LIMITATIONS OF THE PANEL REGRESSION MODEL APPLICATION: THE EXAMPLE OF THE WESTERN BALKAN COUNTRIES

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A B S T R A C T

Panel regression model may seem like an appealing solution in conditions of limited time series. This is often used as a shortcut to achieve deeper data set by setting several individual cases on the same time dimension, where cross units visually but not really multiply a time frame. Macroeconometrics of the Western Balkan region assumes short time series issue. Additionally, the structural brakes are numerous. Panel regression may seem like a solution, but there are some limitations that should be considered.

1. INTRODUCTION

This paper presents the shortcomings of the application of the panel regression model to macroeconomic problems. It is not attempted to claim that the application of this approach is not a valid macroeconomic technique, but that a certain amount of caution is required in the procedure itself.

At the same time, the interconnectedness of individual countries with the emphasis on individual specifics implies caution in the econometric interpretation of the problem. It is necessary to consider the essential characteristics of the available individual time series, before drawing conclusions based on the final results of the panel regression model.

First of all, the panel can be viewed as a series of measurements at different equally spaced time intervals. Each individual measurement refers to an individual case that can be identified with the classical sampling in space.

The ergodic nature of the econometric model is something that needs to be reconsidered, as it forms the foundation of serious econometric analysis, and limitations on data availability can be an obstacle in this regard when looking at the countries of the Western Balkans.

However, the problem of applying the panel regression model is of a general nature and is not specific to the countries of the Western Balkans. A possible starting point is the fact that this approach was initially developed for microeconomic problems.

The microeconometric approach implies greater control when sizing and structuring the sample itself. Of course, the question of the cost-effectiveness of the procedure itself can be called into question. The researcher has the ability to influence the characteristics of the sample to a certain extent. It is easier to achieve randomness and independence of the sampling process, unlike macroeconomic time series, which the researcher takes over as defined by the competent institutions (statistical agencies) and they are determined by a number of factors that are beyond the influence of the researcher.

The procedure of parameter evaluation, in addition to the interpretation of the results, must be conditioned by the stated specifics of the application of panel regression models to macroeconomic problems. Micro-panels are static in nature, and this means sizing with a large number of individual cases covered, which are observed over a relatively short period of time (not more than a few years).

For macroeconomic phenomena, dynamics is unusually important, as these are time series that are the result of official statistical measurements published by government agencies, and the researcher uses them as ready-made input material. On the other hand, a large enough number of individual cases is needed. These individual cases must not have a problem with autocorrelation, and must have a constant variance, if we consider the classical panel regression framework. In practice, these conditions are often not met. Also, the wide distribution of software solutions that allow econometric view of the problem on the principle of “black box”, leads to the results of the research being adopted, although the above conditions, which are assumed to be overlooked, simply do not stand.

If we set a dynamic framework, we can talk about homogeneous and heterogeneous panels. Macro-panels are often heterogeneous in practice, and on the other hand micro-panels can much more easily meet the condition of homogeneity.

We will present these problems through the prism of foreign direct investments in the countries of the Western Balkans. The problems in this regard can be multiple.

First, the Western Balkans have relatively strong country-specific characteristics.

Second, the panel itself is not large in size. A relatively small number of countries make up the observed region, and the lengths of the time series are not adequate for all cases.

Furthermore, we can talk about a whole series of problems, such as the great dependence on movements within the economy of European countries, structural disruptions and the like.

The rest of the work is organized in the following order. The next section presents an overview of the relevant literature. The third part describes the data set used in the empirical analysis. The fourth part presents the theoretical and methodological framework and the implications of choosing certain approaches in this regard. The last part presents discussion and implications of the use of panel regression models, ie warnings for their potential application.

2. LITERATURE REVIEW

The conclusion of most research is that foreign direct investment must have a positive effect on economic growth (Mahmoodi&Mahmoodi, 2016). Basically, investments have a positive effect, but this effect can be conditioned by a number of factors, which are defined differently by different authors (Tintin, C. 2013). The case of Bosnia and Herzegovina was also considered in this context (Popović

& Erić, 2018). On the other hand, there are also results that do not indicate exclusively the direct proportionality of investments and the sizes that determine growth (Kosova, 2010).

When observing econometric techniques, then the robustness of the methodological approach is assumed in relation to the problem of constancy of variance of regression errors and the problem of correlation that occurs at the level of an individual variable in the time dimension (deMelloJr., 1999).

