Doctoral (PhD) Thesis Summary

MEASURING AND INTERPRETING PROCESSES OF REAL CONVERGENCE IN ECONOMICS

A Study in Growth Econometrics and Simulation

ATTILA GÁSPÁR

Supervisor: Dr. János Kormos, CSc, university professor

UNIVERSITY OF DEBRECEN

Doctoral School of Economics
"Competitiveness, Globalisation and Regionalism" PhD Program

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1. INTRODUCTION

1.1 Previous research experience

Multiple factors influenced the selection of the main topic for the doctoral dissertation. Firstly, my consultants, Balázs Ferkelt and Emese Molnár Ilyésné, who proposed me this topic in 2007 during my undergraduate studies (regarding a TDK research paper). Secondly, both in economic and methodological point of view this research field is closely linked to my – macroeconomic and econometric – professional interest. Thirdly, a kind of ideological mindset also drove my choice: understanding and examining convergence and growth trends is extremely relevant – not only in economic terms. Fourthly, my macroeconomic and statistical work experience also contributed to my decision, even though I have not done any explicit convergence analysis during my work-related activities.

Finally, it is important to emphasize that in the recent years I have tried to pay attention to convergence analyses: I attended several conferences and some of my manuscripts were also published. Convergence analysis was also the main topic of my master thesis in 2011. However, the goal of my decision regarding this topic was to understand this highly complex and diverse area in a more comprehensive way.

1.2 The initial questions and problems

„Let Achilles and the tortoise start along a road at the same time, the tortoise (as is only fair) being allowed a handicap. Let Achilles go twice as fast as the tortoise, or ten times or a hundred times as fast. Then he will never reach the tortoise. For at every moment the tortoise is somewhere and Achilles is somewhere; and neither is ever twice in the same place while the race is going on. Thus the tortoise goes to just as many places as Achilles does, because each is in one place at one moment, and in another at any other moment."

Source: Akhilleusz és a teknősbéka – szöveg (2015) (Zeno ~B.C. 450)

Zeno drafted his well-known paradox in around 450 B.C. The short introductory story of the philosopher reflects the initial problem that distance measures need to be interpreted cautiously: it is possible that certain approaches lead to different conclusions. This problem is well known among convergence indicators.

Baumol (1986) was the first one to point out that convergence can be observed among industrialized countries – between 1870 and 1979 –, meaning that less developed

economies showed relatively faster real GDP per capita growth. De Long (1987), however, highlighted that the empirical results are biased, which is due to endogeneity and sample selection bias. Subsequently, however, following mainly the research of Barro and Sala-i-Martin (1991), several researchers estimated a catching up speed of around 2–3%, for example among the following regions and countries:

- US regions (Barro – Sala-i-Martin, 1991, 1992)
- regions of Italy (Bianchi – Menegatti, 2005)
- OECD member countries (Sala-i-Martin, 1996b)
- regions of Mexico (Diaz-Bautista, 2000)
- some South American economies (Barrientos, 2007)
- Islamic (OIC) economies (SESRIC, 2013)
- EU regions (Dall'erba, 2003; Martin, 1998)
- Central and Eastern Europe (Dedák és Dombi, 2009).

Many refer to the convergence rate of 2–3% as a new Káldor fact, despite of the fact that convergence cannot be detected among world economies. Another approach suggests, however, that this "mystique" rate may be due to the fact that we cannot sufficiently control on the unobserved heterogeneity. This means that some factors may grow at a similar rate (for example, as a result of the technological progress or preferences), which generates similar rates of convergence (Quah, 1996b). The rate of 2% can also be explained by the fact that the process is not necessarily stationary. Quah (1993) also pointed out that catching up can also be estimated based on cross-sectional samples, when the standard deviation is not decreasing. This fact is also considered to be controversial. Measurement error may also lead to biased estimation showing convergence.

