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On the Role of Portfolio Indicators of the Capital Flows in the Convergence Processes – An Application of Systems of Regression Equations in the Case of Selected CEE Countries

Piotr Adamczyk* and Mateusz Pipień†

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Abstract

We analysed the empirical importance of the capital flows in processes of economic convergence of the CEE region. We depart from reference net measures of capital flow reflecting the level of development of the financial system and focus on gross capital flow. Our econometric model is based on Seemingly Unrelated Regression Equation (SURE) elaborated by Arnold Zellner. This environment seems an alternative to standard panel regression, because it enables cross-country heterogeneity of parameters of interest (like pace of convergence). We tested several restrictions of the unconstrained SURE model, leading to simpler specifications that would allow for regional homogeneity of the role of a particular factor (like capital flows) in growth fluctuations and β-type convergence.

Keywords: convergence, labour productivity, economic growth, SURE, capital flows

JEL Classification: C30, O47

*Cracow University of Economics; e-mail: piotr.adamczyk@phd.uek.krakow.pl; ORCID: 0000-0003-0112-0568

†Cracow University of Economics; e-mail: eepipien@cyf-kr.edu.pl; ORCID: 0000-0003-1007-3871

1 Introduction

The convergence hypothesis stemming from the basic model of growth is a vital part of macroeconomic research initiated by Solow (1956). Convergence is one of the most important indicators showing how economic growth differs between countries or regions. It also provides information about a (any given) country's own path of catching-up processes. In the empirical literature there is no consensus about the existence of convergence. There are a lot of studies on the topic, but a variety of datasets and econometric models entail differences in the estimated results. In the literature there are different methodological approaches that can result in different estimates of parameters of convergence as well as contradicting conclusions about the very existence of convergence in some countries or regions.

However, there are a few seminal papers that seem crucial in convergence research, such as Barro and Sala-i-Martin (1990), Mankiw et al. (1992) or Rodrik (2013). All these papers bring some methodological novelties that aim to make the models more suitable and accurate based on the data. Barro and Sala-i-Martin proved that extending the neoclassical model to an open economy perspective leads to accelerating the speed of convergence. The authors showed that allowing for mobility of means of production results in faster catch-up speed in poor countries. In Mankiw et al. (1992) the application of human capital in growth regressions in order to capture the growing importance of knowledge in the economy changed the inference about the speed of convergence. Rodrik (2013) tested the existence of convergence in the manufacturing sector as a response to the lack of tendency for catching-up in poor countries at aggregate level.

In this study we would also like to take a step towards developing a more general approach to estimate the convergence effect. We enrich the studies of economic convergence by utilizing a new explanatory variable and applying a model adopted to test the convergence hypothesis in a heterogeneous environment. We provide two changes to the model of the convergence taken from Barro and Sala-i-Martin (1990). We employ capital flow in a set of explanatory variables and utilise systems of regressions instead of estimating the speed of convergence common for the analysed panel of countries. As regards the capital flows, we depart from popular approach to analyse the net capital flow variable reflecting the current account imbalances or the level of development of the financial market. The approach commonly met in the literature ignores important dimensions of the international adjustment process resulting from capital flows; Gourinchas and Rey (2014). It also does not reflect the high volatility of capital flows and its economic consequences; see Davis et al. (2019). Therefore, utilising disaggregated gross capital flows in the convergence model may yield more appropriate results which requires further investigation. Following Blanchard et al. (2019) we postulate that temporary shocks in real economy could have led to persistent change of output. Thus, we decided to test whether portfolio investment inflow (perceived as short run capital flows) can change the inference about

long run economic growth pace reflected in the conditional convergence models.
As regards our econometric approach we utilise a novel approach proposed by Pipień and Roszkowska (2018) elaborated for the purpose of convergence analysis in the Central and Easter European (CEE) countries and the Commonwealth of Independent States (CIS). The research methodology is built in the environment of the Seemingly Unrelated Regression Equations (SURE) introduced by Arnold Zellner; see e.g. Zellner (1962). The empirical methodology departs from commonly used panel regression analysis, making detailed insight into cross-country heterogeneity of the catching-up speed possible. By recalling SURE as one of the most interesting generalisations of the simple linear regression model, we perform an econometric exercise that enables testing whether convergence is a country-specific phenomenon or an attribute of the whole analysed regions or a group of countries.
Empirical analyses is based on the annual time series for eight Central and Eastern Europe countries covering the period from 2004 to 2019 (the time span of the study is based on the availability of data on capital flows from the International Monetary Fund). The data utilised in this research are capital flows taken from balance of payment statistics (financial account; FA and portfolio investment inflow; POR_IN) and additional regressors such as investment rate, government consumption, the rate of inflation and others, taken from The Penn World Tables 10; see Feenstra (2015).
The article is organised as follows: in Section 2 we review the literature on the conditional convergence in the CEE countries, Section 3 provides literature review about the role of the capital flows in the process of convergence. Section 4 introduces the econometric model, while in Section 5 we discuss empirical results, and in Section 6 we make final conclusions.

2 Convergence in the CEE region – literature review

The phenomenon of the conditional convergence in the CEE countries has been studied in many empirical works but there is no consensus whether the convergence empirically occur and what is the potential speed of convergence or divergence of the whole region. However, most of the studies confirm the existence of the conditional convergence, making – with some very minor exceptions – an assumption that each CEE economy catch-up at the same pace. In particular Szeles and Marinescu (2010) confirm the existence of the conditional convergence in the CEE region analysing the data taken from the period 1998–2009. Monastiriotis (2011) also found statistically significant conditional convergence in the region with catching-up speed equal to 31.3%, estimated on the basis of the panel regression model with fixed effects (FE). Cavenaile and Dubois (2011) showed that there is diversity in the effect of the conditional convergence between the old member states and the CEE countries in the period 1996–2007. In both analysed regions there is statistically significant convergence towards own steady states, with the speed of catching-up 19.8% and 41.6% respectively. Paper by Monfort et al. (2013) proves that during the process of economic integration with the old member states in 1990–2009, the CEE region was converging to its own steady state. Heller and Kotliński (2018) analysed the conditional convergence in CEE countries in 2004–2016 and estimated the annual catching-up speed at 17.97%. In paper by Alcidi (2019) there was the catching-up speed equal to 31% in 2000–2015 within the EU member states at country level and 20% at the regional level. In one of the latest study by Eftimoski (2020) conditional convergence was also confirmed when analysing data from the period 1997–2016.

In contrast Reza and Zahra (2008) rejected the hypothesis of the existence of the conditional convergence between ten countries that joined European Union in 2004 and the rest of the EU countries using a panel unit root model.

One may also find in the literature papers conjecturing that the phenomenon of the real convergence varies over time and the pace of the catching-up processes is subject to cyclical fluctuations; Greta and Lewandowski (2015). In case of the European Union, the most intense convergence took place in the years 2000–2007. Due to the economic impact of the global financial crisis that occurred in 2008 these processes seemed to slow down in the period from 2008 until 2015; see Matkowski et al. (2016). Cabral and Castellanos-Sosa (2019) confirmed existence of the convergence in the EU countries, but the crisis reduced the pace of output per capita growth in the region. There was also proved that EU membership contributed towards stronger both absolute and conditional convergence for the new member states.

In the aforementioned studies real convergence phenomenon was measured as GDP per capita, however there are also papers testing the convergence hypothesis in terms of the long run labour productivity. In the study of Rodrik (2013) the existence of the convergence effect in case of the labour productivity in the industrial sector in a group of 118 countries was found. There are also papers using mixed approach. In the study by Pipień and Roszkowska (2018) the convergence is tested subject to both GDP per capita and the labour productivity. The authors analysed two regions, the Commonwealth of Independent States and the Central and Eastern Europe in the period from 1992 to 2015. In the pre-crisis period, a relatively high variability of the catching-up speed between the CEE countries was observed, while in the post-crisis period the differences in the speed of convergence between countries decreased and the region became more homogeneous. There was no such regularity in case of the CIS region.