In addition to technical-econometric reasons, essential conditions may be more important, and one of them is income. Thus, the adopted assumption is that foreign direct investment has a more pronounced positive effect when realized in countries with relatively higher income levels (Blomsrtom, Lipsey &Zejan, 1992). On the other hand, income can be linked to labor productivity, which can be further linked to the minimum level of human capital required (Borensztein, DeGregorio &Lee, 1995). This is one of the reasons why the part of the literature that deals with labor economics is fruitful and which, as we will present below, also offers answers in a methodological sense.

De Mello offered an approach that is technically acceptable. Namely, analyzing the effect of foreign direct investment, he observed two homogeneous groups - members of the OECD versus the group of countries that are not members of this organization (deMelloJr., 1999). However, such an approach is not possible for the countries of the Western Balkans. The region is small. Croatia is the only EU member that could be classified as a region, but if the situation was different, and if we had a larger number of countries that are members of the EU, and a larger number of countries that were not, we could do two homogeneous groups of countries. Thus, we would avoid the problem of heterogeneity, and this would free us from a whole range of technical problems.

It should be emphasized that when we talk about a homogeneous panel, we do not talk about a balanced panel. The panel is balanced when all observed individual cases have the same number of time units. If we have the same number of time units, but not the same time moments, then we get a panel that is in “weak balance”. A homogeneous panel, on the other hand, can be intuitively explained as a feature of individual cases that, although grouped, lie on the same regression line. Likewise, it is desirable that these regression rights have an upward trend.

Problems with panels in macroeconomic problems should be sought in the very origin of the panels. As we said, initially it was about microeconomic problems, ie a certain number of cases of interest were monitored in a certain period of time. Changes were recorded by certain attributes at certain time intervals that were not particularly long.

Meanwhile, the term panel has become a generic term. This was due to the fact that we have an intensive development of information technology, which has enabled the collection of data on a large scale. Now, panels are understood as data sets that are organized by several dimensions, of which time is one dimension.

Research was initially focused on linear panels of exclusively exogenous explanatory variables. Early works relied on the distinction between “fixed” versus “accidental” effects. Mundlak offered a solution that can be applied to linear panels that have one level (Mundlak, 1978). With this approach we can, in certain cases, approach problems that are heteroskedastic, but we are not yet fully ready to observe the problem in a dynamic framework, especially if we assume “accidental” effects. The solution to this problem has led to the widespread application of the generalized method of moments as a method of estimating parameters (Arellano & Bond, 1991). Again, this approach was originally intended for microeconomic problems that have greater n than T, where n is the number of individual cases in the model, and T defines time dimension.

When we have bigger T, then we come to an additional problem because of the “overexpressed memory” that the time series has. An absurd situation, but a real one: we need to see a larger pattern in time. At the same time, it can give us a distorted picture due to a number of characteristics of time series that should always be treated with special care.

Previously said can be summarized as follows. Panel involves sampling in time and space. Initially, sampling was oriented towards appropriate sizing in relation to space. On the other hand, sampling over time (if we can put it that way) is associated with a number of risks and it is not possible to have a parallel approach that we have when sampling in space.

To be more precise, Box-Jenkins', that is Engle-Granger's approach (Elliott,Granger & Timmermann, 2006) to the problem of data organized in the form of panels, has problems when there is a pronounced cointegration. It is possible that cointegration is not identified, both its occurrence in general and its adequate form, and then the equilibrium is identified where it does not exist. On the example of nominal courses it is shown that I (1), but due to the effect of the "long memory" Johansen test finds no link, and fractional cointegration gives false confirmation of nonstationarity (Baillie & Bollerslev, 1994).

When it comes to foreign direct investment in a panel regression environment, Pohelhekke & van der Ploeg (2013) reveal the shortcomings of the classical approach in a systematic way.

The answer, which in technical terms can be applied to a whole range of related problems, was given by macroeconomic researchers who primarily dealt with the relationship between investment and the labor market. Some examples are the works of Canova, et al. (2007) and Fujita (2012). Problem solving as described above has different expressions that often involve multivariable models, or models of vector autoregression, if desired, and robustness related to the problem of endogeneity. In this sense, the vector autoregression model as initially presented by Sims (1980) has come a long way, where in the circumstances of a panel regression environment classical statistical inference loses its primacy in favor of Bayesian statistical inference (Baumeister & Hamilton, 2015). The debate over the relationship between classical and Bayesian statistical inference is described in a paper written by Moon and Schorfheide (2012).

3. DATA

In this paper, we used data for Albania, Bosnia and Herzegovina, Croatia, Macedonia, Serbia and Montenegro in the period from 1998 to 2015. Data on gross domestic product (GDP) growth, real interest rates, data on foreign direct investment and consumer price indices are taken from the World Bank website.