At the same time, comparing empirical results may be difficult due to many factors. Firstly, many convergence definitions exist within economics. Unconditional convergence occurs when catching up takes place ceteris paribus. If convergence takes place under same or very similar structural variables/initial conditions, we can talk about conditional convergence or convergence clubs. The latter two approaches, however, can be identified as concepts of partial divergence (Kim – Heshmati, 2014).

In practice, convergence typically refers to diminishing disparities or to the catching up process of countries to each other or to a certain level. We can also find statistical, econometric and economic political interpretations, which cover different approaches.

Former ones typically refer to consistency, while the latter to the convergence of growth rates.

Secondly, macro models do not provide a universal and theoretical guidance. It means that different theoretical, initial conditions lead to quite different results. The structure and shape of the production function and the output elasticity of capital determines essentially whether steady state and transition dynamics exist, i.e. whether the hypothesis of the conditional convergence can be accepted or not. Consequently, convergence and divergence can be both implied by the macro models.

In neoclassical models, diminishing return on capital leads to conditional convergence among economies, in which the structural variables (typically the savings rate, population growth, depreciation, exogenous technological progress, the structure of production function) are the same. This means that the newly invested capital generates higher output than the previously invested one. In the endogenous growth theories, hypotheses of diminishing return on capital may typically not be accepted and due to certain spillover effects economies show long-run growth without any type of convergence. One typical example of such factors is the spillover effect of human capital.

Thirdly, convergence indicators also raise many questions. Beta-convergence occurs when a negative coefficient between the initial level of income and the rate of growth is estimated. Sigma-convergence refers to diminishing inequalities, which is typically measured as diminishing standard deviation. The two indicators are related: beta-convergence is required to achieve sigma-convergence, but the latter is also affected by many other factors.

In a regression analysis we would like to control on the main factors, which influence the steady state (based on beta-convergence). Estimations are, however, typically biased due to simultaneity, omitted variables or measurement error. In addition, identification problems and issues related to the choice of instruments, non-linear effects may arise and the estimation of the model can also be complicated by various sources of heterogeneity. Indicators based on standard deviation are also affected by these type of problems (e.g. by measurement error), in addition, the choice of weights and different types of data transformation can also lead to different results.

1.3 The goal and hypothesis of the dissertation

In this doctoral thesis I would like to contribute to the topics of convergence analyses, which can be considered to be a very popular stream within economics. Both theoretical

and empirical considerations drove researchers to deepen their knowledge. This thesis can be considered as an empirical study, but it is also based on the formal mainstream theoretical approach.

The primary aim of this dissertation is to demonstrate, analyse and verify the relationship among indicators of real convergence. Firstly, I give a summary of the major convergence definitions, theories and indicators. Secondly, I try to demonstrate the relation between theories of growth and real convergence in detail. Thirdly, empirical and simulation analyses are presented. Finally, I also try to demonstrate and quantify an alternative convergence indicator.

Based on these aspects, the following hypotheses were formulated:

1) In line with empirical results, divergence can be observed among world economies, but if we can control on appropriate variables, convergence can be estimated at global level.
2) Convergence indicators can be differentiated: the heterogeneous data can be divided into homogeneous sub-groups, different type of transformations can be performed, data can be weighted by population and so on. This allows us to better understand the convergence processes. The population-weighted results may show faster convergence process, which can be explained significantly by China's outstanding growth dynamics.
3) If the data is filtered by trying to minimalize the impact of business cycles and certain types of measurement error, a different pattern of convergence may be observed. I will attempt to do this on the basis of an alternative convergence indicator.
4) Theoretically, there is a link between the convergence indicators and concepts, but in practice they do not always follow each other. This is due to different type of shocks, endogeneity bias and incorrect assumptions regarding the data generating process. The extent of this discrepancy might be estimated with simulations.

