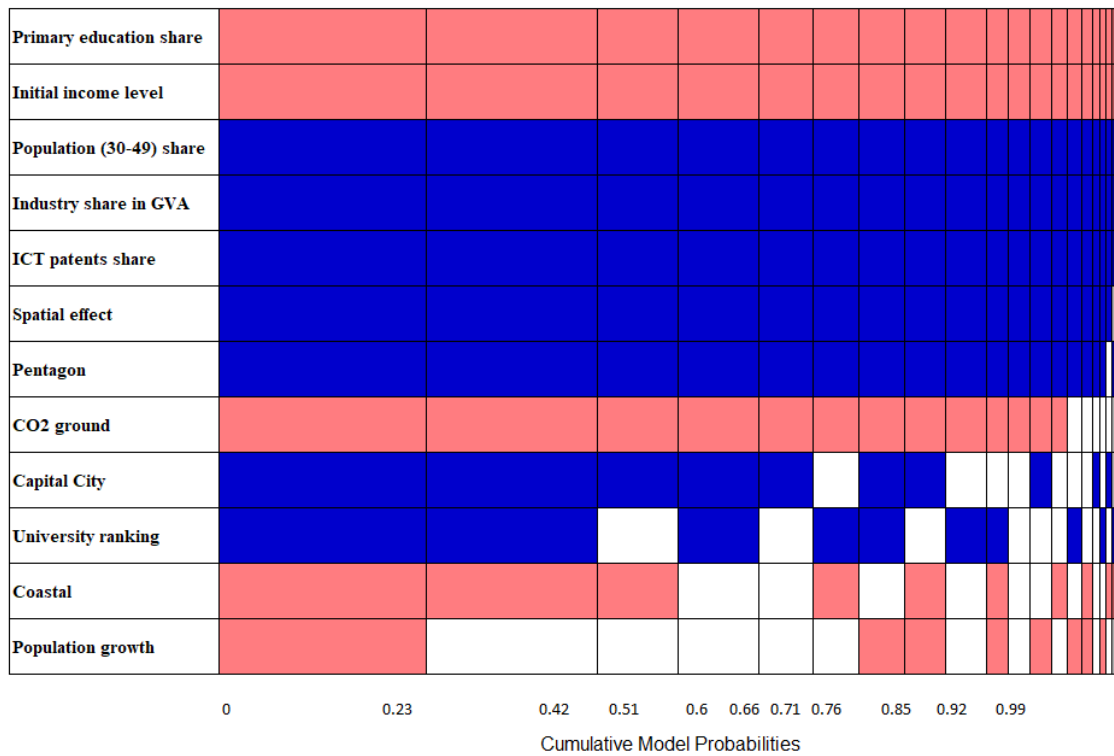
Figure 4. Cumulative Model Inclusion Probabilities based on the best 500 models.

Blue color (dark in black and white version) represents a positive relationship with GDP PPP per capita growth, while red color (light in black and white version) represents a negative relationship. White areas show that variable was not included into the model.

Source: Graph created by the authors using the data described in the Data section and RStudio software.

The best model explains 23% of the total cumulative model probabilities. From Figure 4, we can observe that posterior inclusion probability of initial income is very close to 100%. Additionally, it is negatively related to income growth, thus, the presence of conditional convergence is observed. In other words, when controlling for other factors, the lower is the initial income the higher is the subsequent economic growth.

The most significant negative relation with economic growth has a share of poorly educated people. The more people have only primary education in a region the lower is the economic growth. This creates a bound to the possible explanation of economic growth – the more educated population the higher the economic growth. In fact, Li, Loyalka, Rozelle, and Wu (2017) argue that human capital accumulation matters depending on the state of the country. For a low-income country to reach the middle-income level a centralized mechanism for a mandatory pre-tertiary education is required; however, in order to jump to a high-income level, a decentralized tertiary education mechanism is required. Moreover, the significance of poorly educated population supports the inclusion of the variable representing an index of universities being in top 500 ranking. In other words, low education variable shows the number of educated people in the region, but variable representing top 500 universities describes the quality of tertiary education in the respective territory.

We found that prime age has a significant positive relationship with GDP per capita growth and has a 100% posterior inclusion probability. We test various age groups such as 30-34, 30-39,30-44. 30-49, 35-59, 35-45, etc, by including different age groups, we managed to understand that prime age population for European Union NUTS2 regions are people aged 30-49. Similarly, Gomez and De Cos (2008) find that increase in prime age persons aged 35-54 relative to younger counterparts aged 15-34 has a positive effect on GDP growth. The larger the share of working population the more GDP per capita could potentially be created. The chosen period represents people that have already graduated from a university and have accumulated some working experience.

A variable representing the emission of CO_2 has a posterior inclusions probability of 97.27% and it is negatively related to economic growth. This might be explained by the fact that there is too much ground transport in the regions, and cars can be declared as not one's assets, but rather a liability or bad investment. Also, this could be explained by the fact that the more cars are on the street the more pollution is present, thus, the more polluted regions develop slower when controlling for other factors.

Moreover, a share of information and communication technologies appears to be a good predictor of economic growth. The positive sign could relate to the ease of information access and as a consequence a faster growth (Farhadi, M., Ismail, R., & Fooladi, M., 2012). Potential explanation could be that with an intense technological development the ICT might affect the GDP growth much stronger in 2018. For our study we used the ICT data from 2005 - when the information technology was not as broadly accessible as it is now. Thus, the effect of ICT might have an even higher correlation with GDP growth in 2018 than in 2005.

Population growth has a negative relation with economic growth, which is in line with the Solow model and the preceding literature. Logically, the higher the population growth the lower the income growth per inhabitant.

In turn, the spatial effect, being calculated using second method described in the methodology section, appears to be significantly and positively contributing to economic growth. The finding goes in line with Cuaresma (2014) with a posterior inclusion probability of 99.57%. Meaning that regions with a fast economic growth increase economic growth of neighboring regions, which, later on, might benefit them back. This fact also could indicate that having no trade or travel barriers might be the prerequisite for higher spillover effect.

Interestingly, pentagon area has a positive economic effect on economic growth, which coincides with the results of Cuaresma et al (2014). This means that there is a certain determinant within the area of the pentagon that would explain the growth. In turn, coastal regions tend to grow slower on average. Although, the cities located near seas have an additional trading channel – merchant's vessels, there is another explanatory variable which decreases economic growth. We tried to check this by adding variable representing the amount of nights spent in a hotel by tourists in the region, however, it ends up being insignificant; while variable Coastal retained its significance level. These issues are a great focus for the further research.