A comparison of the CEE region with others such as Western Europe or Commonwealth of Independent States shows that there are some different patterns of the conditional convergence between different group of countries. Consequently, one may conclude that there are certain conditions that make convergence within the CEE region different than in other regions. In this article, we postulate that the factor that may determine the differences in the path of the conditional convergence are the gross capital flows.

As noted by Igan et al. (2020), there are many studies investigating the impact of financial liberalization on economic growth, but the impact of capital flows as well as of any of its components seems uncharted. Some researchers take into account reference measures of the capital when analysing the convergence effect, where the human capital seems the most popular choice; e.g. Mankiw et al. (1992). Other authors focus mainly on foreign direct investment (e.g. Sohinger, 2005). In turn, in the research of Miron and Alexe (2014), the only factor influencing the speed of the real convergence is the current account. Another stream of research deals with the role of the capital accumulation in catching-up processes in case of the countries of the "old" EU countries. In the study by Młynarzewska-Borowiec (2017) it was found that capital accumulation was not of primary importance in the processes of the real convergence. There are also studies focusing on the role of the capital flows in the Balassa-Samuelson effect; see Belke et al. (2009), Belke et al. (2015).
However, the role of the portfolio flows and its impact on the conditional convergence processes has not been studied in detail. This obvious gap in the empirical literature motivated us to perform analyses presented in this paper.

3 The role of capital flows in processes of economic convergence

Capital flows are an important driver of economic growth for developing economies, where some shortage of inputs may occur during allocation processes. The inflow of capital to the economy allows to increase availability of production inputs, making costs of acquisition relatively smaller. According to the neoclassical growth models, this should stimulate investment and consumption at aggregate level, and thus should also amplify economic growth; see NBP (2012). In case of the CEE region, the role of the capital flows could be described in the period from 1990 to 2008 through the lenses of the neoclassical school; see NBP (2012). The inflow of capital seems important factor guaranteeing stable economic development of this region.
The consequences of the economic crisis that occurred in 2008–2009 changed the volume of capital flows and the nature they influence the growth. In recent years the literature emphasizes the role of the value of the gross flows (i.e. the value of inflow and outflow instead of analysing only the net value). This is due to the fact that gross flows are recently more volatile than net flows. Theirs impact on economic fluctuations may be stronger; see Blanchard and Summers (2019), Davis et al. (2019), Forbes and Warnock (2012) and Rey (2015). As Obstfeld notes, "recent experience shows, however, that gross international asset and liability positions furnish the key conduit through which financial meltdown is transmitted and amplified" (Obstfeld, 2012, pp. 15–16). Hence, the study of gross flows is considered as a more appropriate, as it reflects the impact of the volatility of capital flows on the economy. Analysing only net flows precludes capturing this effect. Previous research that concentrated

only on net measures did not take into account the fact that capital inflows and outflows may be caused by different factors (Janus and Riera-Crichton, 2013) and consequently they may affect the economic fluctuations differently; see Eng and Wong (2016). Analysing the data on gross flows is important for another reason as well. It makes it possible to study the effects of capital outflow, which so far seemed not to be a popular topic of research in case of developing countries; see: Suh (2019).

The use of gross measures of capital flows allows to spot certain regularities that are imperceptible when analysing the net flows. In particular the net approach ignores important dimensions of the international adjustment process resulting from capital flows; see: Gourinchas and Rey (2014). Also it does not reflect the high volatility of capital flows and theirs economic consequences; see Davis et al. (2019). In most empirical studies on economic growth capital flows appear only in the form of net flows reflecting a country's current account imbalance or is used as a variable approximating the level of development of a given financial system. In such approach, units of domestic and foreign capital are equal, and the balance sheet value shows whether more capital flowed out, reducing its availability in the country, or whether the inflow increased the capital stock in the economy. Recognition of the capital in this form, does not reflect the threats resulting from the growing value of gross capital flows, which were revealed during the global financial crisis. The dynamics of flows of the foreign capital is characterized by greater volatility that may have destabilizing impact on the economy. This is the case when abrupt changes in capital flows occur in response to crises, when both capital inflows and outflows plummet, which may not necessarily be reflected in a country's net balance sheets. In this sense, the unit of domestic and foreign capital may not be equal. Consequently we cannot simply include a balance of capital flows in the convergence equation. Therefore, we postulate that analysing capital flows in the net form lacks the ability to reflect the nature of capital flows and their impact on the economic growth.

Capital flows are perceived in recent years as factors potentially destabilizing the economic situation of developing countries. This is reflected in the literature on the causes and effects of international capital movements. The current economic situation in many countries makes the statement that economies tend to stabilize in the long run by themselves questionable. This may be proved by the fact that 10 years after the crisis, the United States or the euro area countries did not return to the pre-crisis path of economic growth. The dynamics of basic macroeconomic indicators is highly heterogeneous and susceptible to local trends; see Blanchard and Summers (2019). It has been assumed in the past that serious macroeconomic instabilities mainly occur in developing countries. The post-crisis difficult economic situation around the world has changed this approach. Developing countries are also exposed not only to internal imbalances, but also to serious shocks that may unexpectedly occur in highly developed countries; see Spence (2012). The problems of economic growth in developing countries result not only from the internal instability ascribed to them, but also from the changing macroeconomic situation of developed countries.

Capital flows may be considered as one of the main channels through which developed countries influence developing countries. Moreover, a sluggish return to the pre-crisis growth path suggests that factors that ought to affect the economy only in the short run could also have important influence on long run stability. Potentially such factors could be for example short term changes of capital flows.

Previous studies on the impact of capital flows on economic growth are inconclusive; see Aizenman et al. (2013). Vilutiene and Dumciuviene (2020) reach similar results in one of the latest research on the countries of Central and Eastern Europe. Neanidis (2019) states that not the level but the volatility of the capital flows negatively affects growth in the long run. Moreover the banking sector regulations are a factor mitigating the negative economic effects. In the work of Aizenman et al. (2013) the positive relationship between capital flows and economic growth in developing countries weakened during the crisis and became less stable. Additionally a change in the direction of the impact of particular types of capital flows on economic growth was found. In the study of Igan et al. (2020) it was found that during the pre-crisis period industries with a relatively high share of foreign capital developed faster than the others. Also a positive impact of capital inflow on economic growth in the long run was also found, which was interrupted by the outbreak of the crisis in 2008–2009. The authors also suggest that research on economic growth should take into account the composition of capital flows. The heterogeneity of the balance sheet composition of countries and its different impact on the economy is also part of the research by Gourinchas and Rey (2014). However, the aforementioned papers do not analyse the role of disaggregated capital flows in real convergence processes, which is the main goal of this article.

Recently economists are more likely to see the potential impact of short run factors on economic growth in the long run. Among many different measures of the capital flows, FDI has been perceived as an important factor for stable economic growth. However, the short run volatility of macroeconomic variables and its impact on medium and long run equilibrium prompts us to consider the long run consequences of short run capital flows such as portfolio investments.

The exposure to volatile capital flows may cause economic instability in developing countries. However the issues related to international capital flows described so far have been focused primarily on their impact on the economy in the short run. An important addition to the picture of the functioning of the economy in the environment of increasing capital mobility is the medium and long-run analysis. Therefore in this paper we analyse the impact of portfolio investments (perceived as a short run form of the capital flow) on the processes of economic convergence.