1.4 Methodologies applied

The topic of this thesis is related to growth econometrics and simulation. Growth econometrics basically refers to applied or theoretical research, based on statistical and econometric methods estimating transitory or long-run growth dynamics. Simulations are based on partly or fully constructed data using certain initial assumptions. From the

economic point of view – within the macroeconomics – this thesis relates to growth theories and especially to theories of transition dynamics.

Sections of the thesis related to economic theory are partly based on the textbook of Barro and Sala-i-Martin (2004), while sections of econometric theory are partly based on the study of Durlauf et. al. (2004). In addition to these benchmark materials, I tried to cover a relatively wide range of the theoretical and applied literature.

The primary objective of the empirical studies based on growth econometrics is to explore the convergence process, that is, estimating the fact of catching up or falling behind and quantifying the time interval needed for the – potential – catching up. My goal was to get general conclusions, so I tried to maximize the sample size: 143 countries are taken into account from the 70's until recently (some models included 99 countries). The relative large sample size may also lead to the decrease of the distortion caused by sample selection bias.

In the convergence analyses I tried to model the evolution of GDP per capita, first of all by taking into account its initial level. Testing the coefficient of the lagged variable can be interpreted as testing convergence: if the coefficient is negative, then catching up took place in the time interval analysed, that is, the relatively less developed countries grew faster, ceteris paribus.

Since the speed of convergence is influenced by many factors, in case of controlling on these factors a partial, conditional convergence can be estimated. Such factors are, among others, demographic, fiscal, human development factors and balance indicators. Controlling on these variables makes it possible to identify the main growth determinants. On the other hand, however, in case of conditional convergence less developed economies will not convergence automatically.

The empirical research in the thesis is largely based on regression models, especially on panel models. Among different concepts of convergence, I tried to focus primary on catching up, which is due to two main factors. Firstly, convergence is usually defined as catching up. Secondly, the theoretical derivation, interpretation of the convergence is essentially linked to catching up.

In addition to the traditional techniques (within group, pooled OLS) I paid attention to more robust procedures (GMM) and methods less frequently applied (e.g. spatial correlation) for estimating convergence. I also paid attention to diagnostic tests (such as J-statistics, Hausman-test, conventional model selection and residual tests).

The main purpose of the relatively wider range of regression methods applied is of non-technical: firstly, I tried to reduce endogeneity bias. Secondly, alternative methods can be used in order to verify the robustness of the estimation. Thirdly, growth processes can be understood in a more comprehensive way by controlling on different sources of heterogeneity (geographical and country-group heterogeneity, different interactions, major traditional factors determining growth). In addition to the regression estimates, calculations based on standard deviation and further descriptive statistics are also demonstrated.

Analyses are based on data from the Penn World Table, UNCTAD, UN and IMF. The estimates were primarily calculated in EViews (v7) and Stata (v13). In addition, some simple indicators (e.g. standard deviation) were quantified in Excel (v2007 and v2016). Some calculations were run in SPSS (PASW v18) (mainly cluster analyses).

Some simulation procedures are constructed for the empirical analyses. Namely, a simple Bayesian model is run in order to illustrate how estimates of catching up change when initial assumptions are modified.

The conclusions derived from empirical analyses are based on samples, meaning that those are affected by measurement errors, different shocks, which may cause significant bias. Lack of knowledge regarding the data generating process might also raise a number of additional questions. Thus, the empirical studies are not automatically suitable to demonstrate the relationship among convergence indicators, which is a key objective of the doctoral dissertation. This is examined – by a Monte Carlo method – performed on simulated data. In addition, a simple endogenous growth model is defined, for which – compared to the Solow-model – the speed of convergence is quantified for different initial conditions. Hence, simulations possess an additional advantage, namely, that the data generating process is basically known, in contrast to a standard econometric analysis, which is considered to be completed, when the possible background of the data generating process is presented.

The simulations are programmed and run in MATLAB (vR2010a), in R (v3.2.0) and in Excel (v2007).