Lastly, following the findings of Cuaresma (2009), capital city regions tend to grow faster than other regions, keeping all other factors constant. Hence, the capital city variable, being a dummy variable, has a potential determinant that would explain the growth of the region. We try to explain the capital city variable by applying a unique determinant – an index which is assigned to each region if a region has a university from top 500 Shanghai Jiao Tong university ranking in the world. We believe that quality of tertiary education in a region can foster the economic growth of a region.

In fact, the results are not so obvious. The capital city does not lose its significance in models with the given variables. The university variable explains the capital city growth for some models but not enough to prove that it is the key determinant. This fact provides a space for further researches, since dummy variable should not be a significant factor because it might be not endogenous by itself; rather the capital city dummy depends on a wide variety of factors that are still to be researched.

Robustness check

The choice of inclusion of each determinant is combined using a nested regression technique. It means that we add variables one by one in the regression and observe how the output has changed; this approach helps to define the specific set of variables that prove an economic meaning of the model. Hence, we start with a fundamental study by Solow and Swan (1956), which positions that investments have a positive economic effect on economic growth. Consequently, the next criterion to determine the best economic model is to identify variables that have proven to be significant in previous research. For instance, population growth has a negative effect (Mankiw, Romer and Weil, 1992; Kelley and Schmidt, 1995), positive spatial effect (Ciccone & Hall, 1996), negative effect from initial income (Solow, 1956, Kormendi and Meguire, 1985; Barro, 1991), etc.

When all the variables are included, the significance level of the variables is far from being absolute. This problem is mainly because of correlation among explanatory variables (see correlation matrix in Appendix C). We excluded variables which had almost perfect positive or negative correlation. Another problem is a big number of dummy variables which were included in the regression. It leads to failure in regression analysis if the output of dummy variables can be perfectly predicted from the result of another dummy variable. Hence, we exclude all the country-specific effect in order to see the statistical reasoning of chosen variables, although country-specific effects proven to be important determinants of conditional convergence (Cuaresma et al, 2009). We also exclude variables with the least number of observations, for instance, variable representing average level of investments as a percentage of GDP in the years 2003 and 2005 is missing a lot of data and its inclusion will end up in a truncation of our data sample.

Lastly, it is important to carefully adjust the model with the variables which improve the statistical sense and economic meaning of the model. For example, unemployed aged 18-24, who also do not study in the university, appear to have a significant and positive effect on

economic growth which contradicts the economic sense. One can argue that people aged 18-24 can take a part in shadow economy activities, however, we also adjust the model for people with primary education. Interestingly, the variable representing people with primary education is significant in 100% of the models, while unemployed 18-24 lose its significance level, therefore, its economic meaning, since these people have primary education. In this case, we exclude such variables from the final regression because their significance was explained by other economic determinants.

Once we added industry gross value added the investments are no longer significant in the model. It might reflect that investments in industrial sector take a significant part of economic growth (Table 2). Also, we would expect industrial gross value added to take the significance away from pentagon variable since there are plenty of industrial giants within the area of pentagon such as BMW, Volkswagen, Bosch, BASF, Airbus, etc. However, pentagon variable almost retained its significance level (Appendix D). This means that there are more variables that can explain significant abnormal GDP per capita growth level of the regions located within pentagon area.

Table 2. BMA regression: Explanation of Investments' significance level with Industry GVA

	PIP	Posterior Mean	Posterior SD	Conditional Sign
Nat_Income PPP per inh	0.9993	-0.0000	0.0000	0
Population growth	0.9969	-0.8319	0.2126	0
Investments	0.9211	0.0615	0.0286	1

	PIP	Posterior Mean	Posterior SD	Conditional Sign
Industry GVA	0.9999	0.0774	0.0129	1
Nat_Income PPP per inh	0.9999	-0.0000	0.0000	0
Population growth	0.4049	-0.1528	0.2289	0
Investments	0.3757	0.0143	0.0230	1

Note. Table created by the authors using the data described in the Data section and RStudio software.

The regression (Table 3) showed that majority of the factors chosen and included indeed are related to economic growth. By applying OLS we check the robustness of the determinants. Evidently out of all factors only population growth loses its significance at 10% significance level, keeping all other factors constant.

Table 3. Linear regression: Spatial Autoregressive Model

	Estimate	Standard Error	t value	Pr(>|t|)	Significance level
(Intercept)	-0.0206	0.0128	-1.604	0.1100	
ICT patents	0.0149	0.0037	3.961	0.0000	***
Pentagon	0.0062	0.0018	3.43	0.0007	***
Coastal	-0.0028	0.0014	-1.891	0.0597	*
Capital City	0.0051	0.0023	2.177	0.0304	**
Nat_Income PPP per inh	-0.0000	0.0000	-5.465	0.0000	***
Population growth	-0.1290	0.1340	-0.963	0.3364	
Industry GVA	0.0445	0.0097	4.593	0.0000	***
Population (30-49)	0.2163	0.0476	4.536	0.0000	***
University ranking	0.0000	0.0000	1.902	0.0584	*
Primary	-0.0499	0.0055	-8.936	0.0000	***
CO_2 ground	-0.0046	0.0013	-3.493	0.0005	***
Spatial effect	0.1278	0.0348	3.672	0.0002	***
Significance codes:	*** 0.01		** 0.05	* 0.1	

Note. Table created by the authors using the data described in the Data section and RStudio software.

Thus, we continued the analysis with Bayesian Model Averaging, in order to investigate what is the effect of these variables on economic growth in all potential models. Lastly, we investigate what is the most appropriate prior that should be used in BMA regressions. We concluded that due the notion that with sufficient data any low-information prior results will not change with the prior belief about the distribution of the parameters. Thus, we decided to use a Beta-Binomial model prior. The choose of this prior is in line with Carmen Fernandez, Eduardo Ley and Mark F. J. Steel paper that aims specified the usage of "automatic" or "benchmark" priors that can be applied in a situation with the large sample of visiting models (Fernandez et al., 2001).