4 Zellner's SURE model in the problem of empirical verification of the convergence effect

Econometric analysis of the convergence phenomenon utilises the standard regression form of the conditional convergence equation established for a particular economy for observables taken in time points t=1,...,T:

$$\Delta \ln y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i \cdot z_{it} + \beta \cdot \ln y_{t-1} + \varepsilon_t, \tag{1}$$

where: y_t denotes labour productivity (GDP per employed) in year t (in PPP); z's are sets of additional explanatory (control) variables determining productivity in an equilibrium. Parameter β informs about the speed of convergence and according to theory it is expected to be negative. The quest for appropriate choice of a set of control variables in (1) is well documented in the broad stream of literature on growth regressions – a very popular subject of empirical inquiry in the 90's. A comprehensive study on empirical importance of factors determining differences in growth dynamics among countries all over the world was presented by Sala-i-Martin (1997).

Following Pipień and Roszkowska (2018) and Jarco and Pipień (2020) in this paper we apply the vector of control variables consisting of investment rates, government expenditure in relation to GDP, the inflation rate, and trend as a proxy for institutional or technological changes. Additionally we augment the equation by observables representing capital flows. In the empirical part of the paper we present full definition of capital flows measures used in our research. For an exemplary country, Equation (1) has the following form:

$$\Delta \ln y_t = \alpha_0 + \alpha_1 \cdot \left(\frac{G_t}{Y_t}\right) + \alpha_2 \cdot \pi_t + \alpha_3 \cdot \pi_t^2 + \alpha_4 \cdot i_t + \gamma \cdot CF_t + \omega \cdot t + \beta \cdot \ln y_{t-1} + \varepsilon_t, \tag{2}$$

where y_t denotes GDP in the country at year t, G_t denotes government consumption expenditure in country in year t, i_t is the investment rate (gross fixed capital formation in relation to GDP), π_t is the inflation rate (percentage change of consumer prices over previous year), t is the time trend component with the slope parameter ω and finally CF_t represents observation of capital flows with γ measuring theirs impact. When analysing convergence processes the inference about parameter β in (2) is of particular importance. However some additional information about the long-term growth rate of labour productivity can be analysed by estimating the nonlinear function of parameters given by

$$g = -\frac{\omega}{\beta};$$

see: Pipień and Roszkowska (2018), Jarco and Pipień (2020).

Next, for a cross-sectional analysis we build the system of regression equations as an alternative for the very popular strategy utilising the panel regression approach. Our model is based on Seemingly Unrelated Regression Equations (SURE) developed by Arnold Zellner (1962). The methodology elaborated by Zellner departs from commonly used cross sectional regression and makes it possible to test relationship between regressors and exogenous variables between heterogenous units. This approach seems to be an adequate alternative to standard panel regression models where random effects are estimated imposing an assumption of the constancy of parameters in the group of countries being analysed. In the environment of Zellner's methodology we are able to relax the assumption of constant structural parameters and obtain more generalised econometric structure compared with standard panel regression.

Suppose that we analyse n countries, and for j-th country $j = 1, \ldots, n$ the convergence regression (2) is considered without making any assumptions about cross country constancy of structural parameters. In the following system of equations the impact of all variables on the right side of equation may vary across countries:

$$\Delta \ln y_{tj} = \alpha_{0j} + \alpha_{1j} \cdot \left(\frac{G_{tj}}{Y_{tj}}\right) + \alpha_{2j} \cdot \pi_{tj} + \alpha_{3j} \cdot \pi_{tj}^2 + \alpha_{4j} \cdot i_{tj} + \\ + \gamma_j \cdot CF_{tj} + \omega_j \cdot t + \beta_j \cdot \ln y_{t-1,j} + \varepsilon_{tj}. \quad (3)$$

The assumption that for each j, the Gaussian error terms ε_{tj} in (3) are uncorrelated, makes the system of equations independent. This case, denoted by M_0, formally refers to the empirical strategy of estimating convergence parameters separately within a particular j-th regression. However in general error terms ε_{tj} may exhibit cross correlations, and the system (3) can be treated as a SURE model; see Zellner (1962). We define this case as M_1. Nonzero contemporaneous correlations of error terms in (3) define a more ample stochastic structure particularly suitable for testing formally M_0 as a special case. The standard interpretation of nonzero contemporaneous correlations is also used as indicators describing linkages in the variability of related parameters across countries; see Olszak and Pipień (2016), Pipień and Roszkowska (2019), Jarco and Pipień (2020).

In our notation $\varepsilon_t = (\varepsilon_{t1}, \ldots, \varepsilon_{tm})$ is the row vector of error terms at time t with the covariance matrix Σ. In case of model M_1, the Σ matrix is symmetric and positive definite with $\frac{n(n+1)}{2}$ free elements σ_{ij}^2 , i=1,...,n and j=1,...,n. The variance of the error terms in the i-th country is denoted by $\sigma_{ii}^2 > 0$ and covariance between error terms in the j-th and i-th country stays as $\sigma_{ij}^2 \in R$.

The deterministic part of the right sides in system of equations (3) contain four elements, as it is presented below:

$$\Delta\ln(y_{tj}) = z_{tj}\alpha^{(j)} + [CF_{tj}]\gamma_j + [t]\omega_j + [\ln(y_{t-1,j})]\beta_j + \varepsilon_{tj}.$$

Consequently the whole model can be expressed in the following regression form:

$$y^{(j)} = z^{(j)}\alpha^{(j)} + CF^{(j)}\gamma_j + TR\,\omega_j + y_{-1}^{(j)}\beta_j + \varepsilon^{(j)}, \quad j = 1, ..., n$$

where
$y^{(j)}_{[t\times 1]} = (y_{1j},\ldots,y_{Tj})'$, $z^{(j)}_{[T\times 5]} = (z'_{1j},\ldots,z'_{Tj})'$, with: $z_{tj} = (1, \frac{G_{tj}}{Y_{tj}}, \pi_{tj}, \pi^2_{tj}, i_{tj})$, $CF^{(j)} = (CF_{1j},\ldots,CF_{Tj})'$, $TR = (1,2,\ldots,T)'$, and $y^{(j)}_{-1} = (y_{0j},\ldots,y_{T-1,j})'$. Additionally $\varepsilon^{(j)} = (\varepsilon_{1j},\ldots,\varepsilon_{Tj})'$ and $\alpha^{(j)} = (\alpha_{0j},\alpha_{1j},\alpha_{2j},\alpha_{3j},\alpha_{4j})'$.
In the next step, we stack the observations expressing the system of regression equations in the closed form:

$$Y = Z\cdot\alpha + CF\cdot\Gamma + BIG\_TR\cdot\Omega + Y_{-1}\cdot B + \varepsilon \tag{4}$$

where
$Y_{[nT\times 1]} = \left(y^{(1)'},\ldots,y^{(n)'}\right)'$, $\varepsilon_{[nT\times 1]} = \left(\varepsilon^{(1)'},\ldots,\varepsilon^{(n)'}\right)'$, $\alpha_{[n5\times 1]} = \left(\alpha^{(1)'},\ldots,\alpha^{(n)'}\right)'$, $\Gamma = (\gamma_1,\ldots,\gamma_n)$, $\Omega = (\omega_1,\ldots,\omega_n)'$, $B = (\beta_1,\ldots,\beta_n)'$ and:

$$Z_{[nT\times n5]} = \begin{bmatrix} Z^{(1)} & 0_{[T\times 5]} & \cdots & 0_{[T\times 5]} \\ 0_{[T\times 5]} & Z^{(2)} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0_{[T\times 5]} \\ 0_{[T\times 5]} & \cdots & 0_{[T\times 5]} & Z^{(n)} \end{bmatrix},$$