The methods applied and growth theories presented are briefly summarized by two charts and one table in the appendix.

2. CONCLUSIONS

2.1 Summary and theses

On the basis of empirical experiences, economic growth typically leads to the strengthening of convergence in homogeneous groups. Convergence usually stands for catching up or reduction of inequalities. The primary objective of the thesis is to present different approaches and indicators of real convergence in economics and to compare these through empirical and simulation analyses. In the thesis I also constructed and analysed a new convergence indicator, which I called omega-convergence.

The main results of this dissertation are summarized in the following theses:

Thesis 1: Substantial differences exist between endogenous and neoclassical growth models, among others, regarding the convergence properties. At the same time, we can also discover several relevant differences within each theoretical stream, which can also significantly influence transition dynamics and thus the speed of convergence. By endogenizing savings, by assuming an open economy model or capital-dependent depreciation, the speed of convergence would be faster, while adjustment costs, human capital, the introduction of a productive government sector, as well as capital-dependent savings rate lead to slower speed of convergence.

Neoclassical growth theories imply conditional convergence due to the diminishing return on capital. Mainstream models have the common feature regarding long-run trends: technological progress is actually the only long-run growth factor, but regarding the transition and convergence properties we can find significant differences among them, which is shown in the dissertation in a relatively detailed way.

Endogenous theories typically imply divergence and they also explain the technological progress in a more comprehensive way. On one hand, under certain parameter restrictions conditional convergence can be obtained. On the other hand, models can also be extended to achieve conditional convergence. In this case, however, more than one steady state may exist. This topic was also discussed in the thesis.

Thesis 2: Based on panel data regressed on the logarithm of GDP per capita growth, absolute convergence cannot be observed among world economies. At the same time, with

appropriate and sufficient variables we can control on the steady state differentials, and by doing so partial catching up can be estimated, which verifies hypothesis 1. It means that convergence takes place among homogenous countries, i.e. it does not automatically lead to the catch up of less developed economies. Moreover, the speed of convergence is relatively low, about 1–2% and we should also take into account that practically all models are subject to small or larger specification errors.

I got mixed results on the basis of beta-convergence: both divergence and convergence could be quantified based on panel regressions estimated on log GDP per capita values. The results are significantly influenced by the specification of cross sectional and period effects, instruments and control variables.

Taking into account various model selection criteria (e.g. p-values, J-statistics, Hausman-test, Wald statistics) and theoretical aspects, the convergence rate of about 1–2% seems to be the most likely based on the data of 143 countries, from 1970 to 2011. It is important to note that in case of such a slow speed, several hundred years are needed to catch up, ceteris paribus. Nevertheless, we should also note that estimations are subject to specific error terms. Note also that these results refer to relative homogenous countries.

By taking the Solow variables (investments, population growth) as control variables, this rate of convergence could also be reproduced (also with GMM procedure). This means practically that major part of growth trends can be explained by the Solow variables. Period effects were fixed, which is largely due to general technological progress and globalization trends typical for all countries.

A key task in case of using a GMM model, is to find appropriate instruments, because weak instruments can lead to substantially biased results. In practice, lagged variables are typically used as instruments, but this does not have to be necessary: as an alternative, I used, among others, Solow variables as instruments, which can be regarded as a kind of production function approach.

A simple Bayesian model is also demonstrated, which showed relative slow convergence dynamics, as well. Still, several factors, such as the prior variance and the selection of the benchmark economy do not only influence the scale of the coefficient, but also its sign.

Thesis 3: By applying sigma-convergence I estimated the standard deviation based on logarithm of GDP per capita values and I also decomposed the convergence indicator in several ways, among world economies. If – in contrast to the traditional approaches – data are weighted by the number of population, we can see diminishing inequalities, which is mainly explained by China's outstanding performance. Thus, the 3rd thesis confirmed hypothesis 2.