VI Discussion

Economic findings of the research have quite broad implications in policy analysis. Either the government or a local regulator can affect quite a few economic growth drivers. The complexity of the application of each variable is depicted on the Figure 5.
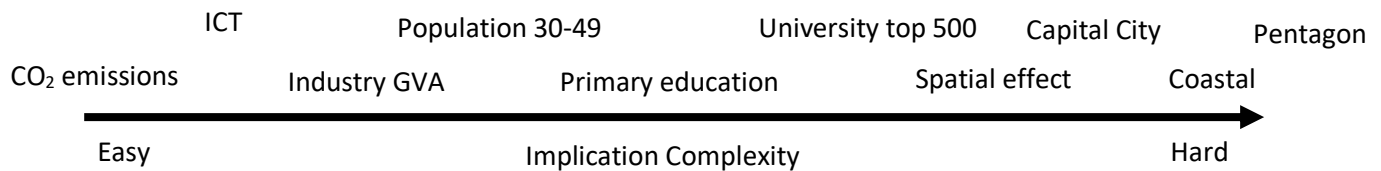
Figure 5. Implication complexity of growth determinants.
Source: Created by the authors.

For instance, the regulator can boost industrial investments, or increase the tax on CO_2 emissions to push up the economic growth in the region; or invest more in the information and communication technologies as well as attract the middle age (30-49) population from abroad. To ensure that regions have enough funds to stimulate the economy, these policies might be implemented together. Therefore, funds for additional investments in industrial sector can be collected from increased taxes on CO_2 emission.

Although almost all the determinants require additional investments, some variables also require a significant amount of time to be implemented. One of the policies which is difficult to stimulate would be boosting education level. Although the major economies have a mandatory primary education, the higher education still remains an individual choice. The complexity comes when economic growth is determined by the inclusion of top 500 best universities in the world's rating and explaining the capital city effect. Although the capital city effect has decreased when controlling for best universities in the world, yet it is not excluded completely because some of the top world schools simply are not located in the capital city. For instance, such top-class universities as the University of Oxford, University of Cambridge, Utrecht University are not located in the capital city. Sometimes they could be even far from the capital city but being one of the top schools in the world. Capital city effect does not lose its effect completely, but it is still decreased, because there are some top schools that are located in capital cities. For example, London School of Economics, Imperial College London, University Paris Sud, University of Helsinki, etc. are located in the capital city and boost the regional growth. In fact, this supports the argument that education is one of the significant determinants of economic growth since only a few universities located in the capital city were enough to decrease the posterior inclusion probability of the dummy

variable from 87.74% to 79.43%. Moreover, in order to get a decent place in the ranking, a sufficient investment and time resources are required.

Furthermore, variables such as coastal or pentagon are time-invariant and cannot be stimulated or changed. Either a country does have access to the sea or it does not; or it is located in the pentagon area, or is located outside. Nevertheless, these variables are related to economic growth and, despite the inclusion of other variables, retain its high significance level. A potential explanation of the significance level of pentagon variable might be a unique set of the regions which are part of pentagon area. Such cities as Luxembourg – banking center of Europe, which is growing on 91 basis points faster than average region in European Union during the period from 2006 to 2015; or Milan – Europe's most famous shopping city positively contributes to the growth of the region. Moreover, the major part of the pentagon area belongs to Germany. Growth rate of Germany is on 68 basis points higher than the average regional growth in European Union during the period from 2006 to 2015. Nevertheless, when controlling for industrial sectors and tourism the pentagon variable still retains its significance.

Coastal variable is negatively related to economic growth. One of the potential explanations might be the fact that regions near the seas developed earlier, thus, now have higher initial income and consequently lower growth rate. The remaining posterior inclusion probabilities might be due to the fact that coastal regions have an additional exposure to risks, such as a high exposure to tourism sector, thereby, exposure to seasonality issues; and additional non-related to economic development government spending, such as investments in cultural events, reconstructions, art or architecture. Analysis of regional unemployment level, government and consumer spending potentially can provide more coherent information and decrease significance level of the coastal determinant.

Nonetheless, the implication of each variable would have boosted the economic growth in a region, thus, to robustly estimate the effect of an economic policy in an individual region, we predict the economic growth of each region by our model (Appendix E). In fact, the R^2 of the predicted variables explain 70.07% of the actual economic growth purchasing power parity per inhabitant (Figure 6).
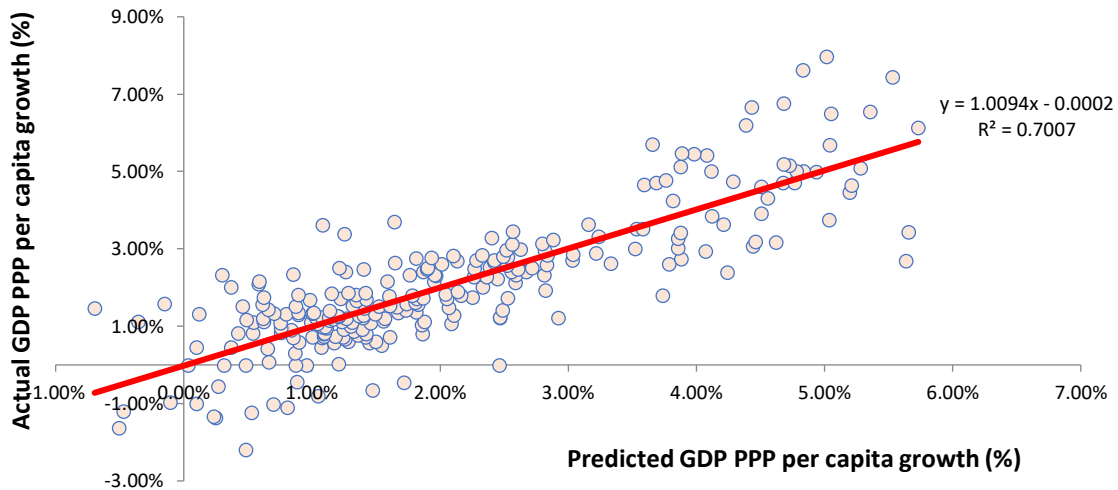
Figure 6. Predicted economic growth per capita growth rate versus actual economic growth per capita growth rate.

Source: Graph created by the authors.

