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Time stability of the impact of institutions on economic growth and real convergence of the EU countries: implications from the hidden Markov models analysis

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Keywords: *catching up; convergence; Bayesian model averaging; hidden Markov models; Viterbi path*

Abstract

Research background: It is not straightforward to identify the role of institutions for the economic growth. The possible unknown or uncertain areas refer to nonlinearities, time stability, transmission channels, and institutional complementarities. The research problem tackled in this paper is the analysis of the time stability of the relationship between institutions and economic growth and real economic convergence.
Purpose of the article: The article aims to verify whether the impact of the institutional environment on GDP dynamics was stable over time or diffed in various subperiods. The analysis covers the EU28 countries and the 1995–2019 period.
Methods: We use regression equations with time dummies and interactions to assess the stability of the impact of institutions on economic growth. The analysis is based on the partially overlapping observations. The models are estimated with the use of Blundell and Bond's GMM system

estimator. The results are then averaged with the Bayesian Model Averaging (BMA) approach. Structural breaks are identified on the basis of the Hidden Markov Models (HMM).
Findings & value added: The value added of the study is threefold. First, we use the HMM approach to find structural breaks. Second, the BMA method is applied to assess the robustness of the outcomes. Third, we show the potential of HMM in foresighting. The results of regression estimates indicate that good institution reflected in the greater scope of economic freedom and better governance lead to the higher economic growth of the EU countries. However, the impact of institutions on economic growth was not stable over time.

Introduction

Economic growth depends on many factors. The direct factors represent both the demand and the supply-side areas of the economy. On the one hand, to accelerate GDP growth it is necessary to increase aggregate demand. Higher demand implies higher spending and an increase in the production of goods and services. On the other hand, the rise in GDP can also be achieved by the greater accumulation of inputs, including labor, physical capital, human capital, and technology. However, apart from the above determinants which can be called direct factors of economic growth there are also the so-called ‘deep’ economic growth determinants. These are institutions. Institutions affect economic growth indirectly through the impact on the relationship between the direct growth factors and output dynamics. For example, institutions shape the following areas: product market competition, wage-labour nexus, financial system, and corporate governance, the housing market, social protection, and education and knowledge subsystems, and in this way they affect the performance of the countries (Rapacki (Ed.), 2019).

The role of institutions in the process of economic growth is not unambiguously clear. The possible unknown or uncertain areas refer to nonlinearities, time stability, transmission channels, and institutional complementarities. Hence, the relationship between institutions and economic growth requires careful examination. There is still much room for such studies. The review of literature shows that many new studies on the institutions-growth nexus have emerged recently.

The research problem tackled in this paper is the issue of the stability of the relationship between institutions and economic growth and real economic convergence over time. We aim to verify whether the impact of the institutional environment on GDP dynamics was stable over time or differed in various subperiods.

The novelty of the study is threefold. First, we do not divide the analyzed period into subperiods using the arbitrary structural breaks. We use the hidden Markov models (HMM) approach to find structural breaks. We allow structural breaks to differ between institutional variables. Second, we do not want our results to be biased by the choice of the specified set of control factors in the regression model. The Bayesian model averaging (BMA) method is applied to assess the robustness of the outcomes. Third, we want to show the potential of the HMM method in foresighting. We carry out projections (simulations) of countries' performance in terms of economic freedom.

The analysis covers the 28 European Union (EU) countries and the 1995–2019 period.

The structure of the paper is as follows. In section 2, after the introduction, the literature review is presented. The applied methods and data are described in point 3. Section 4 shows the main results in terms of time stability of the impact of institutions on economic growth and real convergence. The potential of HMM as a tool to conduct foresights based on simulations is given in point 5. Section 6 concludes.

Literature review

In the review of the literature, to avoid data redundancy compared with many other articles in this area, we decided to check the newest articles in which the relationship between institutions and economic growth (convergence) is examined. Whether time stability is the main area of interest, or maybe there are the other scopes of research which play an important role nowadays.

There are a number of studies that cover developing countries. Ahmad and Hall (2017) show that the impact of institutions on economic growth is not so simple as one could think. The cited authors examine the spatial effects: to what extent the institutional environment in one country affects economic growth in other countries. They analyze 58 developing countries from Africa, East Asia, and Latin America over the 1984–2007 period. Two institutional variables are used: an index of institutional quality that reflects the security of property rights (from ICRG) and an index of institutional quality that reflects the political institutions (being the average of four democracy variables). The authors extend the regression based on the Mankiw-Romer-Weil model to include institutions. To account for spatial effects, they use, i.a., spatial Durbin regressions with institutional proximity weight matrices. The results suggest the positive spillover effects of institutions on neighbors' economic growth. Our study explores in detail not spatial effects, but time stability of the impact of institutions on output dynamics.

Abdulahi *et al.* (2019) analyze the relationship between resource rents, economic growth, and institutions. One of their contributions is the introduction of the threshold effect of the institutional quality variable. The cited study covers 14 resource-rich countries of Sub-Saharan Africa and the 1998–2016 period. They estimate panel threshold regression where the thresholds for the institutional quality variable (rule of law) allow dividing the countries into three categories with the different roles of institutions. The cited authors, by allowing the varying influence of the institutional environment, make their studies similar to ours, but in our research the impact of institutions varies over time. However, as we can see, our assumption of no constant relationship between institutions and economic growth is justified and suggested by the other authors as well.

Maruta *et al.* (2020) analyze the relationship between foreign aid, institutional quality, and economic growth for 74 developing countries in Africa, Asia, and South America. The study covers the 1980–2016 period. Institutional quality is measured by the International Country Risk Guide (ICRG) index. The authors estimate a lot of models with different estimators (including panel 2SLS and Blundell-Bond system-GMM). Regression equations include interactions and nonlinearities. This study is a good reference point to our approach; our approach expands the cited article's method in a variety of ways, e.g. by measuring time stability of institutional variables.

Mahjabeen *et al.* (2020) analyze the energy and institutional stability's relation with economic growth for the 8 developing countries (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan, and Turkey) during the 1990–2016 period. The institutional variable is measured with the use of the mean of political rights and civil liberties indicators from the Freedom House database. The study employs a variety of econometric techniques, including Autoregressive Distributive Lag (ARDL), Fully Modified Ordinary Least Square (FMOLS), and Dynamic Ordinary Least Square (DOLS) tests. The results indicate that the variable of institutional stability positively impacts economic growth and environmental quality. As we can see, regardless of the exact area of research, institutions in econometric analyzes are proxied by qualitative variables representing a given, narrow area of the institutional environment. It is not possible to take into account those institutions which are non-measurable.

Another interesting area of new studies on institutions-growth nexus refers to the research regarding the influence of institutions not on the absolute level of GDP growth rate, but its volatility. Mathonnat and Minea (2019) discuss the relationship of the democracy and economic growth volatility in the group of 140 countries observed in the 1975–2007 period.

Five institutional dimensions of democracy are taken into account (age of democracies, electoral rules, government forms, number of veto players, and state forms). It turns out that the choice between various forms of democracy matters while economic growth volatility is taken into consideration and may also influence the development path of individual countries.

It is proposed in some studies to use economic freedom as an indicator of the institutional environment and analyze the relationship between economic freedom and economic growth.

Bengoa and Sanchez-Robles (2003) examine the interactions between economic freedom (from the Fraser Institute), foreign direct investment (FDI) and economic growth for 18 Latin American countries during 1970–1999. In economic growth regressions, the coefficient standing on economic freedom is positive and statistically significant in the majority of cases confirming the positive impact of economic freedom on output dynamics. However, the time stability of this impact is not analyzed, like in the current study.

A similar analysis between economic freedom (from Fraser Institute), FDI inflow, and economic growth was conducted by Zghidi *et al.* (2016) for African countries. Their research covers four North African countries (Algeria, Egypt, Morocco, and Tunisia) and the 1980–2013 period. Like in our study, the cited authors use Blundell and Bond's GMM system estimator which seems to be one of the best econometric techniques in dynamic economic growth models. In the estimated regression equations, the coefficient on economic freedom is positive and statistically significant, suggesting an important role of economic freedom in promoting economic growth.

Like indices of economic freedom, worldwide governance indicators are also used in empirical studies as the proxy of institutions. For example, Agbloyor *et al.* (2016) examine the FDI-institutions-economic growth nexus with the use of the World Bank's worldwide governance indicators as the measure of institutional quality. The cited authors use both the aggregate governance indicator (being the average of the six category indices) as well as the individual components (to avoid multicollinearity, they are included in regression models separately). As we can see, our alternative measure of institutions, which is the aggregate worldwide governance indicator, is used in empirical studies on the subject and its choice to measure institutional quality is justified.