In case of sigma, results pointed out the positive impact of population weights on convergence. If China is excluded from the database, a similar pattern can be observed, as in the initial, unweighted case, which showed divergence. It means that China's outstanding performance – in parallel with the high number of citizens – explains substantially the diminishing inequalities. This result is in line with Milanovic's (2002) research.

Thesis 4: I verified the connection between sigma- and beta-convergence in several ways (derivation in an AR(1) framework, Monte Carlo simulations) and I also highlighted that substantial differences may exist between the mainstream approaches. Hence, the applied techniques verified hypothesis 4.

The discrepancy between beta and sigma is due to the fact that beta-convergence is a necessary condition for sigma-convergence, but the latter also depends on other factors as well. I derived in an AR(1) framework that different type of shocks influence sigma-convergence, which is also highlighted in the literature (e.g. Barro-Sala-i-Martin, 2004).

The Monte Carlo simulations confirmed that the sigma and beta lead to the same results in case of same initial conditions (the identity rate = 100%). However, if the variance of the error term is modified, i.e. some kind of shock is initiated in the current period, this one-to-one relationship no longer holds: the relative difference of one and a half times leads to the reduction of the identity rate by 40%. Nevertheless, the relationship between the variance and the rate is non-linear: the relative difference of two times leads to an identity rate of zero. This means that if an economy faces a crisis, then the correlation between the two indicators might be – even substantially – reduced.

Thesis 5: I developed a new alternative convergence indicator, which I called omega convergence. This indicator drew attention to partial convergence among world economies at aggregate level. This means that convergence can be estimated, if we try to measure conditional sigma-convergence and if we try to concentrate on some kind of "core growth", instead of the actual growth. Omega is an indicator based on cluster groups of GDP per capita values, proxies of the steady state and initial conditions, and it is calculated in a base- and current period, by taking into account the level of development. Thus, the omega can be interpreted as a weighted cluster difference. Consequently, the indicator verified hypothesis 3.

The basic idea of omega is based on the study from Durlauf et. al. (2004). The authors argued that it would be very useful from theoretical point of view to measure conditional sigma-convergence based on the concept of the conditional beta-convergence but the authors did not formalize this approach. In the thesis I have attempted to do so in a certain sense.

The idea of omega is based on data reduction (clusters) of GDP per capita, structural variables (i.e. convergence is basically conditional) and the initial conditions and after then changes of clusters are quantified. The alternative indicator is actually a modified, weighted indicator of standard deviation based on „cluster jumps" for measuring the presence and speed of convergence or divergence, while controlling on the relative level of development. Thus, the less developed a country is and the higher the growth rate, the higher the speed of convergence is.

At aggregated level partial convergence was found based on the alternative indicator between 1971 and 2011 (by taking into account the indicators listed) due to several factors. Firstly, when we take into account that each economy has different steady state levels (i.e. when we try to control on the steady state with proxies), we can get much better results in respect of convergence trends. Secondly, many countries were very developed in the base period as well, so many of them did not jump any clusters. Thirdly, some of the least developed countries doubled their income, which is not necessarily substantial in absolute terms, but it is significant in relative terms. Fourthly, the significant growth of the Chinese economy supported the convergence process substantially.

When interpreting results, we have to take into account, among others, that due to direct cyclical adjustments in connection with determining clusters, the clustering method, the indicators included, as well as the choice of the base and current period (1971

and 2011) affect the estimations. Nevertheless, based on various models the results seem to be robust at the aggregated level. In addition, based on simulations, omega relates to sigma much closer compared to beta, thus it may indeed measure a certain type of conditional sigma-convergence. In fact, out of the simulations run, in 70-80% of the cases omega led to the same result (convergence/divergence) as the mainstream indicators.

Thesis 6: Convergence trend is greatly supported by factors, which positively affect external demand and export share. At the same time, the speed of convergence and even its sign substantially depends on the time interval analysed. In the second half of the 2000's divergence was estimated, which may be a result of excessive consumption trends financed by debt accumulation.

Calculations were done to estimate and compare convergence trends in the 80's (1982, 1987) and in the 2000's (2002, 2007) among world economies. Convergence was found in the 80's, while in the 2000's divergence was observed.

Convergence analyses are basically based on aggregate level of GDP per capita, but I assumed that individual GDP components may carry relevant information. Decomposing the GDP into demand items, calculations showed that convergence was boosted in both periods by factors that influenced external demand and export share positively. This is related to the well-known fact that the market share of the world's emerging economies is increasing.

It also means that the divergence process observed in the second half of the 2000's is due to other factors. I found divergence only in the consumption equation, i.e. the (final) consumption was relatively higher in the developed economies. This is probably due to increasing debt levels in many developed countries, i.e. excessive government spending leading to consumption growth. During the economic and financial crisis of 2008, this trend has led to a significant, long-lasting balance sheet adjustment, which is still in progress.

2.2 New academic results

The novelties of the thesis are – on one hand – that I established, presented and analysed a new alternative convergence indicator that I call omega-convergence. On the other hand, the empirical research applied in the thesis is new to the current academic literature in a certain sense.

Firstly, this research is partially related to the alternative indicator, thus it can be considered as a new academic result.

Secondly, I presented and compared a wide spectrum of models – e.g. GMM panel data models and indicators of standard deviation – building on mainstream methods to analyse the various sources of heterogeneity (for instance with control variables like the geographic location, country groups in current and base period; also with or without logarithmic transformation and population weights). So the results of these methods can also be considered as non-standard.

In addition, I explored the properties of the alternative and mainstream indicators with simulations (MC, Bayesian model) and formal derivation. The programming and running of such simulations cannot be considered as typical applications in the framework of convergence analyses either, so the results obtained can also be interpreted as new academic results.

2.3 Future research

Analyses and calculations presented in the dissertation can be extended in several ways. Firstly, theoretically, both mainstream and non-mainstream approaches offer many research possibilities. For example, simulations regarding the speed of catching up can be extended. Synthesizing endogenous and the neoclassical theories, for example through analysing models with multiple steady states, may let us better understand the nature of economic growth.

Secondly, there are many possibilities to extend the empirical parts of the research. Extending the time horizon, controlling for other variables may improve the explanatory power of the models, reduce the biasedness of the estimates and in this way the reliability of the models can be enhanced. In addition, further growth factors can be identified: in addition to the institutional variables, for instance variables highly correlated with human capital and technological progress may substantially improve confidence.

Due to the significantly different growth trends among world economies, a more comprehensive analysis of heterogeneity is also necessary. Such approaches are, for instance, regime switching models and time-varying parameter estimates.

In addition to estimating catching up, indicators measuring standard deviation should be taken into account in a more comprehensive way, for example through determining the shape and changes of the income distribution as well.

Thirdly, extending the simulations would be also important because the results may substantially depend on the initial conditions and the techniques chosen. These extensions are necessary because the goal of the alternative indicator presented in the thesis was to measure some kind of conditional sigma-convergence, thus with further analyses we can evaluate the theoretical properties of the omega in a more detailed way.

In addition to the models presented in the thesis, working out further calculations and comparisons leveraging the toolbox of the Bayesian econometrics may open up many new areas of research. The Bayesian estimation has the major advantage that the results from other data sources and our expectations can be incorporated into the same framework. Especially the former one can be relevant in this context because it offers a kind of synthesis among multiple data sources from different empirical studies.

Fourthly, it might be interesting to separate factors which affect convergence positively or negatively (theoretically or empirically), on short-, medium- or long-term. For instance, the structural measures introduced in developing economies may accelerate potential economic growth in the long-run, but may also generate slower growth rate in the short-run. This is due to the fact that the implementation of such measures may take resources from economic agents, while it may take time until the savings measures may stimulate growth. The approaches shown in the thesis may solve this kind of problem partially because instead of one-year lags, averages of three years are calculated, in line with the empirical standards. However, it is possible that in case of some comprehensive reforms, a higher lag order is needed. At the same time, various shocks may also be filtered out (for example by the Hodrick-Prescott filter), so we could have a focus on the trend estimated instead of the actual data.

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4. APPENDIX AND PUBLICATION LIST

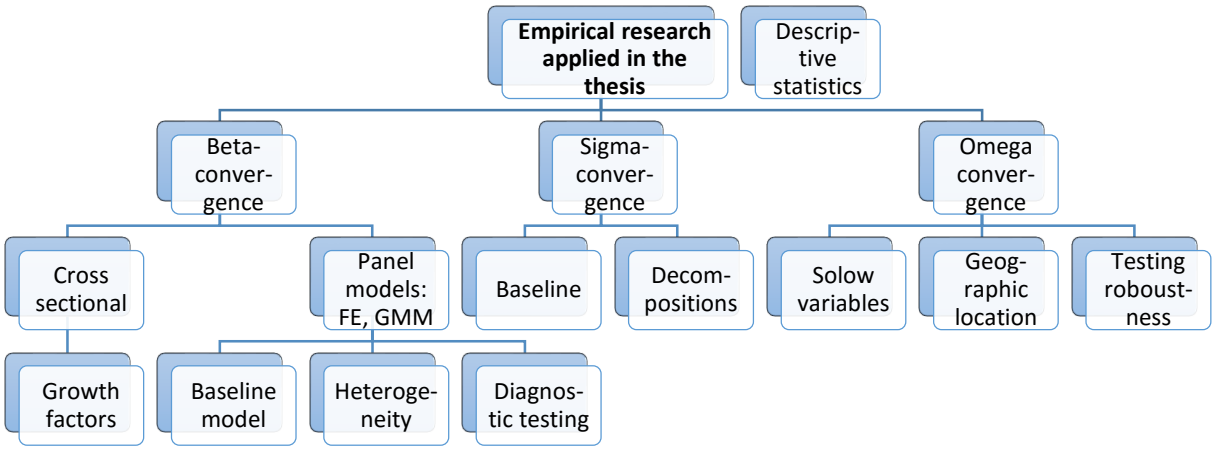

Chart 1.: Framework of the empirical research – applied in the thesis

Source: own construction

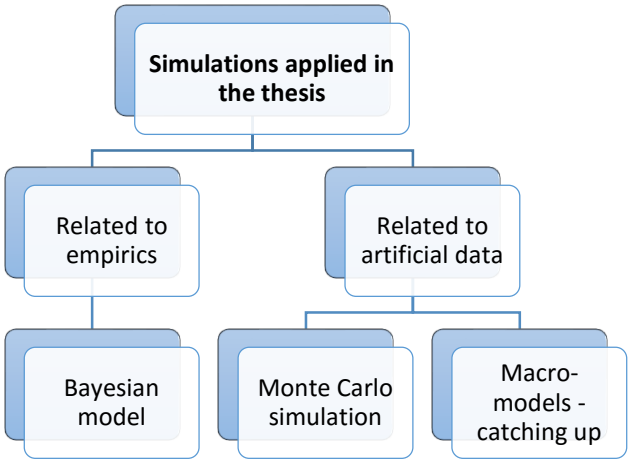

Chart 2.: Framework of the simulations – applied in the thesis

Source: own construction

Table 1: Speed of convergence in some growth models – presented in the thesis

Model	Speed of convergence	References
Solow-model	$\lambda = (1-\alpha)(n+g+\delta)$	Solow (1956)
Ramsey-model	$2\lambda = \left[\zeta^2 + 4\left(\frac{1-\alpha}{\theta}\right)(\rho+\delta+\theta g)\left(\frac{(\rho+\delta+\theta g)}{\alpha} - (n+g+\delta)\right)\right]^{1/2} - \xi$	Barro – Sala-i-Martin (2004)
Solow-model augmented by human capital	$\lambda = (1-\alpha-\beta)(n+g+\delta)$	Mankiw et. al. (1992)
Endogenous savings rate, human capital, unproductive government	$2\lambda = \left[\zeta^2 + 4\left(\frac{1-\alpha-\eta}{\theta}\right)(\rho+\delta+\theta g)\left(\frac{(\rho+\delta+\theta g)}{\alpha+\eta} - (n+g+\delta)\right)\right]^{1/2} - \xi$	Nemeskéri (2003)
Adjustment costs	$\lambda = (1-\alpha-\beta)(n+g+\delta)\left[\frac{1+1/2b(n+g+\delta)}{1+b(n+g+\delta)}\right]$	Barro – Sala-i-Martin (2004)
Capital-dependent depreciation	$\lambda = (1-\alpha)(n+g+b_1) + (1-\alpha+\phi)b_2 k^{*\phi}$	Duczynski (2003)
Capital-dependent savings rate	$\lambda = (1-\alpha)(\delta+g+n) - \vartheta a_2 k^{*\alpha+\vartheta-1}$	Duczynski (2003)
Productive government	$\lambda = \left(1-\frac{\alpha}{1-\beta}\right)(\delta+n)$	Angelos (2003)
Integration	$1-\lambda \approx (1-\alpha)(n+g+\delta+\varsigma-h)$	Kutan – Yigit, 2007
Open economy	$\lambda = (1-\alpha)(\delta+g+n) + \nu(1-\alpha)\frac{\rho}{k^*}m(\alpha k^{*\alpha-1} - \rho)^{m-1}$	Duczynski (2003)
Augmented open economy	$2\lambda = \left[\zeta^2 + 4\left(\frac{1-\varepsilon}{\theta}\right)(\rho+\delta+\theta g)\left(\frac{(\rho+\delta+\theta g)}{\varepsilon} - (n+g+\delta)\right)\right]^{1/2} - \xi$	Nemeskéri (2003)
Augmented open economy (constant savings rate)	$\lambda = (1-\varepsilon)(\delta+g+n)$	Nemeskéri (2003)
CES-function ($0 < \psi < 1$)	$\lambda = \left[1 - a\left(\frac{bsA}{n+g+\delta}\right)^{\psi}\right](n+g+\delta)$	Barro – Sala-i-Martin (2004)
Endogenous production structure with stable equilibrium	$\lambda_k = sk^{*-\frac{1}{k^*}-1}\left(1-\ln k^*\right)$	Ligeti (2002)
AK-model	$\lambda = (1-\alpha)(n+g+\delta) = (1-1)(n+g+\delta) = 0$	Romer (1986)
Technology diffusion	$\lambda = (1-\alpha-\beta)(n_i+g+\delta-c_i)$	Boulhol (2004)
Solow-model augmented by institutions	$\lambda = (1-\alpha\gamma)(n+g+\delta)$	Tebaldi – Mohan (2008)

Source: own construction based on studies of authors presented in column 3

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List of publications related to the dissertation

Articles, studies (4)

1. **Gáspár, A.**: Recent Convergence Trends among World Economies.
   The Empirical Economics Letters.[1-8], 2016. ISSN: 1681-8997.
2. Ferkelt, B., **Gáspár, A.**: Konvergenzerfahrungen und Perspektiven in der EU.
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Conference presentations (4)

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List of other publications

Articles, studies (1)

9. **Gáspár, A.**: A magyar gazdasági növekedés és a fiskális politika kapcsolata: modellezésen alapuló vizsgálat.
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BGF Tudományos Évkönyv. *2008*, 27-41, 2009. ISSN: 1588-8401.

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of Web of Science, Scopus and Journal Citation Report (Impact Factor) databases.

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