It is necessary to clarify certain doubts with the data that exist for Serbia, ie Montenegro. Montenegro declared independence from the state union of Serbia and Montenegro in June 2006. In accordance with that fact, where possible, the data were separated.

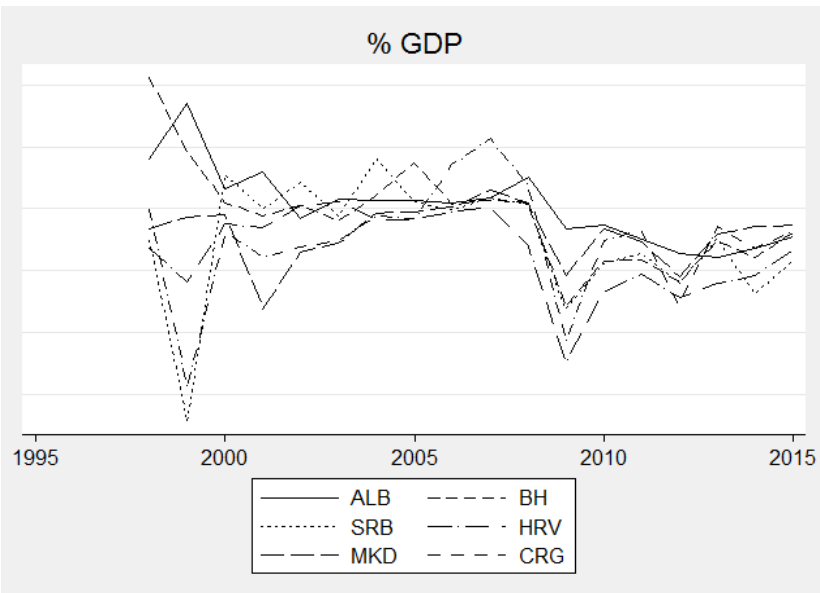
The real interest rate is the rate on loans adjusted for inflation, which is measured on the basis of the GDP deflator.

Note that the base year for the consumer price index is 2010.

Croatia is the only country in the observed group that is defined as a country whose income belongs to the upper middle level. This can serve as an indicator of the heterogeneity of the observed panel.

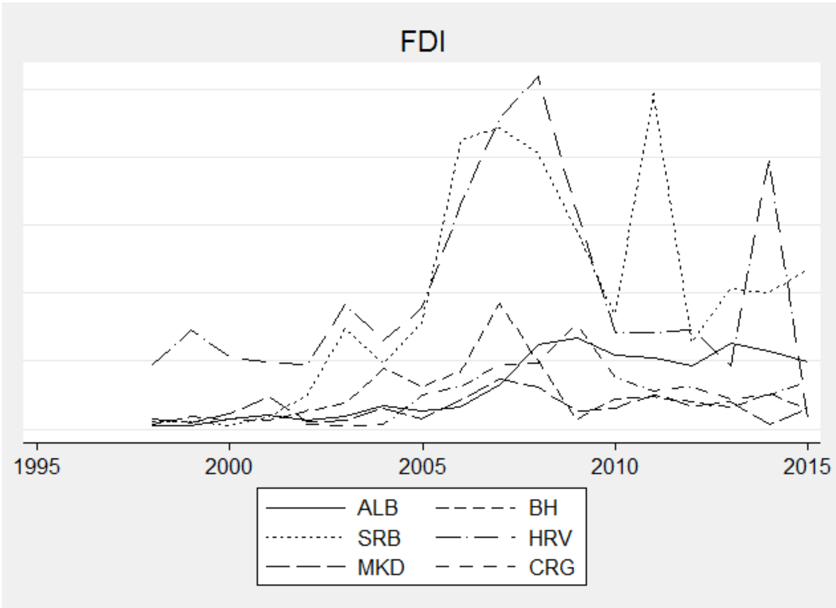
Let us look at data related to gross domestic product growth. We can see that Albania is a "special story" compared to other countries. Visually, we can state a high level of linear agreement between Serbia, Bosnia and Herzegovina and Montenegro.

Graph 1. Gross domestic product (GDP) growth for the observed group of countries



When we look at foreign investments, we get an insight into even greater heterogeneity.