There are also studies focused on European countries that include various measures of institutions and analyze their links with macroeconomic performance. For example, Campos *et al.* (2019) build counterfactual growth paths for countries that joined the EU from 1973 to 2004 and analyze their growth effects from EU membership. It turns out that institutional integration matters because, without European integration, the income per capita would have been approximately 10% lower (on average) in the first ten years after joining the EU. The cited authors when calculating the regression equations include a proxy of an institution, inter alia, an indicator of employment protection legislation, an indicator of regulation in non-manufacturing sectors, and a measure of a country's political regime. The authors estimate a few regression models; apart from the model with all the explanatory variables, in the other cases the models differ in terms of the institutional variable adopted (to avoid data redundancy, the authors usually introduce a limited number of institutional variables into the single regression equation). The quoted study can be used to justify our approach where we estimate a different set of models for each institutional variable separately.

Ketterer and Rodríguez-Pose (2018) demonstrate the importance of institutions in the regional economic growth of Western Europe. They analyze 184 regions at the NUTS-2 level in the EU15 countries over the 1995–2009 period. The institutional variable (quality of government) is the combination of the World Bank's Worldwide Governance Indicators (at the national level) and an EU-wide regional survey. The quoted study demonstrates that institutions rule in Europe at the regional level, which means that the institutional environment plays an important role in influencing regional economic growth prospects.

In the case of institutional variables, it is necessary to take into account the fact that they often are calculated as averages of a number of narrow category indicators. The behavior of the components need not be the same as that of the aggregated index. For example, Procházka and Čermáková (2015) analyze the relationship between the selected components of the Heritage Foundation index of economic freedom and economic growth for a large sample of countries. In some cases, there is no significant positive link between a given area of economic freedom and economic growth. Moreover, nonlinear relationships have also been found.

Bolen and Sobel (2020) show that the inclusion of the aggregate index of economic freedom does not show the full picture of economic growth paths. The cited authors analyze the components of the Fraser Institute index of economic freedom, as well and show that the poor performance in one dimension of economic freedom cannot be offset by good outcomes in another one. They introduce to the regression equations, apart from the level and the change of the index, also the standard deviation or the range of the individual areas of freedom. The estimated coefficient on the standard deviation of the dispersion between the individual areas of freedom is negative and statistically significant meaning that a balanced institutional structure is vital for the economic growth. This analysis underlines the fact that the relationship between institutional indicators and economic growth is not so straightforward; thus our approach to examine the time stability is fully justified and will contribute to the existing literature.

As we can see, the review of the literature demonstrates that the relationship between institutions and economic growth is not so straightforward. There is still much room for new empirical and theoretical studies in this area.

Method of the analysis and data used

We use the panel of EU28 countries to identify the strength and time stability of the impact of institutions on economic growth and real convergence. To address this question, we use the following approach. Firstly, it needs to be observed that GDP growth is a phenomenon that should be considered in a longer time horizon. Research based on annual (or shorter) time periods is subject to criticism because the GDP change observed during a single year might be distorted by the influence of phase in the economic cycle or the temporary disturbances. On the other hand, dividing the panel of interest into 5-year-long (or even longer) subperiods limits vastly the number of available observations. The strategy that we apply is based on the previous research by Próchniak and Witkowski (2014) — we base the estimation on the partially overlapping observations. Thus, for period t=1 we consider the GDP change in years t-5,…,t and express it as a function of average growth factors' values over these five years.

The typical starting point in the process of real GDP β convergence analysis is the Barro regression:

$$\Delta lnGDP_{it} = \beta_0 + \beta_1 lnGDP_{i,t-1} + x'_{it}\gamma + \alpha_i + \varepsilon_{it}, \quad (1)$$

where $\Delta lnGDP_{it}$ stands for difference of log GDP per capita, $lnGDP_{i,t-1}$ is the logarithmized GDP p.c. level from the previous period, x_{it} represents the economic growth factors considered in the model, α_i are the country-specific effects and ε_{it} is the error term (all of the above for country i in period t)[1]. It is the negative and statistically significant value of the β_1 that indicates the existence of the beta convergence. That further allows for identification of the β-coefficient that measures the rate of convergence as

[1] The analysis here does not include spatial effects which can also be considered in the case of panel data growth models (see e.g. Antczak & Suchecka, 2011).

$$\beta = -\frac{1}{T} ln(1 + \beta_1 T), \quad (2)$$

where T is the length of a single period in (1). Model (1) is typically estimated with the use of one of the instrumental variables or generalized method of moments (GMM) estimators: while it would be possible to apply the fixed effects estimator, its consistency only takes place in the case of very long time series that constitute the panel and strict exogeneity of the regressors, which is rare and does not occur in our case. At the same time, the GMM-based Arellano and Bond (1991) approach (AB hereafter) overcame the problem of the long time series and strict exogeneity requirements. However, ever since the paper by Blundell and Bond (1998) (BB hereafter), the system-GMM estimator popularized in their paper has become the most popular tool which outperforms the AB proposal at the cost of mere additional assumptions which are mostly fulfilled. In consequence, we use the BB approach in this study.

Equation (1) can be equivalently written as:

$$lnGDP_{it} = \beta_0 + (\beta_1 + 1)lnGDP_{i,t-1} + x'_{it}\gamma + \alpha_i + \varepsilon_{it} \quad (3)$$

which is needed to apply the BB (as well as AB) estimation technique as it enables finding proper instruments.

It should be observed that most of the research does not consider the possibility of changes in the convergence parameter over time: they usually assume stability of the relation and do not allow for the different values of the $\beta_1$in different periods, although there are some papers which consider this possibility.

The following strategy is applied in this paper: first, a set of time dummies are included in the model (3). In the above framework, the β_1 determines the existence and the strength of GDP convergence[2]: while with β_1<0 the lower developed countries grow faster and make up for the distance that separated them from the higher developed countries. The β_1>0 would imply the existence of divergence — a situation that could be summarized as “the rich get richer”. The potential regressors are allowed to be endogenous, which is easily incorporable in the GMM framework. This choice is made based on economic theory and due to the undoubtful two-way relationship between the GDP growth and most of the macroeconomic indicators.

[2] It is possible to replace GDP with confidence indicators and analyze convergence on the basis of confidence indicators from survey data (see e.g. Vojinović *et al.* (2013)). Under such an approach, we avoid any delays in the availability of figures from official statistics.

The core of the paper is the conditional convergence analysis. This requires us to include GDP growth factors in the x_{it} in equation (1). Apart from the typical macroeconomic factors we additionally include three different institutional variables: HEF (Heritage Foundation index of economic freedom), FRA (Fraser Institute index of economic freedom) and WGI (Worldwide Governance Indicator) in separate models (Heritage Foundation, 2020; Fraser Institute, 2020; World Bank, 2020a). The WGI variable has been calculated by us as the arithmetic average of six governance indicators provided by the World Bank: control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law, and voice and accountability. In the case of the FRA variable, at the beginning of the period the interpolation was applied to obtain the data for missing years (earlier Fraser Institute did not provide the statistics annually). The basic descriptive statistics for the institutional variables are given in Table 1.

The model with each institutional variable is considered in two versions. In the first model, the given indicator is included by itself with a single parameter throughout the considered period. In the second one, we include a structural break. In consequence, the parameter on the given institutional variable is allowed to differ before and after the structural break. As a result, we can check whether the rate of convergence was different in various subperiods.

Structural breaks were identified by us with the use of the hidden Markov models. We allow different institutional variables to have different structural breaks. The HMM method identified the following structural breaks:

- Heritage Foundation index of economic freedom — in 2003,
- Fraser Institute index of economic freedom — in 2001,
- Worldwide Governance Indicator — in 2004.

As we can see, structural breaks exist near the year of the biggest EU enlargement for Central and Eastern Europe (CEE). Such an outcome is justified from the economic point of view and confirms the appropriateness of the HMM approach to identify structural breaks. EU enlargement much affected the institutional environment of the EU countries. The biggest changes in institutions occurred especially in new EU member states from the CEE region. In the case of indices of economic freedom, structural breaks were identified earlier, before EU enlargement. It results from the fact that 'integration anchor' started to work much earlier than the official process of EU entry took place.

Another implication from identifying structural breaks is that, if we assume the existence of one structural break only, they occur around the year of EU enlargement and not during the global crisis. We can infer that the global crisis did not change the institutional environment in the EU countries so much as EU enlargement did. It was EU enlargement that primarily affected institutions. Of course, when allowing two structural breaks, the second one would likely take place at the end of the 2000s, i.e. when the global crisis started. But taking into account the length of the period and statistical requirements of time series to be included in the model we can allow only for a single structural break.

The turning point around the biggest EU enlargement to the East certainly played a more important role for the countries of Central and Eastern Europe than for the countries of Western Europe. In 2004, the new EU member states experienced a huge shock, covering not only the economy, but also other aspects of social and economic life. However, the CEE countries do not function in isolation. The changes that took place in 2004 also affected Western Europe. For example, the opening of the labor market in some countries already in 2004 influenced the economy and the demographic situation not only in the CEE countries, but also in Western European countries. Similar directions of influence can be attributed not only to the flows of labor, but also, for example, to capital flows. As a result, the turning point related to the EU enlargement affected both groups of countries, although this impact was undoubtedly stronger for the CEE.

As has already been stated, the HMM method was used to identify structural breaks. To determine the good approximation of the single structural break for each institutional variable concerning all considered countries, the following procedure was used. In the first step, Viterbi paths based on two-state HMM were computed: one Viterbi path for each time series included in the analysis. Therefore, 84 sets of parameters of HMM models of Monte Carlo simulations were used. To increase the probability of obtaining the optimal solution for each HMM model 3000 simulations were performed.

In the second step, the structural breaks were identified for each Viterbi path. We treat the change of states on the Viterbi path as the structural break. Although it is not the same as a turning point in the economy, it seems to be a good approximation of the turning point because it could be signalled in advance. Depending on the country and the time series, there could be only one or many changes in states on the Viterbi path. Since we are interested in capturing the effects of EU enlargement (and the 'integration anchor') as a single structural break from all identified changes, the following rules were applied:

– if there is more than one change, choose the first one which is not earlier than in 2000;
– if there are no changes after 2000, choose the latest one.

Structural breaks, identified according to the HMM procedure, are presented in Table 2. In the vast majority of cases only one turning point was found (see the number of shifts between the HMM states given in the table). For other cases, the rules given above have been applied. Therefore, for each country and each institutional variable, one structural break was chosen. As we can see, the majority of structural breaks exists in the first part of the 2000s. It means that changes related to EU enlargement and the implied institutional reforms had a big impact on the countries' institutional environment.

The third (last) step in the process of structural breaks' identification incorporates the transformation of the structural breaks for individual countries into the single structural break for the whole EU28 group. Such a structural break (which may be different for each institutional variable) will be used in the econometric modeling. For each institutional variable, weighted averages of structural breaks per country were calculated, where the 2010 population figures of each country were used as weights.

Estimating the single regression equation with a structural break in the institutional variable does not solve all the problems with model specification and estimation. There exists a serious problem of the model specification: which variables should be included in it, that is: what are the relative economic growth factors? In the Barro type regression different authors include, depending on their views and data availability, a selection of a few hundred different growth factors and obviously those sets of regressors are in each case different. Failing to do this part of the process properly may result in two main problems: omitted variable bias (if relevant growth factors are omitted while they exhibit correlation with other growth factors included in the model) or loss of excessive number of degrees of freedom and efficiency. A number of econometric tools and procedures have been described. One of the earlier solutions was proposed by Leamer (1978). The idea of his extreme bound analysis was finding a set of robustly significant (in the statistical sense) set of regressors. A serious deficit of the EBA was failing to find hardly any regressor robustly relevant which is why many authors do not find Leamer's algorithm useful.

On the contrary, the Bayesian model averaging does not have this deficit. In 2004, Sala-i-Martin *et al.* (2004, SDM hereafter) popularized this approach on the ground of the economic growth using its simple version called Bayesian averaging of classical estimates (BACE) — the type of BMA for the case of linear regression estimated with the use of OLS. SDM consider moreover 60 potential growth factors. Uncertainty regarding the choice of the relevant regressors implies moreover 2^{60} possibilities to construct a non-empty set of the regressors solely with the variables proposed by SDM. In order to avoid the necessity to select one of them, SDM proposed an algorithm, which in the first step consisted in computing prior probability of relevance of each of the models. While this can be done in many ways, SDM assumes an equal probability of relevance for each regressor. That means that the prior probability of relevance for each of the regressors is the same and equal to the ratio of the pre-assumed number of regressors in the true underlying process to the number of regressors considered as potentially relevant in the analysis and the Bernoulli's scheme can be used to compute the prior relevance probability for each of the possible models. This of course means that the prior probability of relevance is the same for each model with the same number of regressors. The prior probabilities computed for all of the possible models (or a larger random sample of them if it is not possible to estimate each due to the high number of potential regressors) are then "corrected" basing on the Bayes' formula and yielding posterior probabilities of relevance for each of them.

While the formulas are far from simple in the SDM case, they become significantly more complex in the case of the model estimated with GMM (as in our case) rather than OLS. However, for the GMM estimator Kim (2002) has shown how the posterior probability can be effectively approximated.

Suppose that the sample consists of n observations (countries in the considered case). Further, let K be the number of the considered regressors ("candidate" growth factors). Denote $Q(\theta_j)$ as the loss function minimized while the GMM is used to estimate model M_j where j=1,…,2^K. Let D stand for the information used to attain the posterior estimates, which is: the dataset. Thus $P(M_j|D)$ shall denote the posterior probability of model M_j's relevance. This can be used to verify to what extent — in view of D — we can support the hypothesis of M_j being the true model. Kim shows that

$$ln\, P\,(D|M_j) = -0.5nQ(\hat{\theta}_j) - 0.5K'_j\, ln\, n, \tag{4}$$

where K'_j is the number of parameters of M_j and $Q(\hat{\theta}_j)$ is the optimal value of $Q(\theta_j)$. The (4) is the limited information likelihood similarly to Schwarz's BIC. In view of this, posterior relevance probability of M_j can be written as:

$$P(M_j|D) = \frac{P(M_j)n^{-K'_j/2}\,exp[-0.5nQ(\hat{\theta}_j)]}{\sum_{i=1}^{J} P(M_i)n^{-K'_i/2}\,exp[-0.5nQ(\hat{\theta}_i)]}. \quad (5)$$

Lastly, the parameters by the regressors are estimated as weighted averages of the estimates obtained in the particular M_js with posterior probabilities (5) used as weights. A similar approach is used to attain the errors of estimation. Let $\hat{\beta}_{r,j}$ be the estimator of a parameter on variable *r* in model M_j. Let $\hat{\beta}_r$ be the "final" estimator of parameter *r*, being the result of the total BMA process. Using similar notation to the variances $\mathrm{Var}(\hat{\beta}_{r,j})$ and $\mathrm{Var}(\hat{\beta}_r)$ respectively, we have that:

$$\hat{\beta}_r = \sum_{j=1}^{2^K} P(M_j|D)\hat{\beta}_{r,j}, \quad (6)$$

$$\mathrm{Var}(\hat{\beta}_r) = \sum_{j=1}^{2^K} P(M_j|D) \cdot \mathrm{Var}(\hat{\beta}_{r,j}) + \sum_{j=1}^{2^K} P(M_j|D) \cdot (\hat{\beta}_{r,j} - \hat{\beta}_r)^2. \quad (7)$$

Lastly, the relevance of each potential growth factor can be decided either with the use of Bayesian posterior probability for each variable or the weighted *t* test of significance of each regressor. The former consists in comparing the sum of posterior probabilities (5) of the estimated models in which the considered regressor is present with the prior probability of its relevance and considering it as relevant if $P(M_j|D)$ exceeds the prior probability of relevance. The latter uses weighted *p*-values of the *t* test of significance for each analysed regressor from all the models M_j treating posterior probabilities (5) as weights. In this study we apply the second of these approaches and use the pseudo *t*. That is because we include the lagged log GDP per capita in each equation: this reflects the strong belief in the existence of β convergence. This means that the sum of the posterior probabilities (5) for all the considered M_j*'s* in which the lagged log GDP is present is always equal to one and the approach based on the sum of the computed $P(M_j|D)$ cannot be used.

Apart from initial GDP per capita and institutional variables (hef, fra, wgi), we use the following explanatory variables in the set of potential growth factors:

- total investment (% of GDP) [inv],
- general government balance (% of GDP) [gov_bal],
- general government final consumption expenditure (% of GDP) [gov_con],
- inflation rate (%) [inf],

– exports of goods and services (% of GDP) [exp],
– current account balance (% of GDP) [cab].

The variables gov_con and exp are taken from the World Bank (2020b) database. The remaining variables (including GDP per capita, but except institutional variables) are taken from the IMF (2020).

The analysis is based on data averaged into 5-year time spans. For HEF (with the structural break in 2003) the last subperiod included in the regression model estimated for the years before the structural break is the 1998-2002 subperiod (the 1999–2003 subperiod is included in the model estimated for the years after the structural break). For FRA the last subperiod before the structural break is 1996–2000 (1997–2001 refers to post-structural break period) while for WGI the calculations before the structural break finish at the 1999–2003 subperiod (2000–2004 is the first observation for the period after the structural break).

The study covers a group of 28 European Union countries. We analyze the group as a whole, not individual countries separately. Such an approach is fully appropriate. The results obtained in this way should be treated as average trends observed in the entire group of countries. Of course, the economic growth paths of individual countries may be different. From an economic point of view, the study belongs to the group of comparative studies where groups of countries are taken into account, not individual countries. The study is not intended to characterize individual countries. It is, therefore, not a case study. If we wanted to analyze individual countries, the analysis would have to be done for each country separately and such a study could be the subject of a monograph due to its length; in the case of a scientific article, the case study analysis would have to be limited for a single country or a maximum of several countries.

There are many comparative studies on EU countries where conclusions are made on the basis of the average trends observed in the entire group. Obviously, countries could be divided into certain subgroups, such as the countries of Western Europe and Central and Eastern Europe. Among the countries of Western Europe, a further division could be made, e.g. depending on the model of capitalism: one could distinguish countries with a continental model of capitalism, Anglo-Saxon countries, Nordic and Mediterranean countries. The aim of this study, however, is to identify certain trends in the full group of 28 EU countries, therefore these countries are considered jointly and not by subgroups.

By nature, econometric studies involving groups of countries are analyzes that allow average conclusions to be drawn. If we conducted a similar study for individual countries, the results would be different. It is the same with the identification of turning points based on hidden Markov models.

The country-specific procedure produces mixed results. After all, European countries are not identical. Despite many common elements and a high degree of homogeneity, individual countries have their individual characteristics, which means that turning points do not occur at the same time.

We took a detail-to-general approach to determine turning points on the basis of HMM. This means that we first identified turning points for individual countries and then aggregated them to find a common turning point for a whole group of countries, which is an average value and some compromise of often contradictory individual results. When determining turning points for the entire group of EU countries, we also took into account the economic significance.

Empirical evidence

The results of estimating the models of economic growth are presented in Tables 3–5. Each table includes a different institutional variable. The Heritage Foundation index of economic freedom (HEF) is presented in Table 3, the Fraser Institute index of economic freedom (FRA) in Table 4, whereas Table 5 concerns the Worldwide Governance Indicator (WGI). The structure of these tables is similar. Model (1) includes the regression equation without structural breaks. Model (2) takes into account a structural break in the institutional variable to assess whether the impact of institutions on economic growth (and broader — on convergence) was the same or different in the two considered subperiods.

The analysis of Table 3 confirms the appropriateness of the selection of explanatory variables. All the parameters are in line with the economic theory. As regards the lagged initial GDP per capita level, the estimated coefficient is less than 1. It means that in the untransformed convergence regression where the growth rate of GDP per capita (not the level) is the explained variable the coefficient on initial income level would be negative. In such a case, the model confirms the conditional β convergence. It means that countries with lower GDP per capita grew on average faster than countries with higher initial per capita income levels. Conditional β convergence is widely confirmed by economic theory and empirical evidence. For example, the neoclassical models of economic growth (e.g. the Solow or Mankiw-Romer-Weil model) indicate that countries with a lower stock of capita grow faster than richer ones provided that all of them tend to the same steady-state. Our results are in line with the implications of these models. Moreover, our results are consistent with the empirical evidence of the economic growth paths of the EU countries. The majority of studies indicate that the EU countries as a whole, as well as smaller subgroups, confirmed the existence of the β convergence hypothesis. Hence, it would be atypical if our study indicated something different.

The results given in Table 3 suggest the positive role of investments in stimulating economic growth. Whereas the positive relationship between investments and economic growth is undoubtedly in line with the theoretical structural model, empirical results not always confirm this outcome. It is due to two reasons. Firstly, it is not so easy to separate the impact of investments from the impact of the other variables on economic growth. The applied econometric technique with the Blundell and Bond's GMM system estimator is a proper tool to estimate economic growth models; hence, the outcomes are as expected. Secondly, the beneficial supply-side effects of investments depend on the efficiency of spending. Referring to the economic theory, investments affect economic growth through two channels: demand-side one and supply-side one. Demand-side effects are automatic — higher spending means higher aggregate demand and greater GDP in a given period (the expenditure approach is one of the methods of calculating GDP). Demand-side effects exist in the short run — during a given year. Unlike the demand-side channel, the supply-side channel is not automatic. Whether investments lead to greater physical capital accumulation depends on the efficiency of spending. If money is not efficiently spent, there will be no supply-side effects and no impact on potential output. Supply-side effects can be assessed over a longer time span. A 5-year time horizon, as in this study, is sufficient to extract supply-side effects. The positive coefficient on investments variable confirms the beneficial role of investments in stimulating economic growth in the EU countries from the supply-side perspective.

The variables gov_con and gov_bal represent the role of government and fiscal stance on output growth. The first variable (government consumption expenditure as % of GDP) captures the size of the public sector. The second variable refers to the condition of public finance and fiscal stability. The estimated coefficient on the gov_con variable is negative and statistically significant. It means that the big size of the government does not contribute to economic growth. According to this outcome, economic growth should rather be driven by the expansion of the private sector. From the point of view of output dynamics, a good fiscal stance is important. The estimated coefficient on general government balance is positive and statistically significant. It means that budget deficit rather hampers economic growth in the long run. These results shed new light on the nature of the economic growth paths of the EU countries. While in the short run it is likely that expansionary fiscal policy (higher government spending, higher budget deficit) accelerates economic growth, in the long run it need not be so. Our models estimated on the basis of 5-year observations confirm that the expansion of the public sector cannot be the source of long-run sustainable economic growth.

The estimates indicate that inflation hampers economic growth. The coefficients in both models are negative and statistically significant. It turns out that the higher the inflation rate, the slower economic growth (*ceteris paribus*). From the theoretical point of view, the relationship between inflation and economic growth is ambiguous. There may be a causal relationship from economic growth to inflation. If GDP rises due to demand-side factors, inflation appears. However, if the growth of GDP is caused by supply-side factors and the growth of potential output, prices are likely to fall. Hence, prices may behave procyclically or countercyclically, depending on the type of shock. Moreover, there may be a causal relationship from inflation to economic growth. There are costs of inflation (e.g. shoe-leather or menu costs of inflation) which imply that high inflation negatively affects the potential output. Our results are in line with the countercyclical behavior of prices. This is justified because the calculations carried out on 5-year subperiods capture long-run effects. Moreover, the existence of a variety of costs of inflation is also included in our outcomes.

Exports (and broader the openness of the economy) are important economic growth determinants. This is confirmed by our analysis. The coefficient on the export rate is positive and statistically significant. It means that the greater openness of the economy measured by the export rate, the more rapid economic growth. Like investments, exports affect output growth via two channels: the short-run demand-side channel as well as the long-run supply-side channel. The results confirm the beneficial supply-side effects of exports on economic growth.

The next variable related to foreign trade is the current account balance. It shows how the exchange with the rest of the world is balanced. The information contents of this variable are different compared to the exports rate: the exports rate shows the volume of foreign trade (in general, such a volume tend to be higher in smaller countries), while the current account balance shows the interaction between injections and leakages of money within the framework of the current account. As Table 3 suggests, the estimated coefficient on the cab variable in both regression equations is positive and statistically significant. It means that a good foreign stance is beneficial from the point of view of output dynamics.

Finally, let us analyze the effects of institutions on economic growth and convergence and time stability of this impact. The first model presented in Table 3 includes the Heritage Foundation index of economic freedom without structural breaks. The estimated coefficient is positive (0.000739) and statistically significant. It means that good institutions reflected in the greater scope of economic freedom lead to the higher economic growth of the EU countries. The Heritage Foundation index of economic freedom covers the rule of law, government size, regulatory efficiency, and market openness. It turns out that well-defined and secured property rights, judicial effectiveness, government integrity, low tax burden, good fiscal stance, freedom to set up and run enterprises, freedom in hiring and firing workers, trade freedom, investment freedom, and financial freedom all lead to more rapid economic growth. The effect of institutions on economic growth should be assessed on the basis of medium- or long-run data: our estimates based on 5-year time spans indicate that these results are unlikely to be spurious.

It is necessary to state that the positive relationship between economic freedom and economic growth does not necessarily imply the causal relationship from economic freedom to economic growth. It is worth mentioning here, as the example, two studies with contradictory conclusions. For example, Ozcan *et al.* (2017) verify, among others, the causal links between economic freedom (using the Heritage Foundation index) and economic growth for 17 post-socialist countries during the 1996–2012 period. They apply Granger causality tests. It turns out that 16 (out of 17) countries do not confirm any causality between economic freedom and GDP dynamics. The cited study indicates that only for Poland is there unidirectional causality in the form that economic growth Granger causes economic freedom.

Piątek *et al.* (2013) analyze the relationship between economic freedom (from Heritage Foundation) and economic growth for 25 post-socialist countries during the 1990–2008 period. Although the sample of countries, time period, and the estimation method differ across both studies, the outcomes are contradictory. The latter study indicates that there is strong evidence that economic freedom Granger causes economic growth. Given ambiguous econometric outcomes across different studies as to the directions of the causality, the approach adopted in our study aiming at econometric verification of only the direction and strength of the relationship without conducting the formal causality tests seems to be correct.