$$CF_{[nT\times n\ ]} = \begin{bmatrix} CF^{(1)} & 0_{[T\times 1]} & \cdots & 0_{[T\times 1]} \\ 0_{[T\times 1]} & CF^{(2)} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0_{[T\times 1]} \\ 0_{[T\times 1]} & \cdots & 0_{[T\times 1]} & CF^{(n)} \end{bmatrix},$$

$$BIG\_TR_{[nT\times n\ ]} = \begin{bmatrix} TR & 0_{[T\times 1]} & \cdots & 0_{[T\times 1]} \\ 0_{[T\times 1]} & TR & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0_{[T\times 1]} \\ 0_{[T\times 1]} & \cdots & 0_{[T\times 1]} & TR \end{bmatrix},$$

$$Y_{-1} = \begin{bmatrix} y^{(1)}_{-1} & 0_{[T\times 1]} & \cdots & 0_{[T\times 1]} \\ 0_{[T\times 1]} & y^{(2)}_{-1} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0_{[T\times 1]} \\ 0_{[T\times 1]} & \cdots & 0_{[T\times 1]} & y^{(n)}_{-1} \end{bmatrix}_{[nT\times n\ ]}.$$

The system (4) can be written in a compact form of the generalised linear regression model:

$$Y = X\theta + \varepsilon,$$

with the vector of unknown parameters $\theta = (\alpha', \Gamma, \Omega, B')'$, the covariance matrix of the error terms $V(\varepsilon) = \Sigma \bigotimes I_T$ and the matrix $X_{[nT\times 8n]}$ defined by:

$$X = \begin{bmatrix} X^{(1)} & 0_{[T\times 0]} & \cdots & 0_{[T\times 0]} \\ 0_{[T\times 0]} & X^{(2)} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0_{[T\times 0]} \\ 0_{[T\times 0]} & \cdots & 0_{[T\times 0]} & X^{(n)} \end{bmatrix},$$

where $X^{(i)} = [Z^{(i)} : CF^{(i)} : TR : y^{(i)}_{-1}]$, $i = 1, \ldots, n$.
The system (4) allows for heterogeneity of impact of all variables to growth fluctuations, including capital flows and lagged growth measure. Jarco and Pipień (2020) analysed two special cases of unconstrained SURE specification. In the first case they tested for constancy of all regression parameters except β_j, keeping the latter heterogenous across countries. In the second case they tested constancy of convergence parameter allowing for heterogeneity of all remained regression parameters. In this paper, compared to Pipień and Roszkowska (2018) and Jarco and Pipień (2020), we put a small step forward in elaborating econometric environment suitable for testing heterogeneity of the convergence processes. We analyse here some nontrivial restrictions of the system (4) allowing for cross country constancy of above predefined subvectors of θ, namely of α, γ, ω, and B. In particular the system (4) can be restricted to the model with no country specific nature of impact of control variables grouped in $z^{(j)}$. It can be obtained by analysing the following matrix Z_c instead of Z in (4):

$$Z_{c[nT\times 5]} = \begin{bmatrix} Z^{(1)} \\ Z^{(2)} \\ \vdots \\ Z^{(n)} \end{bmatrix}. \tag{5}$$

In this case control variables determine growth fluctuations in the same way in each country because $\alpha^{(1)} = \ldots = \alpha^{(n)} = \alpha^*$. Also one may be interested in testing hypothesis about the cross country homogeneity of impact of the capital flows. It can be performed by analysing the following matrix CF_c, instead of CF in (4):

$$CF_{c[nT\times 1]} = \begin{bmatrix} CF^{(1)} \\ CF^{(2)} \\ \vdots \\ CF^{(n)} \end{bmatrix}. \tag{6}$$

In this case $\gamma_1 = \ldots = \gamma_n = \gamma^*$. Analogously it is possible to test cross country constancy of trend parameters grouped in vector Ω by analysing matrix BIG_TR_c

– instead of BIG_TR in (4) – obtained by stacking trend vectors:

$$BIG\_TR_{c[nT\times 1]} = \begin{bmatrix} TR \\ TR \\ \vdots \\ TR \end{bmatrix}. \tag{7}$$

In this case $\omega_1 = \ldots = \omega_n = \omega^*$. And finally we can test for cross country homogeneity of convergence parameters by analysing the following matrix $Y_{-1|c}$ instead of Y_{-1} in (4):

$$Y_{-1|c_{[nT\times 1]}} = \begin{bmatrix} y_{-1}^{(1)} \\ y_{-1}^{(2)} \\ \vdots \\ y_{-1}^{(n)} \end{bmatrix}. \tag{8}$$

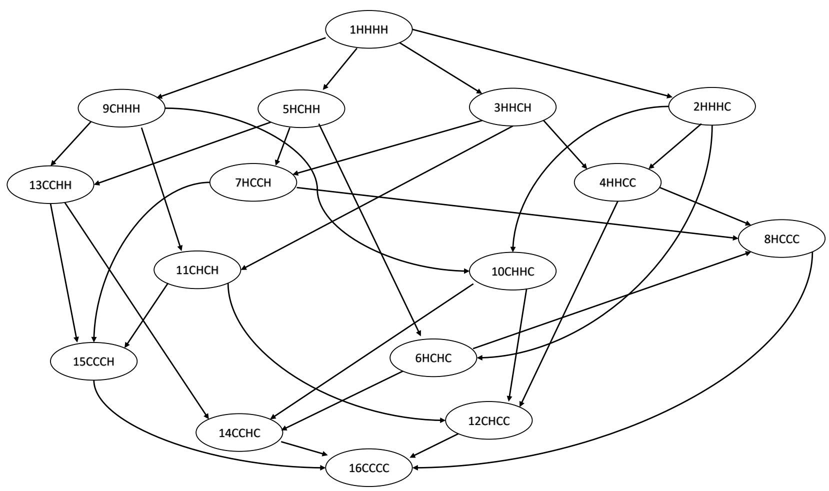
Table 1: The numbering of models being subject to analysis

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Regressors	H	H	H	H	H	H	H	H	C	C	C	C	C	C	C	C
Capital Flows	H	H	H	H	C	C	C	C	H	H	H	H	C	C	C	C
Trend	H	H	C	C	H	H	C	C	H	H	C	C	H	H	C	C
Convergence	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C

Note: "H" denotes heterogeneity of a particular component while "C" means constancy.

Just like in previous cases this requires restriction $\beta_1 = \ldots = \beta_n = \beta^*$. As a result the system (4) can be modified in many ways, because components build on the basis of matrices of observables (5), (7), (6) and (8) may be imposed by apart. Hence constancy of any specified subset of model parameters can be performed irrespectively to assumptions imposed on other elements. Finally there are 15 special cases of the system (4) numbered consecutively from 2 to 16; see Table 1. The unconstrained specification with cross country heterogeneity of all model components is labelled as the first one. Figure 1 illustrates inclusion relationships between competing specifications. We establish the notation that numbers models according to Table 1 and additionally we denote which component of the system (4) is subject to cross-country heterogeneity. We keep consecutive representation in (4) where explanatory variables appear in the following order: control variables including intercept, variable describing capital flows, trend and last but not least the lagged growth measure. For example 6HCHC denotes the model with cross-country heterogeneity of impact of control variables grouped in $z^{(j)}$ and country specific intercept, constancy of the impact of the variable describing capital flows (measured by γ^*), cross-country heterogeneity of trend parameters and constancy of the convergence parameter β^*. According to the graph presented on Figure 1 the model 6HCHC can be directly simplified to 14CCHC or 8HCCC imposing additionally cross country constancy of impact of explanatory variables or constancy of impact of trend respectively. Both models may be directly simplified to 16CCCC. As seen there are many different special cases lying between unconstrained SURE model 1HHHH, that corresponds to (4) and the model 16CCCC representing econometric environment equivalent to the fixed effects (FE) panel regression. All models described above can be estimated given two stochastic assumptions, resulting in the general model framework with models M_0 and M_1 imposing for matrix Σ respectively diagonal form (like in M_0) or unconstrained form (like in M_1).

Figure 1: Graph illustrating inclusion relationship between competing specifications



Note: Notation indicating cross country heterogeneity (H) or constancy (C) is ordered consecutively as presented in the system (5) where four components of the deterministic part are identified, namely: control variables including intercept, variable describing capital flows, trend and lagged growth measure.

Some details related to estimation methods can be found in Olszak and Pipień (2016) and Pipień and Roszkowska (2018). The form of the covariance matrix of ε makes the equation system (4), as well as other analysed model specifications, a generalised linear regression model. Based on Σ, the Aitken Generalised Least Squares estimator of all parameters in the system can be applied according to Zellner (1962).

5 Empirical analysis

Based on the theoretical considerations in previous sections we formulate three main hypotheses of our study:

1. Analysing capital flows in the net form lacks the ability to reflect the nature of capital flows and their impact on the economic growth.

2. Gross capital flows can determine the path of the conditional convergence.

3. Short run gross capital flows such as portfolio investment inflow may have an impact on the path of the long term growth reflected in the β-convergence parameter.

We realise how complex is the issue of economic consequences of international flows of capital and theirs role in the convergence processes. We analyse two variables approximating the capital flows: financial account and portfolio investment inflow. The first one is used by other researchers as a counterpart for the level of development of the financial system in a particular economy. Application of the latter is our contribution to the literature. We postulate that short run gross capital flows such as portfolio investment inflow may have an impact on the path of the long term growth. One of the aims of this paper is to test how model outcomes, particularly estimates of the speed of convergence, change as we substitute the measure of the capital flow, replacing standard financial account measure by the values of the portfolio investment inflow.

Firstly, we conducted maximum likelihood (ML) estimation in case of two competing stochastic specifications: constrained M_0 and unconstrained M_1; see Section 4. Tables 2 and 6 show decimal logarithms of the likelihood function calculated at ML estimates. We also report BIC and AIC score as well as the p-values of the LR tests of M_0 against M_1 in each model setting. The analyses show that unconstrained model is decisively supported by the data for each case. The unconstrained stochastic structure of M_1 is more favourable than M_0 specification. Cross country linkages, represented by non-zero non-diagonal elements of the covariance matrix Σ are empirically important in the problem of analysing heterogeneity of convergence processes within growth regression scheme. This result, being an essential outcome of application of the SURE model, was reported in previous studies by Olszak and Pipień (2016), Pipień and Roszkowska (2019) and Jarco and Pipień (2020).

We also tested direct restrictions along with the scheme presented on Figure 1. Tables 3, 4, 7 and 8 report the p-values of the likelihood ratio tests in case of M_0 (Tables 3 and 7) or M_1 (Tables 4 and 8) for both alternatives used to measure the capital flow, namely the financial account measure (Tables 3 and 4) or the values of the portfolio investment (Tables 5 and 6).

In case of models incorporating constrained stochastic structure (M_0) with financial account variable as a proxy for CF there is no doubt that fully heterogenous model

Table 2: Decimal logarithms of the likelihood function calculated at ML estimates, BIC and AIC scores and the p-value of the LR test of M_0 against M_1 in case of each specification. CF measure: FA

	M_0			M_1			
	Log-likelihood	BIC	AIC	Log-likelihood	BIC	AIC	p-value of the LR test of M_0 against M_1
1HHHH	306.20	-263.06	-468.41	408.59	-331.99	-617.19	8.50e-29
2HHHC	292.79	-270.19	-455.57	378.76	-306.28	-571.25	1.21e-22
3HHCH	293.44	-271.49	-456.88	387.05	-322.87	-588.11	1.74e-25
4HHCC	290.12	-298.82	-464.24	363.53	-309.79	-555.07	4.58e-18
5HCHH	299.87	-284.36	-469.74	401.08	-350.92	-616.16	2.39e-28
6HCHC	286.82	-292.22	-457.64	370.26	-323.25	-568.53	1.04e-21
7HCCH	283.32	-285.23	-450.65	372.72	-328.17	-573.45	6.52e-24
8HCCC	277.24	-307.03	-452.48	352.65	-321.98	-547.29	8.81e-19
9CHHH	263.95	-348.38	-453.91	331.98	-348.57	-533.96	3.78e-16
10CHHC	259.53	-373.51	-459.07	314.38	-347.35	-512.76	1.29e-11
11CHCH	258.36	-371.16	-456.72	314.36	-347.30	-512.72	5.29e-12
12CHCC	257.43	-403.26	-468.86	303.94	-360.43	505.89	6.63e-9
13CCHH	262.76	-379.96	-465.52	321.13	-360.85	-526.27	8.37e-13
14CCHC	254.78	-397.97	-463.57	300.91	-354.36	-499.82	8.80e-9
15CCCH	254.02	-396.44	-462.03	308.89	-370.32	-515.77	1.27e-11
16CCCC	252.38	-427.13	-472.76	297.41	-381.33	-506.82	1.94e-8

can be directly reduced only to model with no cross country variability of the impact of the capital flow variable (Table 3). It means that in the restricted model (5HCHH) country level heterogeneity of net financial account variable do not improve the inference about heterogeneity of the convergence parameter β. As regards the convergence parameter there were only two specifications that improved the fitting of the model to the dataset as a consequence of changing the parameter from constant to heterogenous (namely 1HHHH and 5HCHH fitted better to the dataset compared to 2HHHC and 6HCHC respectively; see diagonal from third row to fifth column in Table 3). In case with all other parameters constant, cross country heterogeneity of the convergence effect do not improve the fitting of the model to the dataset. It is depicted as a connection between 15CCCH and 16CCCC Figure 2; at any reasonable level of statistical significance there is no empirically important difference between models with constant (16CCCC) and heterogenous (15CCCH) convergence

Table 3: The p-values of the LR test of direct restrictions obtained in case of diagonal contemporaneous covariance matrix (M_0). CF measure: FA

Models in null →	2HHHC	3HHCH	4HHCC	5HCHH	6HCHC	7HCCH	8HCCC	9CHHH	10CHHC	11CHCH	12CHCC	13CCHH	14CCHC	15CCCH	16CCCC
Models in H_1 ↓															
1HHHH	4E-04	6E-04		**8E-02**				6E-06							
2HHHC			**6E-01**		**1E-01**				1E-03						
3HHCH			**5E-01**			5E-03				4E-04					
4HHCC							6E-04				1E-03				
5HCHH					5E-04	3E-05						1E-04			
6HCHC							8E-03						2E-03		
7HCCH							**1E-01**							7E-03	
8HCCC															**5E-02**
9CHHH									**3E-01**	**1E-01**		**9E-01**			
10CHHC											**8E-01**		**2E-01**		
11CHCH											**1E+00**			**3E-01**	
12CHCC															**2E-01**
13CCHH													**3E-02**	**1E-02**	
14CCHC															**7E-01**
15CCCH															**9E-01**

Note: The p-values greater than 0.01 are in bold font.

