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Introduction

Content or after 45 min. you will learn...

- Basic modeling framework and applications
- What SLED is and what it does, several layers of presentation:
  - Principles
    - Salient features
    - Block structure
    - Theoretical groundings
    - Assertions
  - Inside the blocks
    - Supply side
    - Demand side
    - Prices and costs
    - Policies and finance
  - Outcomes
    - Closure of the model
    - Baseline scenario
    - Shock analysis
    - Insights

... and contribute in discussion section on where to improve

... the presentation will go on informal stories almost without precise theoretic and econometric specifications (almost no Greeks, no Math, no Stats)
Introduction

Background

• Multi-country model (MCM) is a formal macroeconomic framework describing fundamental macroeconomic features:
  – Supply side explains the long-run equilibrium (mostly neoclassical)
  – Demand side describes the short-run dynamics (mostly (new) Keynesian)
  – Simple and tractable due to data availability, comparability, time-to-build

  – EU countries develop MCM models sharing similar statistical and theoretical properties to ensure comparability
  – Aggregated MCM a counterpart to the ECB’s Area Wide Models (2001, 2008)
  – Small Country Model – a simplified version of a small open economy model (2014)

• Lithuanian Economy Model for Projections and Analysis (LEMPA)
**Introduction**

*Toolbox definition and main features*

**SLED** is a quarterly macro-econometric model of Lithuanian economy for the Surveillance of Lithuanian Economic Development, scenarios of which are produced by the Ministry of Finance (MoF). SLED is designed for the short-to-medium-term projections up to 4 years ahead and its baseline serves as an alternative benchmark for testing the consistency of MoF scenario revisions.

**Key features:**

- a 3 stage sequential dynamic optimisation of a consumer problem
- a medium-run supply-side system with a split into private and public sectors
- small open economy characteristics of the foreign trade
- a detailed decomposition of general government financial accounts
- a link between convergence and dynamic homogeneity restrictions
Bird’s-eye-view on SLED

Methodological framework

Theory: neoclassical and (new) Keynesian synthesis ⇒ AD/AS model:

- Medium-run is driven by imperfectly rational neoclassical micro-founded behavior of economic agents: firms, households, trade unions, general government ⇒ money neutral long-run neoclassical steady state
- Short-run is driven by (new) Keynesian (sluggish) adjustments in wages and prices, which undermines money neutrality in the short-run, *ad hoc* corrections are common

Practice: behavioural equations are represented in an error-correction form:

- Expectations formation: imperfectly rational, explicit backward-looking mechanism, which is equivalent to myopic behaviour of agents
- Real and nominal convergence to the EU-15 average and a dynamic homogeneity restriction, which *together* imply time-varying intercepts in dynamic equations
- Aggregation by chain-links for the real components and prices, imputed capital services and consistent theoretical assumptions (e.g. monopolistic competition)
Bird’s-eye-view on SLED

Flowchart diagram, key assertions

Variables (volumes and prices):
- Z: Aggregated supply (CET or CD)
- Y: Gross value added (CES or CD)
- K^S: Capital services (\(\alpha\) productive capital)
- L: Hours worked (\(\alpha\) employment)
- M: Imports of goods and services

- Z: Aggregated demand
- C: Private consumption
- I: Investments
- G: General government consumption
- X: Exports of goods and services

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- (Non-) utilitarian
- Fixed wages or consumpt.
- Interest rates
- Credit supply
- Monetary policy
- Macro-prudential policy
- Monetary policy
- Macroeconomic policy

Factors supply:
- Fiscal accounts
- Fiscal rules
- Externalities

Utility maximization:
- Smooth consumption
- Inertial, buffer-stocking
- Factor supply

Intro Principles Inside the blocks Outcomes Discussion
Bird’s-eye-view on SLED

Institutional sectors and the rules of the game

SLED is a game: players, bounded information, actions and pay-offs

• Households demand for final goods and services, credit and investment goods (human capital); own and supply the production factors; utility maximizers, who smooth the life-cycle consumption, featuring habit formation and precautionary (“for a rainy day”) savings

• Firms are monopolistically competing profit maximizers, restricted by domestic demand (households and GG), competitors from the rest of the world (price competition), technology, trade unions; possibilities: export or domestic sales, investment

• Financial corporations provide credit supply and set interest rates

• GG fiscal accounts: tax revenue is endogenised by linking them to tax bases; expenditures: transfers, interest payments, consumption and investments