Graph 2. Foreign direct investment (FDI) for the observed group of countries



4. DIFFERENT METHODOLOGICAL APPROACHES AND RESULTS

We start from the following model:

$$y_{it} = x_{it}\beta + \alpha_i + v_{it} \tag{1}$$

Here we have a model with "error as an integral part". If we had an error u_{it} with ordinary regression, now we have $u_{it} = \alpha_i + v_{it}$. Thus, we decompose the regression error into a part that is not variable in the time dimension and refers to individual effects, and an error parallel to the standard model. This is a relation that refers to the individual case in the panel, and with x_{it} we have the regressor vector with dimensions $1 \times k$, and β parameter vector with dimensions $1 \times k$ that need to be evaluated. We can take the next step, and that is to include, in addition to the time dimension, all the observed individual cases

$$y_{it} = \mathrm{X}_i\beta + \alpha_i + \mathrm{v}_i \tag{2}$$

where $\underset{T\times 1}{y_i} = \begin{bmatrix} y_{i1} \\ \vdots \\ y_{iT} \end{bmatrix}$, $\underset{T\times k}{\mathrm{X}} = \begin{bmatrix} x_{i1} \\ \vdots \\ x_{iT} \end{bmatrix} = \begin{bmatrix} x_{1,i1} \cdots x_{k,i1} \\ \vdots \quad \ddots \quad \vdots \\ x_{1,iT} \cdots x_{k,iT} \end{bmatrix}$, $\underset{k\times 1}{\beta} = \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_k \end{bmatrix}$, $\underset{T\times 1}{\alpha} = \begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_i \end{bmatrix}$, $\underset{T\times 1}{\mathrm{v}_i} = \begin{bmatrix} v_{i1} \\ \vdots \\ v_{iT} \end{bmatrix}$.

The specified expression can be written in matrix form:

$$\mathrm{y} = \mathrm{X}\beta + \mathrm{D}\alpha + \mathrm{v} \tag{3}$$

where

$$\underset{NT\times 1}{\mathrm{y}_i} = \begin{bmatrix} \mathrm{y}_1 \\ \vdots \\ \mathrm{y}_N \end{bmatrix}, \underset{NT\times k}{\mathrm{X}} = \begin{bmatrix} \mathrm{X}_1 \\ \vdots \\ \mathrm{X}_N \end{bmatrix}, \underset{k\times 1}{\beta} = \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_k \end{bmatrix}, \underset{NT\times N}{D} = \begin{bmatrix} 1_T & 0_T \cdots & 0_T \\ \vdots & \vdots \ddots & \vdots \\ 0_T \cdots & 1_T & 0_T \\ 0_T \cdots & \cdots & 1_T \end{bmatrix}, \underset{N\times 1}{\alpha} = \begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_N \end{bmatrix}, \underset{NT\times 1}{\mathrm{v}_i} = \begin{bmatrix} \mathrm{v}_1 \\ \vdots \\ \mathrm{v}_N \end{bmatrix}.$$

Here we have 1_T unit vector with dimensions $T \times 1$.

Let us start from the following assumptions

1. $\mathrm{V}(\alpha_i \mid \mathrm{X}) = \sigma_\alpha^2$
2. $\mathrm{V}(v_{it} \mid \mathrm{X}) = \sigma_v^2$
3. $E(\alpha_i v_{it} \mid \mathrm{X}) = E(\alpha_i v_{is} \mid \mathrm{X}) = 0$

We have already stated that we can write $u_{it} = \alpha_i + v_{it}$. The problem is that in the basic model (whether we assumed “fixed” or “random” effects) we assume that α_i is not correlated with the regressor. We also assume for a start that we have homoskedasticity. We note that it is clear that an approach that involves simply minimizing the square of the deviation cannot work because it is clear that we have a serial correlation of errors. We have a part of the error that “repeats” over time, which we can easily show:

$$E\left(u_{it}u_{is}|\mathrm{X}\right) = E\left[\left(\alpha_i + v_{it}\right)\left(\alpha_i + v_{is}\right) | \mathrm{X}\right] = E\left[\left(\alpha^2{}_i + v_{it}v_{is} + \alpha_i v_{is} + \alpha_i v_{it}\right) | \mathrm{X}\right] = \sigma_\alpha^2$$

The problem of inaccuracy of standard errors can be solved to some extent by classifying them into certain clusters.

Why is it a problem if α_i correlates with the regressor for the least square method (OLS)? Then the evaluator is biased and inconsistent, that is, we have:

$$plim\hat{\beta}^{OLS} = \beta + \operatorname{cov}(x_{it}, \alpha_i) \big/ \sigma_x^2 .$$

This problem is usually solved by assuming “fixed” effects, ie by applying a special case of the generalized method of least squares (FGLS).