The x-axis depicts the predicted growth rate per capita, while the y-axis shows the actual growth rate per capita. Ideally, the closer is the red line to the symmetric function $f(x)=x$, the better results are predicted. Nevertheless, we observe a slight bias towards positive growth; yet the trend line is quite close to being fully symmetric. For example, Campania, one of the slowest growing regions, has an economic growth rate per inhabitant equal to 0.45%, whereas, our model predicts the growth for the region of 0.37%; or Opole Voivodeship, small province in Poland and one of the fastest growing regions, has growth rate of 5.09%, whereas our model predicts the growth rate per inhabitant of 5.28% (Appendix E). Indeed, our model is biased towards an average region and is less evident when outliers or rare cases appear. For instance, București – Ilfov (Romania) is the fastest growing region in our sample during 2006-2015. Its actual growth rate per inhabitant is 7.97%, but the model predicted growth is only 5.01%. Such a high growth during the 9-year period is not a usual phenomenon, thus, it is considered rather a rare case than a recurrent event.

The difference between the actual economic growth and theoretically predicted growth per inhabitant does exist due to some unobserved economic factors. Nevertheless, the statistical development and data analysis tools have evolved over time, it is still impossible to catch all the determinants of economic growth. It is almost impossible to insert all the determinants in one model; hence, there will always be an unobserved factor. However, our goal is not to target all the determinants, but rather the ones that affect the economic growth the most.

Limitations and Future Research

We challenged to explain some of the previously developed determinants such as capital city effect or pentagon effect on economic growth. In fact, the inclusion of top 500 university ranking has not decreased significantly the posterior inclusions probability of the capital city effect. For further research, we suggest using universities that are located in capital cities only. These universities would directly influence the capital city variable and might explain the positive effect on economic growth from the capital city dummy variable. Due to the fact, that only part of best universities in the world is located in capital cities, it was enough to decrease the effect of capital city variable by 8.31%. Hence, the idea that good education might stimulate economic growth has been observed in our model and also is in line with the literature. As for pentagon determinant, we have controlled for investments in industrial sector including the area inside pentagon. Nevertheless, the effect of a region being located in pentagon area has not been changed dramatically. Mostly, it comes from the fact that many corporates within the area of pentagon are outsourcing production stages. Hence, we face a problem of omitted variable bias, and a deeper look shall be taken to explore additional potential determinants of a pentagon effect.

Another limitation of the research is the data availability. Due to the fact that some regions either have not reported the data before 2006 or were not able to submit the statistics, regions with missing observations are not taken into account. Consequently, we decreased our dataset from 276 observations to 254 because of the data truncation. An alternative way for further research is determining growth determinants for NUTS3 regions to increase the number of observations.

As for improvement, it might be beneficial for the paper to check the SAR specification results using approach proposed by Cuaresma, Doppelhofer and Feldkircher (2009). They adjusted the weights to the distance between the regions using the equation 9:

$$S_{ij} = d_{ij}^{-\theta}, \tag{9}$$

where, d_{ij} distance between region i and region j, calculated on the basis of the centroid of the regions and criterion θ shows the degree of the sensitivity of distance to the weight of the region. When θ is being equal to 1, weight is completely inversely related to the distance between the regions, if the parameter is lower than one, a decay of weight declines, while an increase of θ will lead to a rise in the weight decay.

VII Conclusion

The paper provides evidence of conditional convergence among European NUTS2 regions, meaning that regions with a lower level of per capita income, controlling all the other factors, tend to grow faster than richer regions. We used post-crisis data to study the economic growth. Our model explains about 70% of the economic growth per capita differences across the European regions. Furthermore, we found that the more people have only primary education in the region the lower is the economic growth. We also investigated other factors that depress the economy - high emission of CO_2 and rapid population growth. In turn, regions which are located in pentagon area, shaped by London, Paris, Munich, Milan, and Hamburg, with a high share of information and communication technologies patents and a high share of industry in GVA have higher economic growth. One of the main findings of the paper is that we present the empirical evidence that education quality positively contributes to economic growth when controlling for top 500 best schools in the world; thus, not only quantity of education, but also quality of education matters. Also, we determined the prime age population of the European NUTS2 regions. People aged 30-49 provide the largest added value to the economic development of the region. The larger the share of working population the more GDP per capita could potentially be created. Following the findings of Cuaresma (2009), we also provide the evidence that capital city regions tend to grow faster than other regions, keeping all other factors constant. Moreover, the economic growth is determined not only by internal factors but also by external factors – the neighboring regions. We obtained that spatial effect appears to be significantly and positively contributing to economic growth. Hence, the rapid growth of neighboring regions has a positive spillover effect on economic development of the regions.

The paper indicates the importance of various economic growth determinants and the ease of implementation of each. As a result, this research might be helpful for regulators to correctly identify their policies and the direction of the structural reforms in order to ensure sustainable positive economic growth of the region and a country as a whole.

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Appendices

Appendix A. List of NUTS2 regions

Austria			
Burgenland	Kärnten	Niederösterreich	Oberösterreich
Salzburg	Steiermark	Tirol	Vorarlberg
Wien			

Belgium			
Prov. Antwerpen	Prov. Brabant Wallon	Prov. Hainaut	Prov. Liège
Prov. Limburg (B)	Région de Bruxelles-Capitale	Prov. Luxembourg (B)	Prov. Namur
Prov. Oost-Vlaanderen	Prov. Vlaams Brabant	Prov. West-Vlaanderen	

Bulgaria			
Severen tsentralen	Severoiztochen	Severozapaden	Yugoiztochen
Yugozapaden	Yuzhentsentralen		

Cyprus			
Cyprus			

Czech Republic			
Jihovýchod	Jihozápad	Moravskoslezsko	Praha
Severozápad	Střední Čechy	Střední Morava	Severovýchod

Denmark			
Hovedstaden	Nordjylland	Midtjylland	Sjælland
Syddanmark			

Estonia			
Estonia			

Finland			
Aland	Etelä-Suomi	Itä-Suomi	Länsi-Suomi
Pohjois-Suomi			

France			
Alsace	Aquitaine	Auvergne	Basse-Normandie

Bourgogne	Bretagne	Centre	Champagne-Ardenne
Corse	Franche-Comté	Haute-Normandie	Île-de-France
Languedoc-Roussillon	Limousin	Lorraine	Midi-Pyrénées
Nord - Pas-de-Calai	Pays de la Loire	Picardie	Poitou-Charentes
Mayotte	La Réunion	Guyane	Martinique
Rhône-Alpes	Provence-Alpes-Côte d'Azur	Guadeloupe	