The question arises whether the impact of these institutions was the same or different before and after the structural break. Model (2) in Table 3 shows the estimated regression equation with a structural break. The structural break was introduced in the institutional variable to assess the time stability of the impact of institutions on economic growth. It turns out that both prior and after the structural break economic freedom affected output dynamics positively and statistically significant. The estimated coefficient standing on the Heritage Foundation index of economic freedom equals 0.00121 for the period before the structural break and 0.000946 afterward. Both coefficients are statistically significant with *p*-value less than 0.001. While the positive impact of economic freedom on economic growth was evidenced in both distinguished periods, the strength of the impact was not the same. The value of the coefficient for the period before the structural break is about 30% higher than that for the period after the structural break. It can be interpreted as the fact that during the global crisis (the second period includes the years of the global crisis) there was a rising role of other factors, different than institutions, on economic growth. A deep recession and a big fall in GDP at the end of the 2000s were caused by short-run demand-side factors with an unchanging role of institutions. Hence, the changes in GDP were primarily influenced by non-institutional factors. This is one of the reasons responsible for a diminishing role of economic freedom as an economic growth determinant. However, this finding requires further testing, also with the use of the other institutional variables (see also Tables 4 and 5).

Table 4 shows the estimated regression equations with the Fraser Institute index of economic freedom as the institutional variable. As in the case of the models with the Heritage Foundation index of economic freedom, the estimates are economically sound. The coefficients standing on initial income level in Models (1) and (2) are lower than 1 and statistically significant which confirms the existence of the conditional β convergence. As regards the other explanatory variables, their estimated coefficients in the models with the Fraser Institute index of economic freedom are similar to those with the Heritage Foundation index of economic freedom. The models reveal the positive relationship between the investment rate and economic growth. High size of the public sector negatively affects output dynamics, but a good fiscal stance reflected by budget surplus accelerates economic growth in the medium run. The negative estimate of the inflation parameter suggests that high inflation was rather an obstacle in economic growth. The variables related to foreign trade confirm again the positive impact of the export rate and current account balance on the growth rate of GDP.

The Fraser Institute index of economic freedom measures economic freedom in another way than the Heritage Foundation index. The component variables are different. Hence, the application of both indices can be treated as a robustness test. Model (1) in Table 4 does not include structural breaks. In such a model specification, the positive relationship between economic freedom and economic growth has been evidenced. Taking into account the construction of the index, these results indicate that the low size of government, good legal system and well-defined and secured property rights, sound money, freedom to trade internationally, and low scope of regulations all benefit to more rapid economic growth.

Comparing with the literature, our results are not controversial; however, some new findings can be drawn. Kacprzyk (2016) in his study for the EU28 group demonstrates that there is a positive link between GDP growth and four (out of five) areas of economic freedom: quality of monetary policy, security of property rights, regulatory policies, and freedom to trade (on the basis of the Fraser Institute index of economic freedom). Moreover, he finds out that the results may be different for different methods of estimation (system-GMM versus LSDV). The cited study indicates that ignoring endogeneity issues may lead to inappropriate estimates; in our study the choice of GMM estimation technique seems to be a proper method to tackle this problem.

If we look at model (2) in Table 4, i.e. the model with a structural break, it turns out that both before and after the structural break economic freedom positively and statistically significantly contributed to output growth. However, the strength of influence was different. The coefficient standing on economic freedom for the years before the structural break is greater than that for the next period. It means that the global crisis weakened the impact of economic freedom (and more broadly — institutions) on GDP growth. The possible reason is the influence of the other non-institutional factors on the rapid decline in GDP during the global crisis. As a result, the impact of institutions was not so large as in the preceding years.

The last institutional variable examined is the Worldwide Governance Indicator from the World Bank database. The models with this variable are presented in Table 5. The results are in line with the economic theory and similar to those for economic freedom indices. However, some differences appear. Nevertheless, such outcomes confirm the robustness of our results concerning institutional variables applied. Table 5 shows that the coefficient for lagged GDP per capita in both models is less than 1 and statistically significant. Such a value indicates the existence of conditional β convergence in the EU countries. Less developed countries exhibited more rapid economic growth than more developed ones controlled for the other growth factors. Such an outcome requires further comments and interpretations of the findings. According to the neoclassical models of economic growth, which are the source of the β convergence hypothesis, the main argument for the countries to converge is the diminishing marginal product of capital (in the basic Solow model) or diminishing marginal product of both physical and human capital (in the Mankiw-Romer-Weil model). Hence, countries that are capital scarce reveal a greater rate of return on capital, and —

as a result — a higher increase of capital and more rapid output growth. Poor countries thus catch up with the richer ones.

A positive relationship between the governance measured by the worldwide governance indicator and economic growth is confirmed by some other studies, e.g. Bota-Avram *et al.* (2018). In the cited study, conducted for more than 100 countries and the 2006–2015 period, the authors find out a strong unidirectional evidence that country-level governance Granger causes economic growth; in the opposite direction the causality has not been confirmed.

In the real world, there are many more factors for convergence. In the EU, convergence was primarily driven by the catching-up process of the Central and Eastern European countries which are new EU member states towards Western Europe (the EU 'core'). The convergence of the CEE countries was fueled, *inter alia*, by the transformation process from the centrally planned to market economies and their institutional reforms (privatization, liberalization), by EU funds which were directed to poorer countries and regions do decrease income disparities, and by the inflow of technology from Western Europe to Central and Eastern Europe. These are only selected examples of the factors which contributed to convergence in the enlarged European Union.

Data in Table 5 show the positive impact of investments, budget surplus (or low budget deficit), exports, and current account balance on economic growth. The respective coefficients are positive and statistically significant. On the other hand, inflation and the share of government consumption in GDP were the factors that slowed down economic growth. All these outcomes are in line with the previous findings for the two examined indices of economic freedom.

In Model (1) presented in Table 5, in which structural breaks are not included, the coefficient on Worldwide Governance Indicator is positive and statistically significant. This finding confirms the positive role of institutions in promoting economic growth. Taking into account the individual components of the WGI variable, it turns out that economic growth is more rapid if citizens can select their government as well as they can freely express, associate, and have the access to a free media. Moreover, output growth is faster if the political scene is stable and there is no violence. The quality of public services, the quality of the civil service, regulatory quality, rule of law, and low corruption also contribute to economic growth.

Unlike the indices of economic freedom, the Worldwide Governance Indicator exhibits different impacts on output dynamics in the periods before and after the structural break. The estimated coefficient for the period before the structural break amounts to 0.135, while that for the next period is equal to 0.154. As we can see, in both periods the impact of good governance on GDP growth is positive and statistically significant. However, here the relationship is more strength after the structural break in 2004. Such an outcome means that from a broad perspective, the impact of institutions on GDP growth varies over time; however, the direction of change is hard to be specified. Economic freedom exhibited greater impact before the structural break; in the case of the quality of governance, it was vice versa — in the second period the impact was larger. Such an outcome partially results also from the fact that structural breaks are not introduced in the same year — hence, the length of both periods differs for three institutional variables examined.

The results presented in Tables 3–5 show the estimated regression equations with a specified predefined set of explanatory variables. Following these, Tables 6–8 demonstrate the BMA coefficients for HEF, FRA, and WGI variables for the period before and after the structural break (each table refers to a different institutional variable). The rationale behind the use of the BMA were discussed in the previous section. In this paper, the results presented in Tables 6–8 can be treated as the robustness test to those presented in Tables 3–5 and they vastly confirm the conclusions that can be drawn based on single equations. The importance of this analysis is enforced by the outcome of the Sargan's test for the models presented in Tables 3–5. While there is no risk of inconsistency of the BB estimator because of autocorrelation (the Arellano and Bond's AR(2) test provides no reason to reject the H0), on the conventional level of significance the null hypotheses is rejected in Sargan's test despite the necessary measures (treating all the macroeconomic regressors as endogeneous, limiting the number of instruments to a maximum of 3 lags so as to avoid the problem of weak instruments). Thus it is vital to validate the results of single regressions described in Tables 3–5 with BMA averaged estimates.

In the case of the Heritage Foundation index, the results based on Bayesian model averaging (Table 6) are the same (in terms of the direction of changes) to those presented in Table 3. The coefficients on the Heritage Foundation variable for the period before and after the structural break are positive and statistically significant (at a 5-percent significance level). It indicates the positive impact of economic freedom on economic growth. Moreover, the coefficient for the period before structural break exceeds that for the second period, meaning that the global crisis weakened the impact of institutions on economic growth.

Like the Heritage Foundation index, the Fraser Institute index of economic freedom also exhibits the same results based on the BMA approach (Table 7) as in the case of a single model presented in Table 4. The coefficients standing on the FRA variable for both periods are positive and statistically significant (at 1-percent significance level). Like HEF, the Fraser Institute index of economic freedom also reveals a stronger impact on output dynamics in the period before the structural break.

As regards the Worldwide Governance Indicator, Table 5 confirmed the positive impact on GDP dynamics in both periods; however, unlike the indices of economic freedom, after the structural break the relationship strengthened. The same finding can be seen in Table 8: the estimated coefficients standing on WGI are positive and statistically significant (at 1% significance level), but that for the period after the structural break is higher than that for the previous period.

Tables 6–8 also confirm the validity of results for the remaining explanatory variables. The estimated coefficients standing on initial GDP per capita level are less than 1, indicating the existence of conditional β convergence. According to the BMA approach, positive coefficients have been recorded for the following variables: investment rate, general government balance, export rate, and current account balance. Hence, our models undoubtedly demonstrate that higher investments, better fiscal stance, higher exports, and better current account balance lead to more rapid GDP growth. In contrast, the coefficients standing on the remaining two variables: government consumption and inflation rate are negative. This indicates that too big a size of government and too rapid increase in prices hamper GDP dynamics.

Simulations

Many empirical studies focus on the analysis of past and present economic trends. However, there are also studies aiming to predict what the future brings. The latter is more complex in cases like the convergence phenomenon. The use of econometric models for predictions is relatively easy if you know the values of the explanatory variables. This, however, means that one must compute predictions for each of the variables separately, and then calculate the forecast of the explained variable.

In this research we would like to present an alternative approach to carry out simulations, i.e. the scenario analysis based on the HMM models. This procedure has been described by Bernardelli *et al.* (2017a, 2017b). The cited authors verify the hypothesis of the HMM convergence for a variety of variables: not only GDP per capita levels and GDP growth rates, but also inflation and unemployment rates, household and government consumption, net exports, and loans (including non-performing loans). The HMM offers a tool to analyze convergence in terms of any variable.

As the paper focuses on institutions, in this section we would like to show HMM's potential for simulation-based foresights. Institutional convergence in terms of economic freedom will be applied as an example. We use the Heritage Foundation index of economic freedom, which is characterized by good data availability and for which the 2019 statistics are available at the time of carrying out the research.

A convergence of economic freedom is verified based on the behavior of differences between the value of the economic freedom index in a given country in a given year and the value of 100, which is the maximum value of the Heritage Foundation index of economic freedom (it ranges from 0 to 100).

Simulations of convergence of economic freedom refer to the year 2020.[3] We consider various what-if scenarios. Under these scenarios, the values of the index of economic freedom for all the EU countries were changed by -5%, -2%, -1%, 1%, 2%, and 5% relative to the values in the year 2019. Next, the same HMM convergence procedure has been applied in each case. The resulting rate of HMM convergence (which is the average of the states on the appropriate Viterbi path and ranges from 0 to 1 where 0 indicates full convergence and 1 means full divergence[4]) was compared to each other and based on that, conclusions have been drawn regarding the possible changes in the rate of convergence under different scenarios.

The big advantage of this approach is the possibility of analyzing one variable separately from other data. The second advantage is low requirements when it comes to assumptions of the method. The whole procedure is based on HMM models and, therefore, it can be considered as automatic pattern recognition. It also has such an advantage over econometric methods, in which changing the input data may result in the lack of validation of the entire model. This is not the case in HMM method, which is highly resistant to changes in input data. Although we cannot assess the strength of impact, we can predict the moment when the most likely change of the hidden Markov chain will took place. One drawback of the presented procedure is that the same percentage change of a given variable (in this case: index of economic freedom) for each country was used. Another weakness of the applied method is the exclusion of the atypical growth paths due to the Covid-19 pandemic. In the case of coronavirus, the future is so uncer-

[3] The procedure is universal and may be applied to any variable. We present here the application to the index of economic freedom. However, the other variables (e.g. GDP per capita) can also be tested.

[4] See Bernardelli *et al.* (2017b) for details of calculating the rate of HMM convergence.

tain that it is almost impossible to predict the exact macroeconomic performance of the EU (and world) countries in the coming years. So the simulations of the possible future changes of institutions should be treated as only the hypothetical example necessary to be employed to show the potential of the presented method in macroeconomic foresighting.

The rate of observed HMM convergence for the Heritage Foundation index of economic freedom and the full 1995–2019 period is depicted in Figure 1. Figure 1 shows the averages of the states on Viterbi paths for the Heritage Foundation index of economic freedom (Viterbi path is calculated for the time series of differences between the value of a given country and the maximum value of the index (100)). Data presented in Figure 1 are country averages for a given year.

Figure 1 indicates that over the past 20 years the long-term HMM institutional convergence of EU28 countries in terms of economic freedom is easily noticeable. It means that differences in institutional environment between the individual EU countries and the desirable outcome (full economic freedom) diminished. The main factor behind institutional convergence was EU enlargement. As we can see in Figure 1, the most rapid convergence of institutions took place in the first part of the 2000s, which is around the biggest EU enlargement for Central and Eastern Europe.

Under various scenarios as to the change in the index of economic freedom in 2020, the procedure of HMM convergence was carried out again, but on a longer time period, ending in 2020 to estimate the rate of HMM convergence in that year. The estimates are summarized in Table 9 and visualized in Figure 2. In Figure 2, the dotted line represents the value of the HMM convergence rate for 2019.

The results show that under the assumed changes in the index of economic freedom at the level ranging from -1% to +1%, the predicted value of the HMM convergence rate for the Heritage Foundation index of economic freedom will remain at the same level as in 2019. The greater rates of decrease in the HEF (-2% and -5%) imply slower HMM convergence of the EU28 countries in terms of the index of economic freedom (HMM convergence coefficients are higher). On the other hand, the assumed increase in the HEF index for each country at the level of at least 2% means a faster rate of HMM convergence.

Figure 3 facilitates the comparison of the differences in predicted values of the rate of HMM convergence of economic freedom depending on the assumed magnitude of percentage changes in the Heritage Foundation index of economic freedom. It shows the observed HMM convergence rates during 2014–2019 (six years before the prediction) together with predictions made for various scenarios of the future behavior of the index of economic freedom. To keep economic freedom convergence at the same or faster pace, the HEF index should fall by not more than 1% or should increase.

Finally, some limitations of the study are worth mentioning. We can indicate two most important obstacles. Firstly, the institutional variables analyzed here are only quantitative measures of institutions. They can be treated as their proxies. It is very difficult to quantify institutions; the available time series are only numerical approximations which have their drawbacks, resulting e.g. from the assumed concept or a way of measurement which reflects the view of the author or organization responsible for a given time series. Secondly, the estimated econometric models have also their limitations resulting e.g. from omitted variables' bias, potential spurious correlations, reverse causality relationships. The approach adopted here tries to limit these shortcomings but the full elimination of these drawbacks is not possible. Moreover, when interpreting the results, the findings are based on statistical significance and there is no guarantee to make type I or type II errors.

Conclusions

The study examines the time stability of the relationship between institutions and economic growth and real economic convergence. The analysis covers the EU28 countries and the 1995–2019 period. The novelty of the study is threefold. First, we use the HMM approach to find structural breaks. Second, the BMA method is applied to assess the robustness of the outcomes. Third, we show the potential of HMM in foresighting based on time series related to a single variable only.

According to the HMM method, the following structural breaks were identified for three institutional variables: Heritage Foundation index of economic freedom — in 2003, Fraser Institute index of economic freedom – in 2001, and Worldwide Governance Indicator — in 2004.

The results of regression estimates indicate that good institution reflected in the greater scope of economic freedom and better governance lead to the higher economic growth of the EU countries. However, the impact of institutions on economic growth was not stable over time.

In the case of economic freedom indices, the strength of the impact in the period before the structural break was greater than that for the period after the structural break. It can be interpreted as the fact that during the global crisis (the second period includes the years of the global crisis) there was a rising role of the other factors, different than institutions, on economic growth. However, in the case of WGI, the reverse outcomes were achieved: the relationship turned out to be more strength after the structural break in 2004.

The results yield a number of policy implications, especially in the time of combating recession or slowdown due to coronavirus pandemic and returning to the normal functioning of the economy. Firstly, the government should reduce the number and the extent of regulations of the economy. For example, the authorities should undertake actions to promote e.g. product market competition. The markets should be decentralized; the government should promote actions enhancing competition. As the result, we can expect a number of new firms entering the market after the coronavirus pandemic and a rapid achievement of fast economic growth. If the institutional environment is not economically free, it will be more difficult for the economy to recover fully to its pre-pandemic level, because it is unlikely that many firms will enter the market to replace the companies that went bankrupt due to the Covid-19 lockdown.

The BMA estimates confirm the robustness of the results in terms of the impact of both institutions and the other variables on output dynamics. The models confirm the existence of conditional β convergence. Moreover, they demonstrate that higher investments, better fiscal stance, higher exports, and better current account balance lead to more rapid GDP growth. In contrast, too big size of government and too rapid increase in prices hamper GDP dynamics.

The HMM method turned out to be a good tool in conducting simulation-based foresights. On the example of the Heritage Foundation index of economic freedom, we have shown various scenarios in terms of institutional catching-up of the EU countries.

This paper indicates a few areas of further research on the subject. First of all, institutions are of special importance as regards the impact on macroeconomic environment. The empirical studies on economic growth determinants should account — quantitatively or qualitatively — for institutional indicators. Institutions should be included in the explanation of causality links between various macroeconomic variables. Secondly, it is not the case that the only one aspect of institutional environment matters. The whole institutional framework is important due to a variety of institutional complementarities. Hence, further research should account for these issues. Thirdly, the relationships under study are not constant over time. After the coronavirus pandemic even greater time instability may be expected. As the result, in the next cross-country analyses on the subject where long time period is examined structural breaks should be accounted for.

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Annex

Table 1. Basic descriptive statistics for institutional variables

Country	HEF				FRA				WGI			
	min	mean	median	max	min	mean	median	max	min	mean	median	max
Austria	64.0	69.7	71.1	72.4	7.3	7.8	7.8	8.1	1.4	1.6	1.6	1.7
Belgium	62.9	68.1	68.6	72.5	7.5	7.6	7.6	7.9	1.2	1.3	1.3	1.5
Bulgaria	45.7	59.5	62.7	69.0	4.9	6.7	7.2	7.5	-0.1	0.2	0.2	0.3
Croatia	46.7	55.6	53.9	61.5	5.1	6.5	6.6	7.3	-0.2	0.3	0.4	0.5
Cyprus	67.2	70.0	69.9	74.1	6.4	7.2	7.5	7.9	0.8	1.0	1.0	1.2
Czech Rep.	64.6	69.5	69.4	74.2	6.2	7.2	7.3	7.8	0.6	0.9	0.9	1.0
Denmark	67.3	74.0	75.4	79.6	7.7	8.0	8.0	8.2	1.6	1.8	1.8	1.9
Estonia	65.2	74.8	75.9	79.1	6.4	7.7	7.9	8.1	0.8	1.0	1.0	1.2
Finland	63.5	71.4	73.4	74.9	7.7	7.9	7.9	8.1	1.7	1.8	1.9	2.0
France	57.4	61.8	62.5	64.7	7.1	7.4	7.4	7.6	1.1	1.2	1.2	1.3
Germany	64.3	70.5	70.6	74.4	7.7	7.9	7.9	8.0	1.4	1.5	1.5	1.6
Greece	53.2	58.8	59.1	63.4	6.4	6.9	6.9	7.5	0.2	0.6	0.7	0.8
Hungary	55.2	63.8	65.0	67.6	6.4	7.2	7.3	7.4	0.4	0.8	0.9	1.1
Ireland	68.5	77.9	78.7	82.6	7.7	8.1	8.2	8.3	1.4	1.5	1.5	1.6
Italy	58.1	61.8	61.9	64.9	6.9	7.4	7.4	7.8	0.5	0.7	0.6	0.9
Latvia	55.0	66.7	66.5	74.8	5.6	7.4	7.7	7.9	0.4	0.6	0.7	0.8
Lithuania	49.7	68.8	71.1	75.8	5.5	7.2	7.5	7.9	0.5	0.7	0.7	1.0
Luxembourg	72.4	75.5	75.3	80.1	7.6	8.0	7.9	8.3	1.6	1.7	1.7	1.8
Malta	55.8	64.2	66.1	68.9	6.7	7.5	7.8	8.0	1.0	1.1	1.1	1.3
Netherlands	69.2	73.9	74.6	77.4	7.6	7.9	7.8	8.1	1.6	1.7	1.7	1.9
Poland	50.7	62.2	61.8	69.3	5.5	6.8	7.0	7.5	0.5	0.7	0.7	0.9
Portugal	62.4	64.2	64.4	66.0	7.1	7.4	7.5	7.6	0.9	1.1	1.1	1.3
Romania	42.9	58.2	61.2	69.7	4.1	6.6	7.2	7.7	-0.2	0.1	0.1	0.3
Slovakia	53.8	63.9	65.7	70.0	5.5	7.2	7.5	7.8	0.5	0.7	0.7	0.8
Slovenia	50.4	60.6	60.7	65.5	5.6	6.8	7.0	7.2	0.9	1.0	1.0	1.1
Spain	59.6	66.7	68.0	70.2	7.3	7.6	7.6	7.9	0.8	1.0	0.9	1.3
Sweden	61.4	69.7	70.8	76.3	7.6	7.7	7.7	7.9	1.7	1.7	1.7	1.8
UK	74.1	77.2	77.3	80.4	8.0	8.3	8.3	8.6	1.3	1.5	1.5	1.7

Table 2. Structural breaks in individual EU28 countries according to the HMM (column *dating*) and number of turning points on the Viterbi path (column *count*)

Country	HEF		FRA		WGI	
	dating	count	dating	count	dating	count
Austria	2005	1	2008	1	2008	1
Belgium	2001	1	1996	4	2004	3
Bulgaria	2004	1	2002	1	2000	1
Croatia	2009	1	2006	1	2001	1
Cyprus	2000	2	2003	1	2003	1
Czech Republic	2013	1	2005	1	2001	4
Denmark	2004	1	1996	2	2013	1
Estonia	2000	1	1999	1	2005	1
Finland	2001	1	1997	2	1999	2
France	1996	2	1996	1	2013	1
Germany	2012	1	2006	1	2002	1
Greece	2011	2	2002	2	2007	1
Hungary	1999	1	2000	1	2007	1
Ireland	2000	3	2000	4	2002	3
Italy	1998	3	1996	1	2003	1
Latvia	2000	2	1999	1	2001	1
Lithuania	2002	1	1999	1	2011	1
Luxembourg	2000	2	2004	1	1999	2
Malta	2004	1	2004	1	1998	2
Netherlands	2000	1	2000	1	2002	1
Poland	2012	1	2003	1	1998	3
Portugal	1997	5	2004	2	2005	1
Romania	2005	1	2004	1	2005	1
Slovak Republic	2003	1	2003	1	2002	1
Slovenia	1997	1	2000	1	1998	1
Spain	2000	2	1997	2	2005	1
Sweden	2001	1	2000	8	2001	4
United Kingdom	2000	3	2007	1	2001	1

Table 3. Regression results for the models with the Heritage Foundation index of economic freedom

	(1) **log_GDP**	**(2)** **log_GDP**
hef	0.001**	
	(2.77)	
hef_1		0.001***
		(4.29)
hef_2		0.001***
		(3.48)
L5.log_GDP	0.795***	0.795***
	(158.90)	(157.40)
inv	0.012***	0.011***
	(27.05)	(26.04)
gov_con	-0.008***	-0.008***
	(-10.70)	(-10.67)
gov_bal	0.017***	0.017***
	(33.93)	(33.29)
inf	-0.001***	-0.001***
	(-7.54)	(-8.09)
exp	0.001***	0.001***
	(12.74)	(13.37)
cab	0.006***	0.005***
	(14.33)	(13.10)
_cons	2.061***	2.044***
	(48.46)	(47.44)
N	560	560
Arellano Bond AR(2)[a]	-0.2756(0.783)	-0.3162(0.752)

Note:
t statistics in parentheses below the respective estimated coefficients.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] *p*-values are given in parentheses next to the test statistics.
Test for the difference in parameters on hef_1 and hef_2: chi^2(1)=32.44(0.000)
One-step Blundell-Bond estimates; the set of instruments includes the lags 2-4 in the difference equation and the lagged by one period difference in the level equation except for the hef variable which is an instrument for itself in both equations.

Table 4. Regression results for the models with the Fraser Institute index of economic freedom

	(1) log_GDP	(2) log_GDP
fra	0.052***	
	(13.78)	
fra_1		0.070***
		(13.42)
fra_2		0.058***
		(13.18)
L5.log_GDP	0.766***	0.762***
	(155.94)	(135.58)
inv	0.010***	0.010***
	(24.97)	(21.39)
gov_con	-0.006***	-0.007***
	(-8.86)	(-8.35)
gov_bal	0.015***	0.015***
	(31.10)	(27.42)
inf	-0.000***	-0.001***
	(-3.42)	(-3.79)
exp	0.001***	0.001***
	(13.69)	(13.24)
cab	0.005***	0.005***
	(13.97)	(11.46)
_cons	2.002***	2.011***
	(53.53)	(47.42)
N	560	560
Arellano Bond AR(2)[a]	-0.4176(0.676)	-0.5923(0.554)

Note:

t statistics in parentheses below the respective estimated coefficients.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] *p*-values are given in parentheses next to the test statistics.

The coefficient -0.000 for the variable inf is the rounded value of -0.0004.

Test for the difference in parameters on fra_1 and fra_2: chi^2(1)=36.21(0.000)

One-step Blundell-Bond estimates; the set of instruments includes the lags 2-4 in the difference equation and the lagged by one period difference in the level equation except for the fra variable which is an instrument for itself in both equations.

Table 5. Regression results for the models with the Worldwide Governance Indicator

	(1) **log_GDP**	(2) **log_GDP**
wgi	0.130***	
	(26.95)	
wgi_1		0.135***
		(27.97)
wgi_2		0.154***
		(27.36)
L5.log_GDP	0.696***	0.675***
	(127.33)	(112.26)
inv	0.008***	0.007***
	(18.06)	(17.00)
gov_con	-0.016***	-0.018***
	(-21.40)	(-22.98)
gov_bal	0.013***	0.013***
	(26.71)	(26.21)
inf	-0.001***	-0.001***
	(-10.16)	(-10.18)
exp	0.001***	0.001***
	(15.33)	(13.00)
cab	0.004***	0.004***
	(10.20)	(10.96)
_cons	3.210***	3.457***
	(55.81)	(53.46)
N	560	560
Arellano Bond AR(2)[a]	-0.5299(0.596)	-0.6730(0.521)

Note:
t statistics in parentheses below the respective estimated coefficients.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] *p*-values are given in parentheses next to the test statistics.
Test for the difference in parameters on wgi_1 and wgi_2: chi^2(1)=67.36(0.000)
One-step Blundell-Bond estimates; the set of instruments includes the lags 2-4 in the difference equation and the lagged by one period difference in the level equation except for the wgi variable which is an instrument for itself in both equations.

Table 6. Bayesian model averaging estimates for the models with the Heritage Foundation index of economic freedom

Variable	Statistics	Value
hef_1	Coefficient	0.005
	Standard deviation	0.00033
	p-value for pseudo *t*-statistics	0.015
hef_2	Coefficient	0.004
	Standard deviation	0.00032
	p-value for pseudo *t*-statistics	0.018
L5.log_GDP	Coefficient	0.767
	Standard deviation	0.00649
	p-value for pseudo *t*-statistics	0.000
inv	Coefficient	0.012
	Standard deviation	0.00047
	p-value for pseudo *t*-statistics	0.000
gov_con	Coefficient	-0.012
	Standard deviation	0.00090
	p-value for pseudo *t*-statistics	0.000
gov_bal	Coefficient	0.025
	Standard deviation	0.00050
	p-value for pseudo *t*-statistics	0.000
inf	Coefficient	-0.001
	Standard deviation	0.00013
	p-value for pseudo *t*-statistics	0.000
exp	Coefficient	0.001
	Standard deviation	0.00006
	p-value for pseudo *t*-statistics	0.000
cab	Coefficient	0.005
	Standard deviation	0.00042
	p-value for pseudo *t*-statistics	0.000

Table 7. Bayesian model averaging estimates for the models with the Fraser Institute index of economic freedom

Variable	Statistics	Value
hef_1	Coefficient	0.145
	Standard deviation	0.01069
	p-value for pseudo *t*-statistics	0.000
hef_2	Coefficient	0.121
	Standard deviation	0.00785
	p-value for pseudo *t*-statistics	0.000
L5.log_GDP	Coefficient	0.714
	Standard deviation	0.01030
	p-value for pseudo *t*-statistics	0.000
inv	Coefficient	0.010
	Standard deviation	0.00068
	p-value for pseudo *t*-statistics	0.000
gov_con	Coefficient	-0.010
	Standard deviation	0.00125
	p-value for pseudo *t*-statistics	0.001
gov_bal	Coefficient	0.023
	Standard deviation	0.00059
	p-value for pseudo *t*-statistics	0.000

Table 7. Continued

Variable	Statistics	Value
inf	Coefficient	-0.000
	Standard deviation	0.00019
	p-value for pseudo *t*-statistics	0.083
exp	Coefficient	0.001
	Standard deviation	0.00009
	p-value for pseudo *t*-statistics	0.000
cab	Coefficient	0.005
	Standard deviation	0.00051
	p-value for pseudo *t*-statistics	0.001

Note:
The coefficient -0.000 for the variable inf is the rounded value of -0.0001.

Source: own calculations.

Table 8. Bayesian model averaging estimates for the models with the Worldwide Governance Indicator

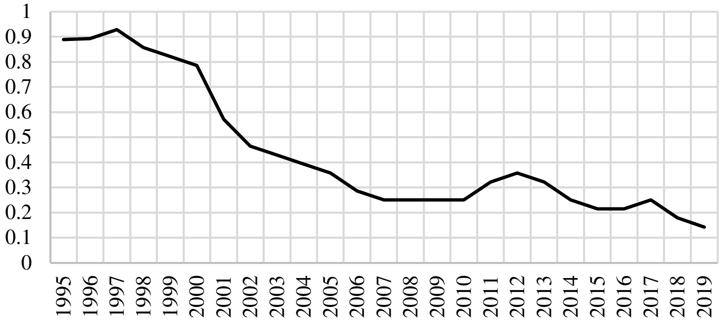
Variable	Statistics	Value
hef_1	Coefficient	0.170
	Standard deviation	0.00510
	p-value for pseudo *t*-statistics	0.000
hef_2	Coefficient	0.197
	Standard deviation	0.00607
	p-value for pseudo *t*-statistics	0.000
L5.log_GDP	Coefficient	0.629
	Standard deviation	0.00737
	p-value for pseudo *t*-statistics	0.000
inv	Coefficient	0.007
	Standard deviation	0.00047
	p-value for pseudo *t*-statistics	0.050
gov_con	Coefficient	-0.024
	Standard deviation	0.00090
	p-value for pseudo *t*-statistics	0.000
gov_bal	Coefficient	0.020
	Standard deviation	0.00051
	p-value for pseudo *t*-statistics	0.000
inf	Coefficient	-0.001
	Standard deviation	0.00012
	p-value for pseudo *t*-statistics	0.000
exp	Coefficient	0.001
	Standard deviation	0.00006
	p-value for pseudo *t*-statistics	0.000
cab	Coefficient	0.005
	Standard deviation	0.00040
	p-value for pseudo *t*-statistics	0.055

Table 9. Predicted rates of HMM convergence in economic freedom in 2020 for different assumed percentage changes of the Heritage Foundation index of economic freedom

Percentage change of HEF in 2020	-5%	-2%	-1%	1%	2%	5%
Predicted rate of HMM convergence in 2020	0.39	0.18	0.14	0.14	0.11	0.07

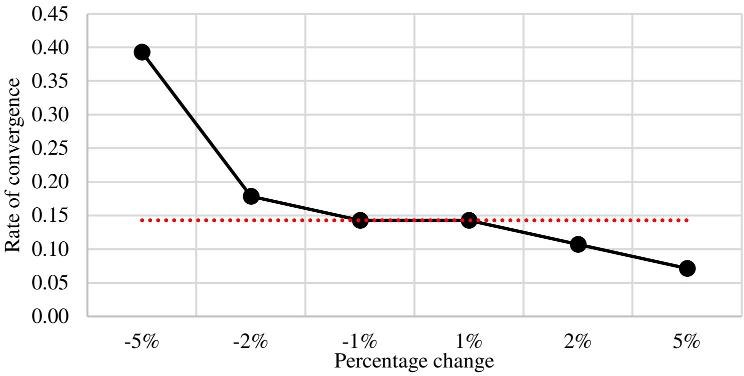
Note:
The lower the rate of HMM convergence, the more rapid convergence.

Figure 1. Rate of HMM convergence for Heritage Foundation index of economic freedom (average for EU28 countries)



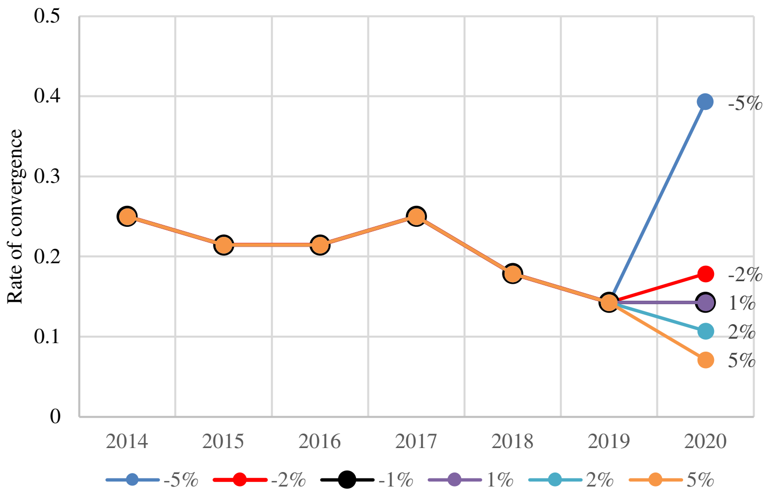
Note:
The values on the vertical axis range from 0 (full convergence) to 1 (full divergence).

Figure 2. Predicted rates of HMM convergence in economic freedom in 2020 for different assumed percentage changes of the Heritage Foundation index of economic freedom



The lower the rate of HMM convergence, the more rapid convergence.

Figure 3. Rates of observed HMM convergence in economic freedom in 2014-2019 and predictions for 2020 for different assumed percentage changes of the Heritage Foundation index of economic freedom



The lower the rate of HMM convergence, the more rapid convergence.