Table 4: The p-values of the LR test of direct restrictions obtained in case of unconstrained contemporaneous structure (M_1). CF measure: FA

Models in null →	2HHHC	3HHCH	4HHCC	5HCHH	6HCHC	7HCCH	8HCCC	9CHHH	10CHHC	11CHCH	12CHCC	13CCHH	14CCHC	15CCCH	16CCCC
Models in H_1 ↓															
1HHHH	2E-10	3E-07		**4E-02**				1E-16							
2HHHC			8E-05		**2E-02**				1E-12						
3HHCH			5E-08			2E-04				2E-15					
4HHCC							3E-03				4E-11				
5HCHH					7E-11	7E-10						7E-18			
6HCHC							1E-05						3E-14		
7HCCH							1E-06							2E-12	
8HCCC															9E-10
9CHHH									1E-05	1E-05		3E-03			
10CHHC											4E-03		3E-04		
11CHCH											4E-03			**1E-01**	
12CHCC															**7E-02**
13CCHH													1E-06	9E-04	
14CCHC															**4E-01**
15CCCH															2E-03

Table 5: Results of estimation of the convergence parameter β and the parameter γ (measuring impact of the CF measure in growth regression). Results are obtained in case of unconstrained contemporaneous structure (M_1). CF measure: FA

	1HHHH		5HCHH		16CCCC	
	β	γ	β	γ^*	β^*	γ^*
CZE	-1.08***	-0.346	-0.742			
	(0.106)	(0.0501)	(0.0771)			
EST	-0.289***	0.293	-0.175**			
	(0.100)	(0.400)	(0.0765)			
HUN	-0.364**	-0.173***	-0.334**			
	(0.139)	(0.0636)	(0.128)	-0.117	-0.118	-0.0149
LTU	-0.454***	0.117	-0.375***	(0.0190)	(0.0192)	(0.00921)
	(0.08)	(0.176)	(0.0773)			
LVA	-0.456***	-0.0368	-0.296***			
	(0.164)	(0.159)	(0.108)			
POL	-1.146***	-0.0868***	-1.284***			
	(0.159)	(0.0158)	(0.198)			
SVK	-0.225*	-0.0466	-0.221**			
	(0.126)	(0.244)	(0.103)			
SVN	-0.525***	-0.334	-0.456***			
	(0.173)	(0.256)	(0.157)			

Note: We chose for presentation unconstrained model 1HHHH, additionally – as a contrast – the FE panel regression 16CCCC and 5HCHH as empirically acceptable restriction of 1HHHH.
We present point estimates of parameters as well as standard errors in brackets. Statistical significance at level 0.01, 0.05 and 0.1 are denoted respectively as ***, ** and *.

parameter. Considering the role of capital flow variable in constrained model (M_0 with financial account variable) we can see that in case of two out of eight specifications (3HHCH and 4HHCC) making financial account variable heterogenous across countries brings improvement to the model. We can state that in constrained model with financial account there are many specifications that can be reduced to simple fixed effects panel data specification, however, in fully heterogenous model such a restriction is rejected.
As regards constrained model (M_0) with portfolio investment inflow used as a proxy for CF there are two specifications that allow one parameter (namely convergence and capital flow parameters) to be constant across countries. These cases are denoted as connections from 1HHHH to 2HHHC and 5HCHH respectively, which mean that fully heterogenous model (1HHHH) can be simplified to models with constant capital flow and constant convergence (Figure 4). Analysing the values of the LR test in Table 7 we can also state that changing convergence parameter from heterogenous to constant did not downgrade the data fit. Interestingly, when we look at the LR test p-values we can see that for each possible specification constant CF parameter

Table 6: Decimal logarithms of the likelihood function calculated at ML estimates, BIC and AIC scores and the p-value of the LR test of M_0 against M_1 in case of each specification. CF measure: POR_IN

	M_0			M_1			
	Log-likelihood	BIC	AIC	Log-likelihood	BIC	AIC	p-value of the LR test of M_0 against M_1
1HHHH	303.54	-257.73	-463.08	402.85	-320.50	-605.70	1.25e-27
2HHHC	298.08	-280.78	-466.16	384.91	-318.57	-583.81	5.88e-23
3HHCH	290.46	-268.54	-450.92	384.94	-318.65	-583.89	8.22e-26
4HHCC	275.91	-270.40	-435.81	368.96	-320.65	-565.93	2.82e-25
5HCHH	297.81	-280.25	-465.63	377.31	-303.39	-568.63	2.89e-20
6HCHC	290.30	-299.18	-464.60	371.36	-325.44	-570.72	7.79e-21
7HCCH	287.26	-293.10	-458.51	363.69	-310.11	-555.38	3.74e-19
8HCCC	274.31	-301.16	-446.61	360.58	-337.86	-563.17	9.38e-23
9CHHH	271.00	-362.47	-468.00	329.65	-343.91	-529.30	6.74e-13
10CHHC	259.73	-373.90	-459.46	301.54	-321.67	-487.09	1.90e-7
11CHCH	256.33	-367.10	-452.66	317.66	-353.90	-519.32	8.14e-14
12CHCC	254.66	-397.73	-463.32	298.70	-349.95	-495.41	3.94e-8
13CCHH	265.08	-384.60	-470.16	321.57	-361.72	-527.14	3.61e-12
14CCHC	255.72	-399.84	-465.44	299.81	-352.16	-497.61	3.82e-8
15CCCH	253.57	-395.55	-461.14	309.26	-371.06	-516.51	6.75e-12
16CCCC	252.35	-427.06	-472.69	297.32	-381.15	-506.64	2.023e-8

was more preferable than heterogeneous CF parameter. It means that in case of constrained stochastic structure M_0 with portfolio investment there is no sense in employing heterogeneity of capital flow across countries in convergence regression. There are two specifications that allow to reduce 1HHHH model, namely 5HCHHH and 2HHHC. Also there are many other simpler specifications that can be reduced to fixed effects panel model 16CCCC.

As regards model with unconstrained stochastic structure (M_1) including as a CF proxy the financial account variable there is also one direct linkage between fully heterogenous and partially fixed effects model. Formally, it is possible to reduce full SURE model 1HHHH to 5HCHH, which means that heterogeneity of capital flow variable does not improve the fitting of the model to the dataset (see Figure 3). In a model with constant value of convergence parameter for the whole CEE region (2HHHC) there was also no improvement when specifying constant value of financial

Figure 2: Graph illustrating restrictions with the p-values of the LR test greater than 0.01 obtained in case of diagonal contemporaneous covariance matrix (M0). CF measure: FA

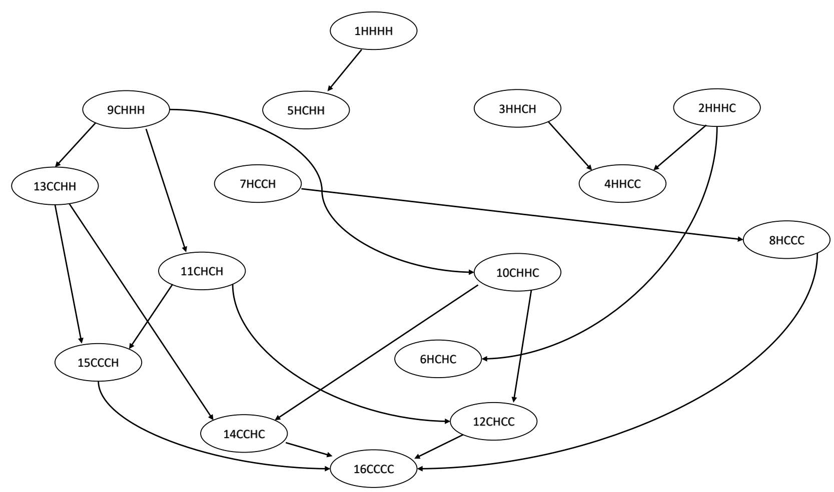


Figure 3: Graph illustrating restrictions with the p-values of the LR test greater than 0.01 obtained in case of unconstrained contemporaneous structure (M1). CF measure: FA