Germany

Arnsberg	Berlin	Brandenburg - Nordost	Brandenburg-Südwest
Braunschweig	Bremen	Chemnitz	Darmstadt
Detmold	Dresden	Düsseldorf	Freiburg
Giessen	Hamburg	Hannover	Karlsruhe
Kassel	Koblenz	Köln	Leipzig
Lüneburg	Mecklenburg-Vorpommern	Mittelfranken	Münster
Niederbayern	Oberbayern	Oberfranken	Oberpfalz
Rheinhessen-Pfalz	Saarland	Schleswig-Holstein	Schwaben
Stuttgart	Thüringen	Trier	Tübingen
Unterfranken	Weser-Ems		

Greece

Attiki	Anatoliki Makedonia, Thraki	Dytiki Ellada	Dytiki Makedonia
Ionia Nisia	Ipeiros	Kentriki Makedonia	Kriti
Notio Aigaio	Peloponnisos	Sterea Ellada	Thessalia
Voreio Aigaio			

Hungary

Dél-Alföld	Dél-Dunántúl	Észak-Alföld	Észak-Magyarország
Közép-Dunántúl	Közép-Magyarország	Nyugat-Dunántúl	

Ireland

Border, Midlands and Western	Southern and Eastern		

Italy

Abruzzo	Basilicata	Calabria	Campania
Emilia-Romagna	Friuli-Venezia Giulia	Lazio	Liguria

Lombardia	Marche	Molise	Piemonte
Bolzano-Bozen	Trento	Puglia	Sardegna
Sicilia	Toscana	Umbria	Valle d'Aosta
Veneto			

Latvia

Latvia

Lithuania

Lithuania

Luxemburg

Luxemburg (Grand-Duché)

Malta

Malta

Netherlands

Drenthe	Flevoland	Friesland	Gelderland
Groningen	Limburg (NL)	Noord-Brabant	Noord-Holland
Overijssel	Utrecht	Zeeland	Zuid-Holland

Poland

Dolnoslaskie	Kujawsko-Pomorskie	Łódzkie	Lubelskie
Lubuskie	Malopolskie	Mazowieckie	Opolskie
Podkarpackie	Podlaskie	Pomorskie	Slaskie
Swietokrzyskie	Warminsko-Mazurskie	Wielkopolskie	Zachodniopomorskie

Portugal

Alentejo	Algarve	Centro (PT)	Lisboa
Norte	Região Autónoma dos Açores	Região Autónoma da Madeira	

Romania

Bucuresti – Ilfov	Centru	Nord-Est	Nord-Vest
Sud – Muntenia	Sud-Est	Sud-Vest Oltenia	Vest

Slovak Republic

| Bratislavský kraj | Stredné Slovensko | Východné Slovensko | Západné Slovensko |

Slovenia

| Slovenia | | | |

Spain

Andalucia	Aragón	Cantabria	Castile and León
Castilla-la Mancha	Cataluña	Comunidad de Madrid	Canarias
Extremadura	Galicia	Illes Balears	La Rioja
País Vasco	Principado de Asturias	Comunidad Valenciana	Comunidad Foral de
Galicia	Región de Murcia	Navarra	
Ciudad Autónoma de Melilla	Ciudad Autónoma de Ceuta		

Sweden

| Mellersta Norrland | Norra Mellansverige | Östra Mellansverige | Övre Norrland |
| Småland med öarna | Stockholm | Sydsverige | Västsverige |

United Kingdom

Bedfordshire, Hertfordshire	Berkshire, Bucks and Oxfordshire	Cheshire	Cornwall and Isles of Scilly
Cumbria	Derbyshire and Nottinghamshire	Devon	Dorset and Somerset
East Anglia	East Riding and North Lincolnshire	East Wales	Eastern Scotland
East Yorkshire and Northern Lincolnshire	Herefordshire, Worcestershire and Warwickshire	York	South Western Scotland
Essex	Gloucestershire, Wiltshire and Bristol/Bath area	Greater Manchester	Hampshire and Isle of Wight
Inner London - East	Inner London - West	Kent	Lancashire
Leicestershire, Rutland and Northamptonshire	Lincolnshire	Merseyside	North Somerset
North Yorkshire	Northern Ireland	Northumberland, Tyne and Wear	Outer London - South
Outer London - West and North West	Outer London - East and North East	North Eastern Scotland	Highlands and Islands
Shropshire and Staffordshire	South Western Scotland	South Yorkshire	Surrey, East and West Sussex
Tees Valley and Durham	West Midlands	West Wales and The Valleys	West Yorkshire

Appendix B. Potential determinants of economic growth

Table B.1. Sample of 277 European NUTS2 regions.

GDPGROWTH	Average growth rate of GPD PPP per capita from 2006 till 2015	Eurostat
Nat_Inc_PPP_per_inh	National income per capita PPP for 2005	Eurostat
Populationgrowth	Population growth	Calculated by the authors using Eurostat data
AREA	Area of the region in square kilometers	Eurostat
Investments Investments0306	Investment share in GDP in 2005 Average investment share in GDP from 2003 till 2006	Eurostat Eurostat
WorkersHigh WorkersMed WorkersLow	Share of workers with higher education Share of workers with medium education Share of workers with low education	Calculated by the authors using Eurostat LFS data Calculated by the authors using Eurostat LFS data Calculated by the authors using Eurostat LFS data
TOTALpatents	Number of patents total per 1000 inhabitants	Eurostat
HighTech	Share of patents in high technology in total patents	Calculated by the authors using Eurostat data
ICT	Share of patents in Information and Communication Technologies (ICT) in total patents	Calculated by the authors using Eurostat data
Biotech	Share of patents in biotechnology in total patents	Calculated by the authors using Eurostat data
Railway	Rail density. Length of rail network (in km) divided by area	ESPON

Road	Road density. Length of road network (in km) divided by area	ESPON
Number_airports	Number of airports	ESPON
Number_seaports	Number of seaports	ESPON
Pentagon	Dummy variable for Pentagon (area shaped by London, Paris, Munich, Milan, and Hamburg)	ESPON
Coastal	Dummy variable for coastal. 0: No Coast, 1: Coast	ESPON
Unemployment	Unemployment rate	Eurostat LFS
Employment	Employment rate	Eurostat LFS
Total_GVA	Initial total GVA of the region in million euro	Eurostat
Agriculture_GVA	Initial share of agriculture, forestry, fishing. Share in nominal gross value added	Calculated by the authors using Eurostat data
Industry_GVA	Initial share of industry, except construction. Share in nominal gross value added	Calculated by the authors using Eurostat data
Information_GVA	Initial share of information and communication. Share in nominal gross value added	Calculated by the authors using Eurostat data
Financial_GVA	Initial share of financial and insurance activities. Share in nominal gross value added	Calculated by the authors using Eurostat data
Arts_GVA	Initial share of arts, entertainment and recreation. Share in nominal gross value added	Calculated by the authors using Eurostat data
Population_1st_jan	Population on the first of January	Eurostat
Population_dens	Population in 1000 / area in km2	Calculated by the authors using Eurostat data
Population_0_19	Share of the people aged from 0 to 19 years old (%)	Calculated by the authors using Eurostat data