• Interaction with the Rest of the world is partly based on small open economy assumptions

• Trade unions set restrictions on wage-setting behavior either seeking to keep purchasing power of real wage unchanged, or maximize the utility of its members (imitated by GG)
Bird’s-eye-view on SLED

Content of the building blocks

1. Supply side: effective use of primary factors (labour, capital) and their costs; monopolistically competing firms are profit maximizers; the same framework is used for private and public sectors

2. Demand side: smooth private consumption of dynastic households; public expenditure ~ value added of public sector; changes in inventories ~ optimal stock; detailed investments (in volumes and prices) explained by credit conditions and past GVA

3. Prices and deflators are weighted averages of by new Keynesian Philips curve defined GDP deflator and foreign competitors (import) prices, costs follow from the interaction of supply and demand blocks, interest rates are linked to EURIBOR futures

4. Foreign trade is symmetrically defined by restricted AIDS model: shares in corresponding domestic and world demands are functions of relative prices, share for exports experience extra market sector potential output trend (aggregation, growth in varieties, re-exports)

5. Macro-financial and macro-fiscal block is mostly recursively defined with several feedback loops arising from credit and public components of the supply and demand blocks
Digging deeper into demand side

*Private consumption in the medium-run*

**Overlapping generations dynastic households** (Blanchard, 1985):

- utility maximizers, who inter-temporally smooth (borrow early, save/invest in the middle, spend at latter stages) the life-cycle consumption by solving 3 stage sequential dynamic optimisation problem:
  
  a) **constraint**: risk-adjusted non-human, human wealth conditional on uncertain lifespan and income
  
  b) **size of the pie**: determine optimal planned path of expenditures on consumption conditional on a) assuming no front-loaded information
  
  c) **pie structure**: choose a mixture of varieties that follows from the two-stage Dixit-Stiglitz type of budget allocation process conditional on b) ⇒ quasi-linear economy case, time varying mark-up

- own and supply all fundamental production factors and wealth (financial and real estate)

- **Inter-temporal optimisation**: determine domestic demand for current and future private consumption: borrow at early stages, at latter – reallocate saved income into investment goods, including investment in human capital, buffer-stock savings
Digging deeper into demand side

*Private consumption in the short-run*

In the short-run randomly mixes between 3 pure strategies:

1) to keep the expectations about income uncertainty unchanged (~ perfect foresight)
2) to consume only from current labour income (~ liquidity constrained)
3) to follow myopic NMCM sequential optimisation a)-b) (~ bounded rationality)

**Lithuanian households profile:**

- average (economic) life-cycle length extending to 43.8 years
- inertial: due to habit formation (0.32) or perfect foresight (0.15)
- cautious: react both to capital and labour market uncertainties and form buffer
- impatient: consume all permanent income and save mostly from transitory income (62.2%)
- constrained: 40% of population consumes from labour related income only

GG behavior is just the reflection of an average household, isn’t it?
Digging deeper into supply side

Firm behaviour, effective factors, technology

Firms are profit maximizers (or cost minimizers) (Dieppe et al. 2011a):

• ignoring adjustment costs solve static optimisation problem restricted by:
  a) households: domestic demand with time-varying elasticity
  b) competitors from the rest of the world – shocks from intermediate goods cons.
  c) nature: normalized CES technology with effective use of labour and capital services
  d) institutional setting: general government and trade unions decisions

• under monopolistic competition the variety market is differentiated (quasi-linear economy):
  – symmetric (Cournot-Nash) equilibrium solution for representative agent problem
  – well defined aggregation
  – time-varying mark-up 1.08-1.41 to set prices above marginal costs
  – X-inefficiency costs for goods differentiation with almost zero economic profits in the long run, yet non-zero (due to > 1 mark-up) normal profits
  – Principles are general for all type of firms: private/public, domestic/foreign
Digging deeper into supply side

Institutional restrictions of the labour markets

Labour market is imperfect with many monopoly trade unions:

- behaviour is mostly exclusive and strategically differs in:
  
  a) utilitarian sense – maximising welfare of its members

  \[
  \frac{P_t^C C_t}{L_t^F W_t^U} = \frac{1 - \rho}{\kappa} \left[ \frac{\rho}{1 - \rho} + (1 - \pi_0) \left( \frac{Y_t L_0}{\xi Y_0 e^{\gamma L(t,t_0) L_t}} \right)^\rho \right] \rho \equiv 0 \frac{1 - \pi_0}{\kappa},
  \]

  b) non-utilitarian – seeking to keep the purchasing power of wages fixed

\[
W_t^{NU} = \left( \frac{F_t^{-1}(K_t, Y_t)}{\omega L_t^F} \right)^\chi \frac{P_t^Y F_L}{\eta_t} = e^{\chi \beta (N t R U_t - U_t)} \frac{P_t^Y F_L}{\eta_t}, \quad \chi > 0,
\]