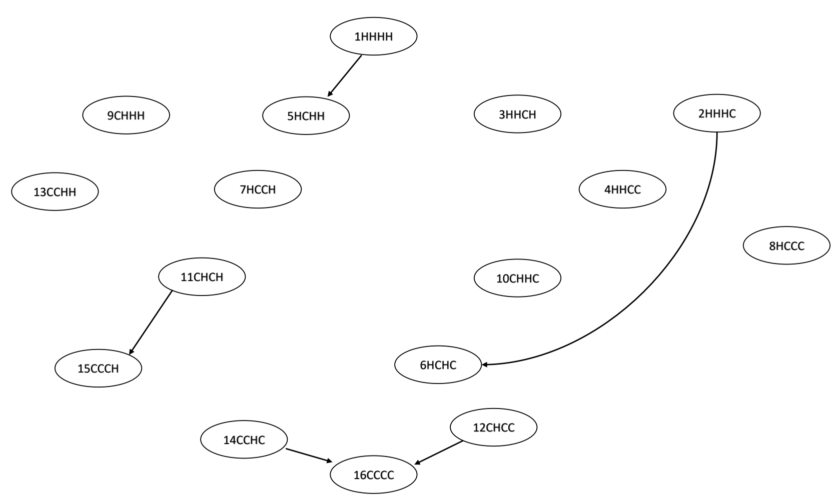


Figure 4: Graph illustrating restrictions with the p-values of the LR test greater than 0.01 obtained in case of diagonal contemporaneous covariance matrix (M0). CF measure: POR_IN

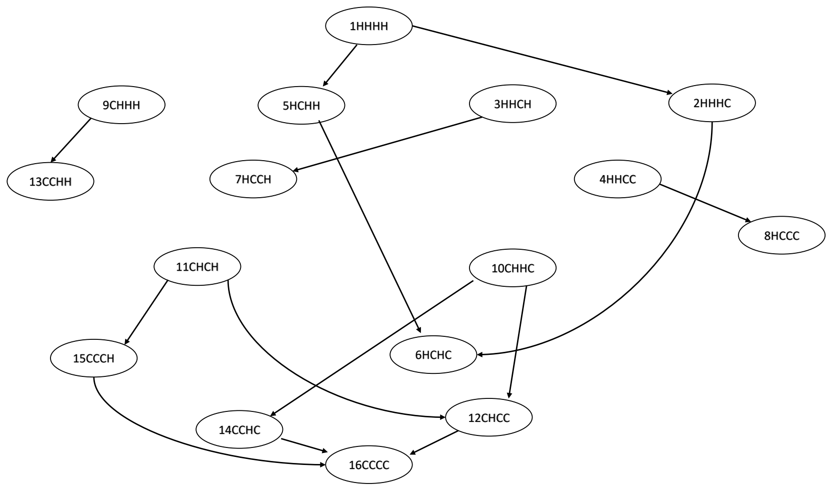


Figure 5: Graph illustrating restrictions with the p-values of the LR test greater than 0.01 obtained in case of unconstrained contemporaneous structure (M1). CF measure: POR_IN

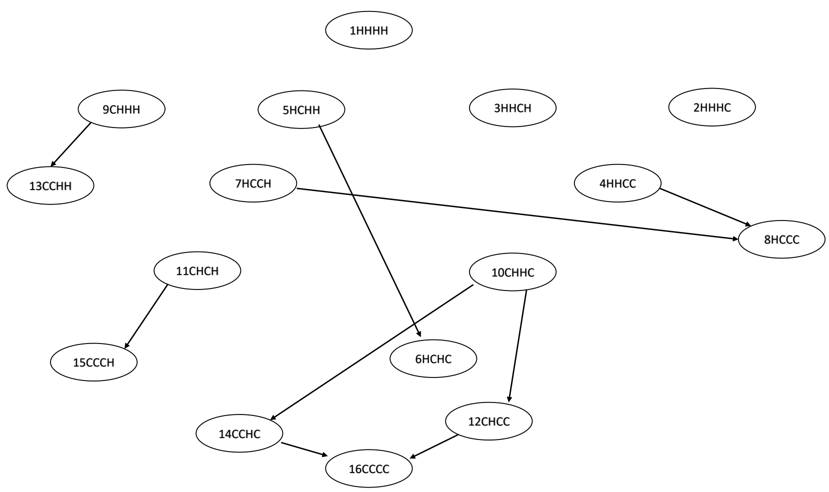


Table 7: The p-values of the LR test of direct restrictions obtained in case of diagonal contemporaneous covariance matrix (M_0). CF measure: POR_IN

Models in null →	2HHHC	3HHCH	4HHCC	5HCHH	6HCHC	7HCCH	8HCCC	9CHHH	10CHHC	11CHCH	12CHCC	13CCHH	14CCHC	15CCCH	16CCCC
Models in H_1 ↓															
1HHHH	**1E-01**	5E-04		**1E-01**				1E-03							
2HHHC			2E-07		**3E-02**				2E-06						
3HHCH			1E-04			**5E-01**				2E-07					
4HHCC							**9E-01**				8E-08				
5HCHH					**4E-02**	4E-03						6E-05			
6HCHC							4E-05						2E-07		
7HCCH							5E-04							4E-08	
8HCCC															2E-08
9CHHH									2E-03	1E-04		**1E-01**			
10CHHC											**2E-01**		**3E-01**		
11CHCH											**9E-01**			**6E-01**	
12CHCC															**7E-01**
13CCHH													9E-03	2E-03	
14CCHC															**5E-01**
15CCCH															**9E-01**

Table 8: The p-values of the LR test of direct restrictions obtained in case of unconstrained contemporaneous structure (M_1). CF measure: POR_IN

Models in null →	2HHHC	3HHCH	4HHCC	5HCHH	6HCHC	7HCCH	8HCCC	9CHHH	10CHHC	11CHCH	12CHCC	13CCHH	14CCHC	15CCCH	16CCCC
Models in H_1 ↓															
1HHHH	8E-06	8E-06		9E-09				1E-15							
2HHHC			4E-05		3E-04				2E-25						
3HHCH			4E-05			4E-07				1E-19					
4HHCC							**2E-02**				2E-26				
5HCHH					**1E-01**	3E-04						2E-18			
6HCHC							3E-03						4E-26		
7HCCH							**5E-01**							1E-22	
8HCCC															5E-27
9CHHH									9E-10	1E-03		**2E-02**			
10CHHC											**6E-01**		**8E-01**		
11CHCH											3E-06			**2E-02**	
12CHCC															**9E-01**
13CCHH													3E-07	9E-04	
14CCHC															**7E-01**
15CCCH															1E-03

account parameter in the regression. As regards competitive specifications with different forms of convergence parameter we can see that there was no specification with constant β parameter that improved the fitting of the model in comparison to specification with convergence parameter varying across countries (Table 4). Furthermore, changing capital flow parameter from constant to varying across countries improved the explanatory power of four out of eight analysed specifications. Moreover, contrary to M_0 only two simpler models can be reduced to the most simple 16CCCC. Consequently the stochastic structure in M_1 makes country heterogeneity of parameters more important in the view of the data.

In models of type M_1 with portfolio investment inflow as a variable reflecting capital flow in the convergence regression there was no specification that could replace a model with all parameters varying across countries (Figure 5). Changing convergence parameter from heterogenous to constant improved the fitting of the model in six out of eight specifications. It means that employing portfolio investment as a variable validates the use of heterogenous specification of the convergence regression. As regards capital flows there were only three out of eight specifications that improved the fit of the model when incorporating constant γ parameter instead of leaving it variable across countries. Interestingly, only in specifications with more heterogenous parameters there was an improvement of the fitting of the model as a consequence of changing the parameters from constants to varying across countries. In case of three specification (5HCHH, 6HCHC, and 7HCCH) replacing a constant CF parameter with a heterogenous CF parameter improved the model. It means that only specifications with no more than two constant parameters (namely 5HCHH with constant CF variable, 6HCHC with constant CF and convergence variable, and 7HCCH with constant CF variable and trend) improved as a consequence of employing heterogeneity of portfolio investment variable (see diagonal from third row and fifth column in Table 8). This may indicate that the effects of including portfolio investment variable in the convergence equation are much clearer in a more heterogenous environment. Moreover, these results are in favor of the hypothesis that Zellner structure (compared with restricted model M_0 is more optimal for testing convergence in heterogenous environment. The SURE system allow for vital differentiation between variables and their significance among countries and reveal linkages that are unobservable in standard panel data approach.

As a next step we analysed estimation results of parameters of interest in case of models reaching substantial empirical relevance. Tables 5 and 9 present ML point estimates and standard errors of convergence parameters as well as of parameters measuring the importance of the capital flows in growth regression. We focused only on stochastic structure given by M_1. In Table 5 we present results in case of application of the financial account measure while Table 9 is focused on results in case of the values of the portfolio investment. The analyses of explanatory power of competing specifications lead us to conclusion that it is useful to present estimation results in case of two models, namely 16CCCC being equivalent to the panel regression

Table 9: Results of estimation of the convergence parameter β and the parameter γ (measuring impact of the CF measure in growth regression). Results are obtained in case of unconstrained contemporaneous structure (M_1). CF measure: POR_IN

	1HHHH		16CCCC	
	β_j	γ_j	β^*	γ^*
CZE	-0.597***	-0.0362		
	(0.0921)	(0.0344)		
EST	-0.143*	-0.0645		
	(0.0837)	(0.283)		
HUN	-0.069	-0.244***		
	(0.165)	(0.0779)	-0.117***	0.012
LTU	-0.297***	0.0938	(0.0195)	(0.0138)
	(0.0834)	(0.174)		
LVA	-0.330***	0.138		
	(0.123)	(0.171)		
POL	-0.272**	0.078***		
	(0.112)	(0.0116)		
SVK	-0.168**	0.381***		
	(0.0755)	(0.0847)		
SVN	-0.315	-0.0844		
	(0.207)	(0.0985)		

Note: We chose for presentation unconstrained model 1HHHH, additionally – as a contrast – the FE panel regression 16CCCC. No other specifications are considered, because no restriction imposed on 1HHHH was empirically acceptable.
We present point estimates of parameters as well as standard errors in brackets. Statistical significance at level 0.01, 0.05 and 0.1 are denoted respectively as ***, ** and *.

FE environment and the model 1HHHH representing unconstrained heterogeneity of all parameters. Additionally, in case of financial account used as a CF measure we present results of the model 5HCHH, because it was not rejected as a restriction of 1HHHH at any reasonable level of statistical significance; see Table 3.
In fully heterogenous environment (1HHHH) there are substantial differences in the estimated pace of convergence in the CEE region in both cases of analysed measures of the capital flow. The estimates of the β parameter range from -1.146 for Poland to -0.225 for Slovakia in case of financial account proxied the CF. As regards the estimates in case of the financial account measure in growth regression there are also strong differences in catching-up processes across analysed set of countries. When considering only statistically significant results we can see that there is a pattern in the values in the region – for three out of four Visegrad group countries (the Czech Republic, Hungary and Poland) net financial account value had negative impact on the pace of growth. In a model with constant impact of the capital flow (5HCHH) there was also a discrepancy in the values of β, ranging from -1.284 for Poland to -0.221 for Slovakia. As regards γ, there was statistically significant value of -0.117

which means that, as in previous specification, the value of net financial account had negative impact on the catching-up process. Interestingly, when comparing 5HCHH with fixed effects panel model (which according to the likelihood ratio test did not improve the inference about convergence in comparison to 5HCHH) we can see that in the latter there was a significant difference in γ. Additionally, in model with constant parameters capital flow variable was not statistically significant.

In Table 9 we present results of estimation of the convergence parameter β and the parameter measuring the impact of the portfolio investment inflow (as a proxy for CF). Again, in fully heterogenous environment 1HHHH there are differences in the estimated values of β, which vary from -0.597 for the Czech Republic to -0.069 for Hungary. Also the values of γ are differentiated between countries (it varies from -0.244 for 0.381 for Slovakia). When we consider only statistically significant estimations we can see a pattern similar to the model with financial account – only in case of countries belonging to the Visegrad group the capital flow variable is statistically significant; here for Hungary, Poland, and Slovakia. Additionally, there are also different directions of the influence of the variable – in Poland and Slovakia inflow of the portfolio investment contributes positively to the catching-up process while in the case of Hungary there is a negative impact of foreign capital to growth dynamics. In comparison to the model with financial account variable we can state that portfolio investment variable in a convergence model brings more plausible beta parameter (mainly in case of Poland).

In contrasting specification with the combination of only constant parameters there was common pace of convergence in the region equal to 11.7%. In that case the capital flow parameter γ is not statistically significant, which may indicate that only in heterogenous environment there are some patterns of the role of capital flows in convergence equation. As we noted the values of γ could be both negative and positive in the region, which could also have an impact on fixed effects estimation. When we compare fixed effects panel models for both financial account and portfolio investment we can see that with all parameters constant there is no big difference in the value of beta parameter in contrast to models with heterogeneity of parameters across countries.

6 Summary

The purpose of our analysis was to scrutinize the role of capital flows in real convergence processes in case of the CEE countries. We contributed to the literature by utilizing a new variable and a model adopted to test the convergence hypothesis in a heterogeneous environment. We employed disaggregated capital flow variable (portfolio investment inflow) as suggested in the recent literature. Consequently we depart from analysing net financial account as a proxy for the role of the foreign capital. Our econometric approach is based on Seemingly Unrelated Regression Equation (SURE) elaborated by Arnold Zellner (1962) as an alternative to standard panel regression models. This model departs from commonly used cross sectional regression allowing for testing the relationship between regressors and exogenous variables between heterogenous units (countries, economies).

If we compare models with financial account and portfolio investment we can see that in constrained model with simple OLS method (M_0) fully heterogenous model (1HHHH) could be simplified to a model with constant capital flow parameters for both financial account and portfolio investment variables. When utilizing Zellner model (M_1) fully heterogenous specification could not be simplified to a model with constant capital flow parameter only in case of portfolio investment variable. It indicates that employing Zellner methodology to convergence analysis allowed to capture the heterogeneity of the role of gross capital flow across countries. It also means that gross capital flow variables can be best fitted to the data in specification with heterogeneity of capital flow parameter across countries.

Our model, being an outcome of the SURE, enabled to distinguish diverse influence of the capital flow to growth processes and convergence. In particular in the Visegrad group countries there was statistically significant value of capital flow parameter in models with both capital flow measures. In the model with financial account in case of the Czech Republic, Poland and Hungary the capital flow variable contributed positively to the speed of catching-up. In the model with portfolio investment inflow in Slovakia and Poland capital flow had positive impact on the speed of catching-up whereas in Hungary there was a negative impact of capital inflow on β convergence parameter. Moreover, such results were obtained only in SURE model – in standard fixed effects panel data approaches the impact of any capital flow was not statistically significant. Additionally, we observed that the measure of capital flows had significant impact on the value of β parameter. In case of Poland in model with financial account the β parameter equaled to -1.146 in comparison to more plausible -0.272 in the model with portfolio investment inflow variable. This might indicate that disaggregated capital flow variables are better fitted to the convergence inference due to less distortion of the estimates.

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