Population_0_19	Share of the people aged from 0 to 19 years old (%)	Calculated by the authors using Eurostat data
Population_20_39	Share of the people aged from 20 to 39 years old (%)	Calculated by the authors using Eurostat data
Population_30_49	Share of the people aged from 30 to 49 years old (%)	Calculated by the authors using Eurostat data
Population_40_59	Share of the people aged from 40 to 59 years old (%)	Calculated by the authors using Eurostat data
Population_60	Share of the people aged from 60 years old (%)	Calculated by the authors using Eurostat data
Males_percent	Percentage of male part of the population	Calculated by the authors using Eurostat data
Females_percent	Percentage of female part of the population	Calculated by the authors using Eurostat data
Life_expectancy	Life expectancy at given exact age (less than one year)	Eurostat
Fertility	Fertility	Eurostat
Available_hosp_beds	Available hospital beds per inhabitant	ESPON
Net_migration	Net migration of the labor as a percentage of total population	Calculated by the authors using ESPON data
Land_transport_100,000inh	Amount of land transport per 100000 inhabitants	Calculated by the authors using ESPON data
CO2_non_tranposrt_1000inh	CO_2 emissions from non-transport territorial fossil fuel combustion per 1000 inhabitants	Calculated by the authors using ESPON data
CO2_ground_1000inh	CO_2 emissions from ground transport per 1000 inhabitants	Calculated by the authors using ESPON data

CO2territorial_1000inh	CO_2 emissions from territorial fossil fuel combustion per 1000 inhabitants	Calculated by the authors using ESPON data
Busses_100.000inh	Amount of busses and bus transport per 100000 inhabitants	Calculated by the authors using ESPON data
Air_transport_100000inh	Amount of air transport per 100000 inhabitants	Calculated by the authors using ESPON data
Primary	Share of low educated people	Calculated by the authors using Eurostat LFS data
Secondary	Share of medium educated people	Calculated by the authors using Eurostat LFS data
Tertiary	Share of high educated people	Calculated by the authors using Eurostat LFS data
CapitalCity	Dummy variables for capitals cities. 0: region without capital city; 1: region with capital city	Calculated by the authors
CEE	Dummy variables for Central and Eastern Europe regions. 0: region not in CEE; 1: region in CEE	Calculated by the authors
HR_in_scienct_tech	Number of HR specialists in science and technology sectors as percentage of total population	Calculated by the authors using data from Eurostat
Tourism_Nights_spent	Nights spent by tourists	Calculated by the authors using data from Eurostat
University_top500_sum	Sum of rating of universities in the region which are included in Top 500 Europe universities according to Shanghai Jiao Tong University Ranking 2005	Calculated by the authors
University_top500_max	Maximum rating of university in the region that are included in Top 500 Europe universities according to	Calculated by the authors

University_top500_average	Shanghai Jiao Tong University Ranking 2005 Average number of ratings of universities in the region which are included in Top 500 Europe universities according to Shanghai Jiao Tong University Ranking 2005	Calculated by the authors
Universitytop500_SQ_sum	Sum of ratings of universities in the region which are included in Top 500 Europe universities according to SQ rating	Calculated by the authors
Spatial	Spillover effect from neighbor countries	Calculated by the authors

Note. Table created by the authors using data described in the Data section.

Appendix C. Correlation matrix

Table C.1. Correlation matrix

	Primary	Secondary	Unempl	Empl	HighTech	ICT	WorkersLow	WorkersMed	Males_%	Females_%	CO2_non-cars	CO2 Land
Primary	1.00	-0.85	-0.08	-0.11	-0.13	-0.17	0.99	-0.82	0.27	-0.27	-0.05	-0.05
Secondary		1.00	0.17	-0.09	0.11	0.11	-0.85	0.99	-0.28	0.28	0.04	0.03
Unemployment			1.00	-0.75	-0.04	-0.14	-0.07	0.10	-0.04	0.04	0.08	0.06
Employment				1.00	-0.04	0.11	-0.09	-0.06	0.18	-0.18	0.00	0.04
HighTech					1.00	0.74	-0.13	0.11	-0.16	0.16	-0.09	-0.11
ICT						1.00	-0.17	0.11	-0.22	0.22	-0.08	-0.09
WorkersLow							1.00	-0.82	0.28	-0.28	-0.05	-0.05
WorkersMed								1.00	-0.25	0.25	0.05	0.03
Males_%									1.00	-1.00	0.07	0.08
Females_%										1.00	-0.07	-0.08
CO$_2$ non-cars											1.00	1.00
CO$_2$ land												1.00

Note. Table created by the authors using the data described in the Data section and correlation function in Microsoft Excel 2016.

Appendix D. BMA regression: Explanation of Pentagon's significance level

Table D.1. BMA regression: Explanation of Pentagon's significance level with Industry GVA

	PIP	Posterior Mean	Posterior SD	Conditional Sign
Nat_Income PPP per inh	0.9999	-0.0000	0.0000	0
Pentagon	0.9843	0.0093	0.0030	1
Investments	0.9119	0.0590	0.0284	1
Population growth	0.8786	-0.5110	0.2799	0

	PIP	Posterior Mean	Posterior SD	Conditional Sign
Industry GVA	0.9999	0.0711	0.0127	1
Pentagon	0.9999	-0.0000	0.0000	0
Nat_Income PPP per inh	0.8722	0.0065	0.0034	1
Investments	0.4182	0.0163	0.0239	1
Population growth	0.2541	-0.0603	0.1522	0

Note. Table created by the authors using the data described in the Data section and RStudio software.