- have a bargaining power to settle the binding restriction on wages to be above the marginal costs with the rigidities on the updating the collective agreements
- utilitarian trade unions could consist from just one member (household)
- utilitarian behaviour is partly imitated by general government on compulsory basis
Digging deeper into supply side

**Private and public sectors**

- Why to move? the IFI needs to have GG separated
- More sectors better? aggregation of heterogeneous sectors
- Theoretical framework for any economic activity is conceptually the same, parameters differ

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Private</th>
<th>Public</th>
<th>Whole economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour income share, $\pi_0$</td>
<td>0.589</td>
<td>0.777</td>
<td>0.629</td>
</tr>
<tr>
<td>Nominal wage restriction, $100(1 - \frac{1}{\mathcal{e}^N})$</td>
<td>29.1% (0.005)</td>
<td>36.2% (0.013)</td>
<td>30.2% (0.016)</td>
</tr>
<tr>
<td>Scale parameter, $\xi$</td>
<td>1.026 (0.003)</td>
<td>1.007 (0.013)</td>
<td>1.028 (0.016)</td>
</tr>
<tr>
<td>CES parameter, $\rho$</td>
<td>0.460 (0.007)</td>
<td>0.960 (0.051)</td>
<td>0.557 (0.010)</td>
</tr>
<tr>
<td>Elasticity of substitution, $\sigma = \frac{1}{1+\rho}$</td>
<td>0.685</td>
<td>0.510</td>
<td>0.642</td>
</tr>
<tr>
<td>Technical progress: $\frac{\gamma_L(t,t_0)}{t-t_0} \Rightarrow$ annual average</td>
<td>$\gamma_L^M = \frac{\gamma_T}{0.5} \Rightarrow 4.5%$ (0.006)</td>
<td>$2.5%$ (0.000)</td>
<td>$4.1%$ (37)</td>
</tr>
<tr>
<td>Mark-up (+1), $\eta_1$</td>
<td>$0.35t^{0.27} \left( \frac{P^M}{P^F} \right)^{1.04}$ (0.05)</td>
<td>$0.996$ (0.008)</td>
<td>$0.32t^{0.29} \left( \frac{P^F}{P^M} \right)^{0.81}$ (0.05)</td>
</tr>
<tr>
<td>Mark-up average</td>
<td>22.8%</td>
<td>-0.4%</td>
<td>19.5%</td>
</tr>
<tr>
<td>Import content of prices, $\frac{\gamma}{1+\gamma}$</td>
<td>0.511</td>
<td>0.000</td>
<td>0.447</td>
</tr>
<tr>
<td>Quarterly risk premium, $RP$</td>
<td>0.007 (0.001)</td>
<td>0.006 (0.000)</td>
<td>0.006 (0.001)</td>
</tr>
</tbody>
</table>

**Notes:** estimation method is full information maximum likelihood (FIML), estimation sample 2000Q1-2015Q4, standard errors in parenthesis. For the public sector instead of $RP$ the total positive external effect $R$ is estimated. All estimated parameters are statistically significantly different from zero at 5% level of significance.
Digging deeper into prices

General approach to the problem

• MCM approach to balance the long run growth of prices (deflators, HICP):
  - the weighted averages of GDP deflator at factor prices and import deflator
  - estimated by econometric tools

\[
p_t^j - \log(1 - z) = (1 - \mu_j)p_t^Y + \mu_jp_t^F + f_j(t) + \varepsilon_t^j, j \in \text{Prices}
\]

  - \(f_j(t)\) is a deterministic trend or that are aimed to deal with aggregation and simplification errors, as well as known abnormal shocks

From mark-up principal it is straightforward to link suggested weighted average to marginal costs and import deflator – better interpretation: competitiveness (marginal costs) and small open economy market power restrictions (import deflator)

• Dynamic equations are modeled as 3-valued Calvo signal

\[
\pi_t = (\theta + \omega(2 - \theta))\pi_{t-1} - \omega\pi_{t-2} + (1 - \theta)(1 - \omega)\pi_t^f
\]