Fixed effects

An evaluator that assumes “fixed effects” implies strict exogenousness and identification, ie for the first condition we have $E\left(v_{it} \mid \mathrm{X}_i\right) = 0$, and the second means that all regressors change over time. The first condition is analogous to the condition we had with ordinary regression, and essentially means that the error can not be correlated with some of the regressors at any time period. Now we extend the condition from the classical regression by the time dimension. This is an important condition, which prevents us from simply including a dependent variable with a time shift (delay) if we want an image in a dynamic frame. Let us look at the following expression

$$y_{it} = \alpha y_{i,t-1} + \mathrm{x}_{it}\beta + \alpha_i + v_{it}$$

where we have a correlation between the regressors from period t and $(t-1)$, because $y_{i,t-1}$ contains $v_{i,t-1}$.

Let us set things in the context in which we take averages for the observed time periods:

$$\bar{y}_i = \bar{\mathrm{x}}_i\beta + \alpha_i + \bar{v}_i \tag{4}$$

So we take the average for T time periods, and in this case it is clear that we have $\bar{\alpha}_i = \alpha_i$. With this we get the “between” evaluator, and with the following expression we get the “internal” evaluator:

$$y_{it} - \bar{y}_i = \left(\mathrm{x}_{it} - \bar{\mathrm{x}}_i\right)\beta + \left(\alpha_i - \alpha_i\right) + \left(v_{it} - \bar{v}_i\right) = \left(\mathrm{x}_{it} - \bar{\mathrm{x}}_i\right)\beta + \left(v_{it} - \bar{v}_i\right) \tag{5}$$

We subtracted equation (4) from equation (1) to get equation (5), that is, by subtracting the mean of the data for a certain period of time from the data, we lost α_i, thus obtaining the “between” estimator:

$$\tilde{y}_{it} = \tilde{x}_{it}\beta + \tilde{v}_{it} \quad (6)$$

Now we can see why it is important to us $E(v_{it} \mid X_i) = 0$, that is, that the errors are not correlated with the regressor, but also in each period, because $\tilde{v}_{it}$ contains v_{it} for all periods for an individual observed case. We also see why the second condition is important, that is, that regressors vary over time. If this is not the case, the specific individual observation simply disappears with the specified transformation. We can use a binary variable in the evaluation process

$$\begin{bmatrix} y_1 \\ \vdots \\ y_N \end{bmatrix} = \begin{bmatrix} X_1 \\ \vdots \\ X_n \end{bmatrix} \beta + \begin{bmatrix} 1_T & 0_T & \cdots & 0_T \\ \vdots & \vdots & \ddots & \vdots \\ 0_T & \cdots & 1_T & 0_T \\ 0_T & \cdots & \cdots & 1_T \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_N \end{bmatrix} + \begin{bmatrix} v_1 \\ \vdots \\ v_N \end{bmatrix} \quad (7)$$

$$\Leftrightarrow y = X\beta + (d_1 \ldots d_n)\alpha + v \quad (8)$$

This allowed each variable to have its own section on the *y* axis. Equations (6) and (8) are equal.

Let us look at a concrete example we have in our case. The panel is poorly balanced. For now, we do not assume that there are errors in the cluster and we have "fixed" effects:

$$GDP\ growth = \underset{0.54}{0.65}\, ln\_fdi - \underset{0.025}{0.06}\, cpi - \underset{0.052}{0.115}\, interest - \underset{9.78}{4}$$

$$R^2 \begin{cases} internal = 0.1357 \\ between = 0.2914 \\ total = 0.0335 \end{cases} \quad (9)$$

$$\text{Prob} > F = 0.0083$$

Let us set the errors in the sense that they are robust to the correlation of residuals within individual cases, but also that they are heteroskedastic.

$$\begin{aligned}
&GDP\ growth = \underset{0.96}{0.65}\,ln_fdi - \underset{0.028}{0.06}\,cpi - \underset{0.046}{0.115}\,interest - \underset{19.73}{4} \\
&R^2 \begin{cases} internal = 0.1357 \\ between = 0.2914 \\ total = 0.0335 \end{cases} \\
&\text{Prob} > F = 0.0083
\end{aligned} \tag{10}$$

Let us see what is happening now with the errors in the evaluation of individual parameters.

$$\begin{aligned}
&\operatorname{var}\left(\hat{\beta}\right)_{cluster} = \left(\sum_{c=1}^{C} x_c x_c'\right)^{-1}\left[N^{-1}\sum_{c=1}^{C}\sum_{j=1}^{N_C}\sum_{k=1}^{N_C}\hat{u}_{jc}\hat{u}_{kc}x_{jc}x_{kc}'\right]\left(\sum_{c=1}^{C} x_c x_c'\right)^{-1} \\
&\operatorname{var}\left(\hat{\beta}\right)_{HW} = \left(X'X\right)^{-1}\left[\sum_{i=1}^{n}\hat{u}_i^2 x_i x_i'\right]\left(X'X\right)^{-1}
\end{aligned} \tag{11}$$

The Huber-White variance, or parameter estimation error (HW-Huber White), would be essentially the same as the one we apply to the cluster, if each observation had its own cluster. The Huber-White method enables robustness if we do not have homoskedasticity, ie constancy of residual variance (regression errors).

If the residues or errors are independent, then we essentially have an equality between the Huber-White method and the one adapted for clusters. That is, when we have a correlation between errors for individual cases within the panel. When we do not have homoskedasticity in the classical regression model, we use the Huber-White method, and as a result we have an increase in the errors of estimating certain parameters. When the error correlation is positive, then we have an increase in errors. On the other hand, sometimes the error correlation is negative, and we have a decrease. We can see this in the example of the coefficient that is related to the variable *interest* in our case. In this sense, not assuming the possibility of correlation of errors at the level of individual cases monitored over a period of time, leads to an even greater possibility of drawing erroneous conclusions.

Let us further explain the “fixed” effects through an approach that involves the application of binary variables, ie allowing each individual country of the observed region to have a separate section on the vertical axis - we have defined characteristics of *i* case that are not variable over time.

With fixed effects, we removed variations between groups within the panel by subtracting the means from individual cases.

The disadvantage of this approach is that we lose certain degrees of freedom, but also in the inability to see the effects of interests that vary over time.

There is a possibility of subtracting individual values, ie defining increments, which removes fixed effects, which is essentially a similar approach to that which implies subtraction of arithmetic means, as we originally presented. This second approach is better in the case when we have the presence of serial correlation.

Serial correlation can be easily treated by placing the analysis in a dynamic framework, that is, we have:

$$y_{it} = \lambda_i - y_{i,t-e} + \beta_i x_{it} + u_{it} \tag{12}$$

where $u_{it} = \gamma_i f_t + \varepsilon_{it}$. For $i = 1...N$ and $t = 1...T$ and $\lambda < 1$ we have a dynamic process that has been current for some time. We have a homogeneous panel if $\lambda_i = \lambda$ and $\beta_i = \beta$.

This procedure is not adequate if we do not meet certain conditions. The bottom line is that we need to have a large panel. Then we can define average values by time or other dimension, and approach the further evaluation process with values that are true indicators of the effects in time or space, if we can put it that way.

We can also apply the classical regression model to data organized in the form of panels, but it is desirable to take into account the serial correlation. We can look at such case on our data. So we have the following model

$$GDP\ growth = -\underset{0.57}{0.36}\, ln\_fdi - \underset{0.026}{0.02}\, cpi - \underset{0.059}{0.079}\, interest - \underset{12.9}{12.73}$$

$$R^2 = 0.0665$$

We see that we get a model, which, in addition to the fact that there is no statistically significant coefficient, does not offer logical conclusions. Of course, we can doubt whether they are not good conclusions or statistical significance. Let us note that we took into account the serial correlation of errors. However, we did not get satisfactory results. It is necessary to pay special attention to the fact that $|\beta_0| = 12.73$. Intuitively speaking, we have a problem with fixed effects that are difficult to identify.

Random effects

If we know the exact form of heteroskedasticity and serial correlation, we can be somewhat more precise by applying the special case of the generalized method of least squares (FGLS). We start from the following assumptions:

1. $E(v_{it} \mid \mathrm{X}_i) = 0$ - strict exogenousness
2. $E(x_{it}\alpha_i) = 0$ - absence of “fixed effects”

If we do not have “fixed effects”, then we have “random effects”, which essentially means that we do not have correlations between regressors and effects that are not observed.

The evaluation process, intuitively speaking, represents a “quasi” removal of arithmetic means from individual observations, ie we have:

$$y_{it} - \lambda \bar{y}_i = (\mathrm{x}_{it} - \lambda \bar{\mathrm{x}}_i)\beta - (u_{it} - \lambda \bar{u}_i) \tag{13}$$

where $\bar{z}_i = \frac{1}{T}\sum_{i=1}^{T} z_{it}$, for $z = y, \mathrm{x}, u$ and $\lambda = 1 - \left(\frac{\sigma_v^2}{T\sigma_\alpha^2 + \sigma_v^2}\right)^{1/2}$. One can look at the covariance matrix in more detail, and see that the mentioned correlation is one zero.

The weight that defines the significance of the variations given to individual variations between groups is denoted by λ. If $\lambda = 1$, we have “fixed effects”, ie the existence of variations between individual groups is ignored. If we have $\lambda = 0$ then we apply the classical regression model to the data organized in the form of panels.

In the case of the Western Balkans, it is difficult to assume that this correlation is zero.

Let us go back to the evaluation process. First of all, we need to evaluate σ_α^2 and σ_v^2. There are several ways. One of them is:

1. We apply the classical regression model to data organized in a panel to estimate $\hat{\sigma}_u^2$', and the variance of composite residues $\hat{u}_{it}$;
2. Based on the values from the first step, we can calculate $\hat{\sigma}_\alpha^2$ as a covariance between two residuals for the same individual case, ie:

$$\sigma_\alpha^2 = \frac{1}{NT(T-1)/2-K}\sum_{i=1}^{N}\sum_{t=1}^{T-1}\sum_{s=t+1}^{T}\hat{v}_{it}\hat{v}_{is}$$

Basically, we obtain all the values we need to do as follows.

$$\begin{aligned}&GDP\ growth = \underset{0.797}{0.195}ln\_fdi - \underset{0.026}{0.038}cpi - \underset{0.051}{0.081}interest - \underset{17.002}{3.02}\\ &R^2\begin{cases} internal = 0.1142\\ between = 0.2478\\ total = 0.0357\end{cases}\\ &\text{Prob} > chi2 = 0.0015\end{aligned} \tag{14}$$

The question is how to decide which approach is adequate. The Hausman test is a standard procedure in this regard. In addition, it is necessary to include basic reasoning, which implies respect for basic economic and econometric settings. Namely, the situation when we have $E(x_{it}\alpha_i)=0$ is essentially an exception. The Hausman test is not exclusively intended for use in the process of determining the application of an adequate panel regression model.

The Hausman test involves calculating the Wald statistics given by:

$$H = \left(\hat{\beta}_{FE} - \hat{\beta}_{RE}\right)\left[\mathrm{V}\left(\hat{\beta}_{FE}\right) - \mathrm{V}\left(\hat{\beta}_{RE}\right)\right]^{-1}\left(\mathrm{V}\left(\hat{\beta}_{FE} - \mathrm{V}\left(\hat{\beta}_{RE}\right)\right)\right) \tag{15}$$

Where $H \overset{\alpha}{\sim} \chi_k^2$. Large values of the stated statistics (higher than the critical value with k degree of freedom) lead to the rejection of the null hypothesis.

However, the standard Hausman test is not effective when we have heteroskedasticity, ie when we have to take into account that we have to look at errors in a kind of clusters that are defined in accordance with the propositions of the panel. Then we have to apply Sargan-Hansen statistics.

The Haumsan test initially, without a realistic view of the errors, favors random effects. The null hypothesis that the difference in the coefficients is significant is accepted with $p = 0.2632$. Often, authors interpret software results superficially, in the sense that they do not see the limitations of certain tests. This can result in wrong conclusions.

However, the Sargan-Hansen statistics that is adapted for use in panel data has $p = 0.0000$, that is, there is no doubt that random effects are the wrong choice.

Let us go back to the basic assumptions. We have always had a strict exogeneity for regressors. How applicable is this in practice?

Let us pose the problem in our case. Can we say that if we know that foreign direct investment has an impact on economic growth, the opposite is not true?

We present the approach of Abrigo & Love, which in this sense represents an upgrade of the basic model of vector autoregression, which was once presented by Sims. We have the following set of linear equations (Abrigo & Love, 2015):

$$\mathbf{Y_{it}} = \mathbf{Y_{it\text{-}1}A_1} + \mathbf{Y_{it\text{-}2}A_2} + \mathbf{Y_{it\text{-}p+1}A_{p\text{-}1}} + \mathbf{Y_{it\text{-}p}A_p} + \mathbf{X_{it}B} + \mathbf{u_i} + \mathbf{e_{it}} \tag{16}$$

where $i \in \{1, 2, ..., N\}$ и $t \in \{1, 2, ..., T\}$. Further, Y_{it} is $(1xk)$ a vector of dependent variables, and X_{it} is (1xl) a vector of exogenous variables; $u_i e_{it}$ are (1xk) vectors of panel fixed effects and errors; Matrices $A_1, A_2, \dots, A_{p-1}, A_p$ are (kxk) dimensions, and matrices B are (lxk) dimensions, and represent the parameters to be evaluated. As for shocks, the following characteristics are assumed: $E[e_{it}] = 0, E[e'_{it}e_{it}] = \Sigma$ и $E[e'_{it}e_{is}] = 0$ for all $t > s$ (Abrigo & Love, 2015).

Note that the evaluation process itself in this case implies a generalized method of moments.

We cite this approach as one of the possible approaches to viewing panels in a dynamic framework. Namely, the author can easily be challenged to apply a dynamic framework. In doing so, he must take into account the probable occurrence of problems with autocorrelation. We explained that it is difficult to justify the use of “random effects”, and on the other hand if we start from “fixed effects”, we are sure of the problem of autocorrelation because α_i for some variable at the moment t remains unchanged compared to the moment $t-1$.

5. CONCLUSION

We can conclude that we need a sufficiently long time dimension, in addition to a sufficiently large number of individual cases. When we have a sufficiently long N and T we should, first of all, evaluate the model for each individual case using T_i observations in time, and then consider the average value for N obtained values. In this way we can see the “typical effect”.

There is also the possibility to take average values for N for for each time moment. Then we have one parameter vector based on the average time series. On the other hand, we can simply take averages over the time dimension.

It is necessary to emphasize the fact that “random effects” imply a completely different method of evaluation, and that the application of this approach implies the existence of unambiguous arguments.

For “accidental effects” we must have a strong grounding. As we have seen, when we assume “random effects” we mean that there is nothing “fixed” in the factors we do not control. We can draw a parallel with a typical microeconometric example. If we follow the success of students in school, then the assumption of “random effects” can be translated as success does not determine anything that is “fixed”, ie given in advance to the individual. Simply put, the assumption related to a certain number of students over time is set in the sense that everyone has the same starting positions. How applicable is this in the case of the Western Balkans?

Hausman test does not essentially exclude the existence of “fixed effects”. If we can express pictorially, “it can only allow us” to use “random effects”. However, “accidental effects” imply the existence of a number of other clear reasons for applying this methodological approach. Random effects would be possible if we had a population of the Western Balkan countries, and the set of countries we used in this analysis represented a random sample from that population. Is there such a reasoning basis?

When the included sample represents essentially the entire population, then we have “fixed effects” in the observed variables. When we have a small sample compared to a relatively large population, then we have “random effects”. Intuitively, we can conclude that if we have statistically significant coefficients that suggest random effects on the example of the Western Balkans region, and “random effects” are assumed, we can claim that foreign direct investment has a positive impact on growth for a group of countries for which our 6 represent a small random sample. This conclusion is not the same as: “foreign direct investment has a positive effect on growth in the Western Balkans region”.

On the other hand, it does not mean that we have confirmed the opposite. We simply have no evidence to make a claim in the sense set forth in the preceding paragraph.

We should also mention the problem with the data in the case of the existence of structural interruptions, which is a common situation. The authors easily resort to the ad hoc solution of using a binary variable in these cases, ignoring the need for an essential specification. Often the inclusion of a binary variable will not lead to a solution to the problem that our residues are not normally distributed. We must not ignore this fact easily. However, the problem of determining the exact moment of a structural break can take on unusual connotations in problems involving panel-organized data.

Let us say we have quarterly data and we are observing the Western Balkans region and we want to take into account the global financial crisis. Can we claim that the effect of the crisis for all countries began at the same time and with the same intensity? Let us neglect the econometric basis, here we have the question of the logical and economic unfoundedness of the assumption.

The question is how to solve all these problems when we have a set of small open economies with relatively short time series related to macroeconomic data.

Contemporary authors strive for a solution that implies a certain a priori attitude related to the theoretical arrangements of controlled variables. Simply put, we use some form of Bayesian statistical inference.

Specifically in this case of foreign direct investment, the use of some form of vector autoregression model with sign restrictions is recommended. In this sense, Uhlig's approach (Uhlig, 2005) provides a number of possibilities for setting sign restrictions based on a priori assumptions in the style of Bayesian statistical inference. In this theoretical framework, when we consider the relationship between capital flows and the labor market in the context of B&H, we can achieve robust results (Baškot, 2020).

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ОГРАНИЧЕЊА ПРИМЈЕНЕ ПАНЕЛ РЕГРЕСИОНОГ МОДЕЛА: ПРИМЈЕР ЗЕМАЉА ЗАПАДНОГ БАЛКАНА

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САЖЕТАК

Панел регресиони модел може изгледати као привлачно рјешење у условима ограничених временских серија. Постављањем података по временској димензији за више појединачних случајева може дати привид повећања димензија прикупљених скупова података. У земљама Западног Балкана постоји проблем кратких временских серија. Поред тога временске серије имају низ структурних прекида. Панел регресиони модели можда се чине као рјешење тих проблема. Међутим, макроекономски проблеми имају своје специфичности које дефинишу ограниченост овог приступа.

Кључне ријечи: панел регресиони модел, хетерогеност, директне стране инвестијције, раст БДП