Appendix E. Predictions of regional GDP per capita growth (2006-2015)

Nr	Region	Reality	Prediction	Nr	Region	Reality	Prediction	Nr	Region	Reality	Prediction	Nr	Region	Reality	Prediction	Nr	Region	Reality	Prediction
1	Sterea Ellada	-2.20%	0.49%	61	Highlands and Islands	1.04%	1.85%	121	Mellersta Norrland	1.68%	0.98%	181	Arnsberg	2.70%	2.28%	241	Wielkopolskie	5.43%	4.08%
2	Ionia Nisia	-1.63%	-0.51%	62	Greater Manchester	1.07%	1.04%	122	Surrey, East and West	1.70%	1.42%	182	Kassel	2.70%	2.42%	242	Małopolskie	5.46%	3.98%
3	Kriti	-1.37%	0.25%	63	Eastern Scotland	1.08%	2.09%	123	Länsi-Suomi	1.71%	2.05%	183	Praha	2.70%	3.03%	243	Łódzkie	5.48%	3.89%
4	Dytiki Ellada	-1.34%	0.23%	64	Dorset and Somerset	1.08%	0.76%	124	País Vasco	1.71%	1.82%	184	Jihozápad	2.73%	3.88%	244	Yugozapaden	5.68%	5.04%
5	Anatoliki Makedonia,	-1.23%	0.53%	65	Comunidad Foral de N	1.08%	1.46%	125	Galicia	1.72%	1.22%	185	Koblenz	2.76%	1.81%	245	Mazowieckie	5.71%	3.65%
6	Ipeiros	-1.20%	-0.47%	66	Principado de Asturias	1.10%	1.32%	126	Darmstadt	1.73%	1.87%	186	Salzburg	2.77%	1.93%	246	Lietuva	6.14%	5.73%
7	Kentriki Makedonia	-1.10%	0.81%	67	Puglia	1.11%	0.55%	127	Helsinki-Uusimaa	1.74%	2.53%	187	Detmold	2.79%	2.53%	247	Dolnośląskie	6.21%	4.39%
8	Notio Aigaio	-1.02%	0.70%	68	Lombardia	1.11%	0.99%	128	Herefordshire, Worces	1.74%	0.62%	188	Rheinhessen-	2.80%	2.49%	248	Sud-Vest Olteni	6.49%	5.05%
9	Thessalia	-1.00%	0.10%	69	Bretagne	1.12%	1.88%	129	Friesland (NL)	1.74%	2.25%	189	Burgenland (A	2.82%	2.10%	249	Vest	6.54%	5.36%
10	Voreio Aigaio	-0.97%	-0.11%	70	Northumberland and Ty	1.12%	0.62%	130	Prov. Hainaut	1.79%	1.60%	190	Unterfranken	2.83%	2.33%	250	Nord-Vest	6.66%	4.43%
11	Dytiki Makedonia	-0.80%	1.05%	71	Algarve	1.12%	-0.36%	131	Gelderland	1.80%	1.78%	191	Berlin	2.83%	2.84%	251	Centru	6.77%	4.68%
12	Border, Midland and V	-0.65%	1.47%	72	Essex	1.12%	1.23%	132	Groningen	1.80%	3.74%	192	Freiburg	2.86%	3.03%	252	Sud - Muntenia	7.44%	5.53%
13	Peloponnisos	-0.56%	0.27%	73	Basse-Normandie	1.13%	1.56%	133	Overijssel	1.80%	2.16%	193	Dresden	2.89%	3.21%	253	Sud-Est	7.62%	4.83%
14	Attiki	-0.45%	1.72%	74	Cataluña	1.15%	1.14%	134	Nord - Pas-de-Calais	1.81%	1.34%	194	Severovýcho	2.93%	4.07%	254	Bucureşti - Ilfov	7.97%	5.01%
15	Ciudad Autónoma de M	-0.44%	0.88%	75	Liguria	1.17%	0.49%	135	Abruzzo	1.81%	0.89%	195	Weser-Ems	2.96%	2.82%				
16	Toscana	0.00%	0.31%	76	Leicestershire, Rutland	1.19%	1.16%	136	Prov. Antwerpen	1.82%	2.04%	196	Mittelfranken	2.97%	2.52%				
17	Umbria	0.00%	0.96%	77	Languedoc-Roussillon	1.20%	0.62%	137	Sydsverige	1.84%	1.15%	197	Schwaben	2.98%	2.63%				
18	Marche	0.00%	0.48%	78	Zuid-Holland	1.20%	1.57%	138	Prov. Namur	1.86%	1.28%	198	Sachsen-Anha	3.00%	3.52%				
19	Lazio	0.00%	0.87%	79	Provincia Autonoma di	1.20%	1.27%	139	Prov. Liège	1.86%	1.42%	199	Észak-Alföld	3.03%	3.86%				
20	Lisboa	0.00%	0.04%	80	Castilla y León	1.22%	1.03%	140	Noord-Holland	1.90%	2.14%	200	Moravskosle	3.08%	4.44%				
21	Pohjois- ja Itä-Suomi	0.00%	2.46%	81	Nord-Est	1.22%	2.92%	141	Noord-Brabant	1.93%	2.82%	201	Mecklenburg	3.12%	2.56%				
22	Canarias	0.03%	1.21%	82	La Rioja	1.22%	1.40%	142	Corse	2.01%	0.37%	202	Tübingen	3.13%	2.80%				
23	Κύπρος (Kýpros)	0.08%	0.66%	83	Drenthe	1.22%	2.47%	143	Limburg (NL)	2.01%	2.33%	203	Közép-Dunár	3.18%	4.62%				
24	Molise	0.31%	0.87%	84	Etelä-Suomi	1.23%	2.47%	144	Cheshire	2.09%	0.58%	204	Észak-Magya	3.19%	4.46%				
25	Illes Balears	0.42%	0.65%	85	Haute-Normandie	1.23%	1.08%	145	Gießen	2.12%	2.59%	205	Brandenburg	3.23%	2.88%				
26	Campania	0.45%	0.37%	86	Åland	1.24%	1.13%	146	Norte	2.15%	0.59%	206	Střední Čechy	3.27%	3.86%				
27	Sicilia	0.46%	1.07%	87	Derbyshire and Notting	1.25%	1.21%	147	Schleswig-Holstein	2.15%	1.95%	207	Stuttgart	3.28%	2.40%				
28	Ciudad Autónoma de C	0.46%	0.10%	88	South Western Scotland	1.26%	1.20%	148	Östra Mellansverige	2.16%	1.59%	208	Niederbayern	3.32%	3.24%				
29	Northern Ireland	0.50%	1.54%	89	Prov. Luxembourg (BE	1.27%	1.37%	149	Bremen	2.23%	2.45%	209	Cumbria	3.38%	1.25%				
30	East Yorkshire and No	0.57%	1.45%	90	Wien	1.29%	2.11%	150	Köln	2.27%	2.36%	210	Dél-Alföld	3.42%	3.88%				
31	Andalucía	0.57%	1.17%	91	Aragón	1.29%	1.40%	151	Stockholm	2.29%	2.26%	211	Yugoiztochen	3.44%	5.65%				
32	Shropshire and Staffor	0.59%	0.90%	92	Aquitaine	1.29%	0.89%	152	Zeeland	2.30%	1.97%	212	Oberfranken	3.45%	2.57%				
33	Bedfordshire and Hert	0.60%	1.28%	93	Alentejo	1.31%	0.12%	153	Hannover	2.33%	2.81%	213	Braunschwei	3.52%	3.53%				
34	Région de Bruxelles-C	0.60%	1.50%	94	Emilia-Romagna	1.32%	0.80%	154	Övre Norrland	2.33%	1.95%	214	Thüringen	3.52%	3.58%				
35	Cantabria	0.67%	1.26%	95	Tees Valley and Durha	1.32%	1.49%	155	Düsseldorf	2.33%	1.76%	215	Malta	3.62%	1.08%				
36	Castilla-La Mancha	0.71%	0.85%	96	West Wales and The V	1.33%	1.00%	156	Provincia Autonoma di	2.33%	0.30%	216	Severen tsent	3.63%	4.21%				
37	Piemonte	0.71%	1.08%	97	Extremadura	1.34%	0.70%	157	Kärnten	2.33%	2.59%	217	Oberpfalz	3.64%	3.16%				
38	Cornwall and Isles of	0.71%	1.24%	98	Merseyside	1.34%	1.01%	158	Småland med öarna	2.34%	0.85%	218	North Eastern	3.70%	1.64%				
39	East Wales	0.72%	1.42%	99	Auvergne	1.35%	0.89%	159	Severozápad	2.40%	4.24%	219	Yuzhen tsentr	3.75%	5.03%				
40	Valle d'Aosta/Vallée	0.72%	1.00%	100	Utrecht	1.35%	1.67%	160	Prov. West-Vlaanderen	2.41%	1.26%	220	Jihovýchod	3.85%	4.12%				
41	Franche-Comté	0.73%	1.61%	101	Hampshire and Isle of	1.37%	1.81%	161	Prov. Oost-Vlaanderen	2.41%	1.87%	221	Střední Mora	3.91%	4.51%				
42	Comunidad Valenciana	0.73%	1.09%	102	Bourgogne	1.39%	1.14%	162	Steiermark	2.42%	2.67%	222	Severoiztoch	4.24%	3.81%				
43	Región de Murcia	0.74%	1.18%	103	Comunidad de Madrid	1.41%	1.73%	163	Prov. Limburg (BE)	2.42%	2.56%	223	Nyugat-Dunár	4.31%	4.56%				
44	Região Autónoma da M	0.77%	1.36%	104	Flevoland	1.42%	2.48%	164	Västsverige	2.47%	1.40%	224	Lubuskie	4.47%	5.19%				
45	Devon	0.80%	1.09%	105	Provence-Alpes-Côte	1.44%	0.66%	165	Île de France	2.47%	1.90%	225	Východné Slo	4.60%	4.51%				
46	Champagne-Ardenne	0.81%	1.42%	106	Gloucestershire, Wiltsh	1.47%	1.41%	166	Tirol	2.47%	2.61%	226	Západné Slov	4.65%	5.21%				
47	Lorraine	0.81%	1.86%	107	Região Autónoma dos	1.47%	-0.70%	167	Trier	2.49%	2.27%	227	Zachodniopo	4.67%	3.59%				
48	Limousin	0.82%	0.54%	108	Alsace	1.49%	2.07%	168	Prov. Vlaams-Brabant	2.51%	1.21%	228	Świętokrzysk	4.71%	3.69%				
49	North Yorkshire	0.82%	0.43%	109	Berkshire, Buckingham	1.50%	1.66%	169	Niederösterreich	2.52%	1.90%	229	Kujawsko-Po	4.71%	4.68%				
50	Sardegna	0.83%	1.10%	110	Pays de la Loire	1.51%	0.87%	170	Karlsruhe	2.52%	2.72%	230	Eesti	4.72%	4.77%				
51	West Midlands	0.84%	0.76%	111	Basilicata	1.52%	1.52%	171	Oberbayern	2.53%	2.39%	231	Warmińsko-M	4.74%	4.28%				
52	South Yorkshire	0.87%	1.33%	112	Lincolnshire	1.52%	0.46%	172	Münster	2.57%	2.52%	232	Bratislavský	4.78%	3.76%				
53	Calabria	0.90%	0.84%	113	Rhône-Alpes	1.54%	1.32%	173	Saarland	2.59%	2.83%	233	Latvija	5.00%	4.94%				
54	Kent	0.91%	1.25%	114	Midi-Pyrénées	1.54%	1.61%	174	Dél-Dunántúl	2.60%	3.79%	234	Podlaskie	5.00%	4.84%				
55	Centre	0.93%	1.39%	115	Poitou-Charentes	1.57%	0.61%	175	Oberösterreich	2.60%	2.01%	235	Śląskie	5.00%	4.78%				
56	West Yorkshire	0.95%	1.11%	116	East Anglia	1.57%	1.83%	176	Közép-Magyarország	2.63%	3.33%	236	Pomorskie	5.01%	4.12%				
57	Friuli-Venezia Giulia	0.95%	0.76%	117	Centro (PT)	1.58%	-0.15%	177	Prov. Brabant Wallon	2.65%	1.65%	237	Opolskie	5.09%	5.28%				
58	Picardie	0.97%	1.09%	118	Southern and Eastern	1.59%	1.74%	178	Vorarlberg	2.65%	2.42%	238	Lubelskie	5.13%	3.88%				
59	Veneto	0.99%	1.10%	119	Hamburg	1.61%	1.81%	179	Lüneburg	2.68%	2.13%	239	Podkarpackie	5.15%	4.73%				
60	Lancashire	1.01%	1.30%	120	Norra Mellansverige	1.66%	1.35%	180	Severozapaden	2.70%	5.64%	240	Stredné Slov	5.20%	4.68%				