3-valued: no change, hard trend-following heuristics and standard ECM for prices
Digging deeper into foreign trade

Small open economy hypothesis

Demand driven story is misleading? If Lithuanian economy is small and open, then export depends mostly on exogenous factors, which are described by Armington model:

$$\frac{p_t^x x_t^R}{p_t^W M_t^W} = g(M_t^W) \cdot b_L \left( \frac{p_t^x}{p_t^W} \right)^{1-\sigma_s}$$

or taking the logs: $$x^d_t = \alpha_1 - \sigma_s (p_t^x - p_t^w) + \alpha_3 m_t^w$$

...but “made in LT” brand is recognized, the model assumptions are based on monopolistic price competition ⇒ SOE is an exports driven story (Holy and Wade):

$$x^s_t = \beta_1 + \beta_2 (p_t^x - p_t^w) + \beta_3 (p_t^x - mc_t^x) + \beta_4 y_t^*$$

• firms are price takers $$p_t^x = p_t^w$$
• production of tradable goods for domestic and foreign consumption
• volume in the long-run restricted by productive capacity of the open sector

Lithuania is small, but exporters are not price takers, yet price competition is less relevant, because supply is much lower than potential demand
Closure of the model

Some practical issues

• Chain-linking is a correct way to link NA data and model projections, but common gain in annual growth rate $\leq 0.5\%$ and permanent changes to temporary shocks may happen
  – SLED chain-links for: the core (less changes in inventories) part of GDP expenditure identity, real investments, HICP aggregation

• Changes in inventories and all discrepancies in real GDP are hidden inside a “garbage” variable so this is a crucial variable to close the output gaps and balance the projections

• Employment is better explained by bottom-up approach summing up private and public employment, as well as wages, which partly resolves

• ...wage-price spiral – a strategic interaction between monopolistically competing firm value of labour and bargained wage from both utilitarian and non-utilitarian trade unions, spiral results in a feedback effect between real private consumption and nominal wage
SLED outcomes

What can we do with the model?

• Baseline scenario projections:
  – *Ex ante* simulations build a pure just as it is baseline scenario without additional expert judgement conditional on exogenous variables assumptions – projection process
  – *Ex post* experiments illustrate the model forecasting ability conditional on actually realized exogenous information – different model (versions) competition

• Impulse responses and shock analysis ~ EDS consistency checks:
  – How the dynamic system responds to the univariate or multivariate changes in exogenous or endogenous variables
  – All shocks are unanticipated, there is no *ex ante* reaction before shock happens
  – Households and firms respond *ex post* updating their future beliefs
  – Yet no fiscal and monetary policy change is assumed (pure shocks)
SLED outcomes

Out-of-sample validation (volumes)
SLED outcomes

Out-of-sample validation (prices and deflators)
SLED outcomes

**Out-of-sample validation uncertainty**

- **GDP**
- **Private consumption**
- **GDP deflator**
- **Nominal wages**
- **Total employment**

Intro | Principles | Inside the blocks | Outcomes | Discussion
SLED shocked

Pure permanent real GG expenditure increase by 1% ex ante GDP
SLED shocked

*Pure permanent 1 % increase in world demand*

Main macroeconomic variables

Prices and deflators

Foreign trade

General government balance

Intro

Principles

Inside the blocks

Outcomes

Discussion
SLED shocked

Pure permanent 7% increase in oil prices

Intro

Principles

Inside the blocks

Outcomes

Discussion
What we have learned so far
... and where to go next (time for a discussion)

Strengths:
• Flexibility
• More players
• Heterogeneity
• Interpretation

Weaknesses:
• Imputation and augmentation
• Agnostic (a-theoretic) technologic growth
• Comparability
• Signal or noise

Threats:
• Data augmentation and review
• Financial and fiscal links
• Closure

Opportunities:
• Sector decomposition
• Policy feedbacks, externalities
• Estimation methods
Thank you for your attention!
Technology

More detailed ~ more flexible

\[
\left( \frac{Y}{\xi Y_0} \right)^{1/\zeta} = \left[ \pi_0 \left( e^{\gamma_K(t,t_0) \frac{g_K}{g_0K_0}} \right)^{-\rho} + (1 - \pi_0) \left( e^{\gamma_L(t,t_0) \frac{L}{L_0}} \right)^{-\rho} \right]^{-1/\rho} \tag{1a}
\]

- Technology is CRS (\(\zeta=1\)) normalized CES production function (R. Klump et al, 2011)
  - flexible agnostic technological growth is defined by Box-Cox (BC) \(\gamma_j(t, t_0) = \frac{t_0\gamma_j}{\lambda_j} \left( \frac{t}{t_0} \right)^{\lambda_j - 1} \):
    - no a priori restrictions, agnostic \(\Rightarrow\) no story, possibility to separate \(\gamma_K(t, t_0)\) and \(\gamma_L(t, t_0)\)
    - test the medium-run debate between:
      - (gross) substitutes (Blanchard) \(\sigma = \frac{1}{1+\rho} \gg 1\): \(\gamma_K = \lambda_K = 0, \gamma_L > 0, \lambda_L = 1\) \((\rho = -0.5\) is Diewert production\)
      - TFP growth constant, labour income share declines, endogenous (fundamental) growth
      - (gross) supplements (Acemoglu) \(\sigma < 1\): \(\gamma_K, \gamma_L > 0, \lambda_L = 1, \lambda_K < 1\)
      - TFP growth U shaped, more relevant for converging small open economy
        - whole economy estimation \(\sigma < 1\): \(\gamma_K \sim 0, \gamma_L = 0.011, \lambda_L = 1, \lambda_K = -3\)
        - without any a priori restrictions \(\sigma < 1\): \(\gamma_K \sim 0, \gamma_L = 0.01, \lambda_L = -0.3(0.2), \lambda_K \sim 0.65(0.59)\)
  - \(\lambda_K < 0\) and imputed capital services allow \(\gamma_K = 0\) restriction (growth is slow and rapidly dies out)
  - \(\gamma_L(t, t_0) = \gamma_L (t - t_0)\) assumption does not hold in general in favor of \(\gamma_L(t, t_0) = t_0\gamma_L \log t/t_0\)

Story? Number of standards (patents), R&D, FDI, human capital, public infrastructure, EU SF
R. Klump, P. McAdam, A. Willman (2011) emphasize the importance of normalization:

- CES parameter $\rho$ is correctly identified if and only if the whole family of CES functions shares the same initial (indexed by 0) data point, in that case CES shape is totally determined by $\rho$
- unpleasant consequences of not normalized estimation is that both scale correction multiplier $\xi(\rho, \cdot)$, and the part attributed to capital services $\pi(\rho, \cdot)$ (no income share interpretation!)

- Normalization point:
  - in deterministic case any point would be adequate, our case is stochastic
  ⇒ a common solution is to calibrate on estimation sample (2000-2015) averages
  - $\pi_0$ is the capital income share imputed and corrected for self employed as in D. Gollin (2002)
    \[
    \pi_0 = 1 - \frac{E_{(L-L^{SE})Y-P(1-x)}}{Y_{0}(L_L-L_{SE})Y-P(1-z)} \approx 0.37 \text{ (was 0.46)}
    \]
  - In CD case ($\sigma = 1$) all normalization is hidden inside the intercept term

- Scale correction ($\xi$) is due to national accounts data discrepancies and aggregation

- Total normal hours worked/ total employment (heads) $\sim 39$ h/week ⇒ main signal comes from total employment (not clear what to do with effective hours worked though)
# Digging deeper into supply side: CES versus CD, NAIRU, and the role of trade unions

<table>
<thead>
<tr>
<th>Equation</th>
<th>CES</th>
<th>CD (ρ = 0)</th>
</tr>
</thead>
</table>
| 1. Productivity | \[
\frac{Y_t L_0}{Y_0 L_t} = e^{\gamma L(t-t_0) \xi} \left[ \pi_0 \left( e^{-\gamma L(t-t_0) \frac{g_t K_{t-1} L_0}{g_0 K_0 L_t}} \right)^{-\rho} + (1 - \pi_0) \right]^{1/\rho} 
\] | \[
\frac{Y_t}{L_t} = A_0 \left( \frac{g_t K_t}{e^{\gamma L(t) L_t}} \right)^{\pi_0}
\] |
| 2. Real wage W | \[
\frac{L_t W_t}{Y_t \pi_t} = \frac{1-\pi_0}{\eta_t} \left( \frac{Y_t L_0}{Y_0 e^{\gamma L(t-t_0) L_t}} \right)^{\rho} \]
| P^Y = P(1 - z), \eta_t = \eta_0 \left( \frac{P^Y}{P^E} \right)^{-\frac{\mu}{1-\mu}} |
| 3. Real UCC P^K | \[
\frac{g_t K_{t-1} P^I_{t-1} (r+\delta+\rho p)}{Y_t P^Y_t} = \pi_0 \left( \frac{Y_t g_t K_0}{Y_0 e^{\gamma L(t-t_0) L_t}} \right)^{\rho} 
\] | \[
\frac{g_t K_{t-1} P^I_{t-1} (r+\delta+\rho p)}{Y_t P^Y_t} = \frac{\pi_0}{\eta_t}
\] |
| \[L_t^{NAIRU} = L_t^F (1 - NAIRUt/100) \Rightarrow L_t^{R} / L_t^{NAIRU} \sim 1 \Rightarrow \text{no LR non-utilitarian restriction} \] |
| 5. Utilitarian union and nominal wage restriction | \[
\frac{P^E_C_t}{L_t W_t} = \frac{1}{\sigma} \left( \frac{Y_t L_0}{Y_0 e^{\gamma L(t-t_0) L_t}} \right)^{\rho}
\] | \[
\frac{P^E_C_t}{L_t W_t} = \frac{1-\pi_0}{\kappa}
\] |
| Total nominal wage \[w^T_t = \alpha w^U_t + (1 - \alpha)w^NU_t = w^U_t + \frac{1-\alpha}{\alpha} \chi \log \frac{L_t}{L_t^{NAIRU}} \Rightarrow \text{in the LR only utilitarian part} \] |
| 6. Capital services | \[g^*_K = g_0 K_t\] |
**Sluggish behavior**

*Derivation of 3 valued Calvo signal equation*

1. With probability $\theta$ institutional sector does not change prices (costs)
   \[
   \pi_t = \theta \pi_{t-1} + (1 - \theta) \pi_t^*
   \]

2. With probability $\omega$ institutional sector applies heuristic rule-of-thumb $\pi_t^b = \Delta \pi_{t-1} + \pi_{t-1}^*$, where $\pi_t^* = \omega \pi_t^b + (1 - \omega) \pi_t^f$ and $\pi_t^f$ is a standard ECM model for prices (costs)
   - Auxiliary expression: $p_t = \theta p_{t-1} + (1 - \theta) p_t^* \Rightarrow \pi_t = (1 - \theta)(p_t^* - p_{t-1})$
   - Reduce 1 and 2 into one equation $\pi_t = \theta \pi_{t-1} + (1 - \theta)(\omega(\Delta \pi_{t-1} + \pi_{t-1}^* - 1) + (1 - \omega) \pi_t^f)$
   - From $\pi_t = \theta \pi_{t-1} + (1 - \theta) \pi_t^* \Rightarrow \Delta \pi_{t-1} + \pi_{t-1}^* = \frac{(\pi_{t-1} - \pi_{t-2})(1 - \theta) + \pi_{t-1} - \theta \pi_{t-2}}{1 - \theta} = \frac{(2 - \theta) \pi_{t-1} - \pi_{t-2}}{1 - \theta}$
   - Finally $\pi_t = (\theta + \omega(2 - \theta))\pi_{t-1} - \omega \pi_{t-2} + (1 - \theta)(1 - \omega) \pi_t^f$

$\Rightarrow$ Standard ECM from MCM model has to be explicitly supplied with 2 lags of inflation
Converging long-run growth: Dynamic homogeneity, convergence to EU-15

- Background of the problem – behavioral equations are in GECM form, which, simulating ahead, have to obey dynamic homogeneity restriction (dhr): roughly dynamic equation growth rates in the LR should be related with LR equation inspired growth restriction.
- Botas, Marques (2002) argue that dhr theoretically holds iff the cointegration relationship exists, and there is no deterministic additions (dummies, trends).
- Kattai (2005) transitory mechanism (structural breaks in parameters due to reforms, liberalization, convergence) makes the constants time varying, i.e. growth rates are such.
- Phillips, Sul (2008) from neoclassical growth model ⇒ DGP of transitory mechanism could be decomposed into EU-15 (or other LR assumption) common growth and transitory component, for convergence cointegration between EU-15 and LT is not important.
- Findings: according to formal tests there is no empirical evidence for convergence in levels (beta) to EU-15 average, but not rejected convergence in growth rates (sigma); informally assuming beta convergence, prices and volumes “close” gaps at different points in time (~86 years 99% of volume gaps are closed and 95% of prices), alternative constant growth assumption closes gaps within ~50 years.
Historic and current output gaps

Implication of convergence on output gap

With convergence
Without convergence
References

MCM models:

NMCM models: