



# How Should Innovation Policies Be Adapted To Local Economic Conditions? An Agent-Based Analysis

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# Overview

- ▶ Introduction
- ▶ Research Questions
- ▶ The EURACE Model
- ▶ Capturing Regional Differences
- ▶ Policy Experiments
- ▶ Summary and Extensions



# Motivation

- ▶ Generation and diffusion of innovations is one of the main factors influencing (local) economic growth (e.g. Maddison (1991), Freeman (1994)).
  
- ▶ Major policy issue in the EU: Lisbon Strategy  
*‘EU should become the most competitive and dynamic knowledge based economy’*
  
- ▶ Main attention is paid to two policy fields:
  - ▶ Investing in human capital
  - ▶ Strengthening R&D activities



# Motivation

- ▶ Recent theoretical work and empirical evidence suggests that effects of different policy measures on (long-run) growth rate is influenced by the distance of an economy to the technological frontier (e.g. Vandenbussche et al., 2006).
- ▶ EU countries differ significantly with respect to composition of human and physical capital stock corresponding to different distances to the technological frontier.
- ▶ Significant differences in this respect exist in particular between ,old‘ and ,new‘ EU member countries.



# Research Questions

- ▶ How do the effects of general skill vs. R&D improving policies compare between economies resembling 'old' and 'new' EU members?
- ▶ How do short- and long run effects of different policies differ?
- ▶ Does it matter for policy effects whether distance to the frontier is due to human or physical capital gaps?

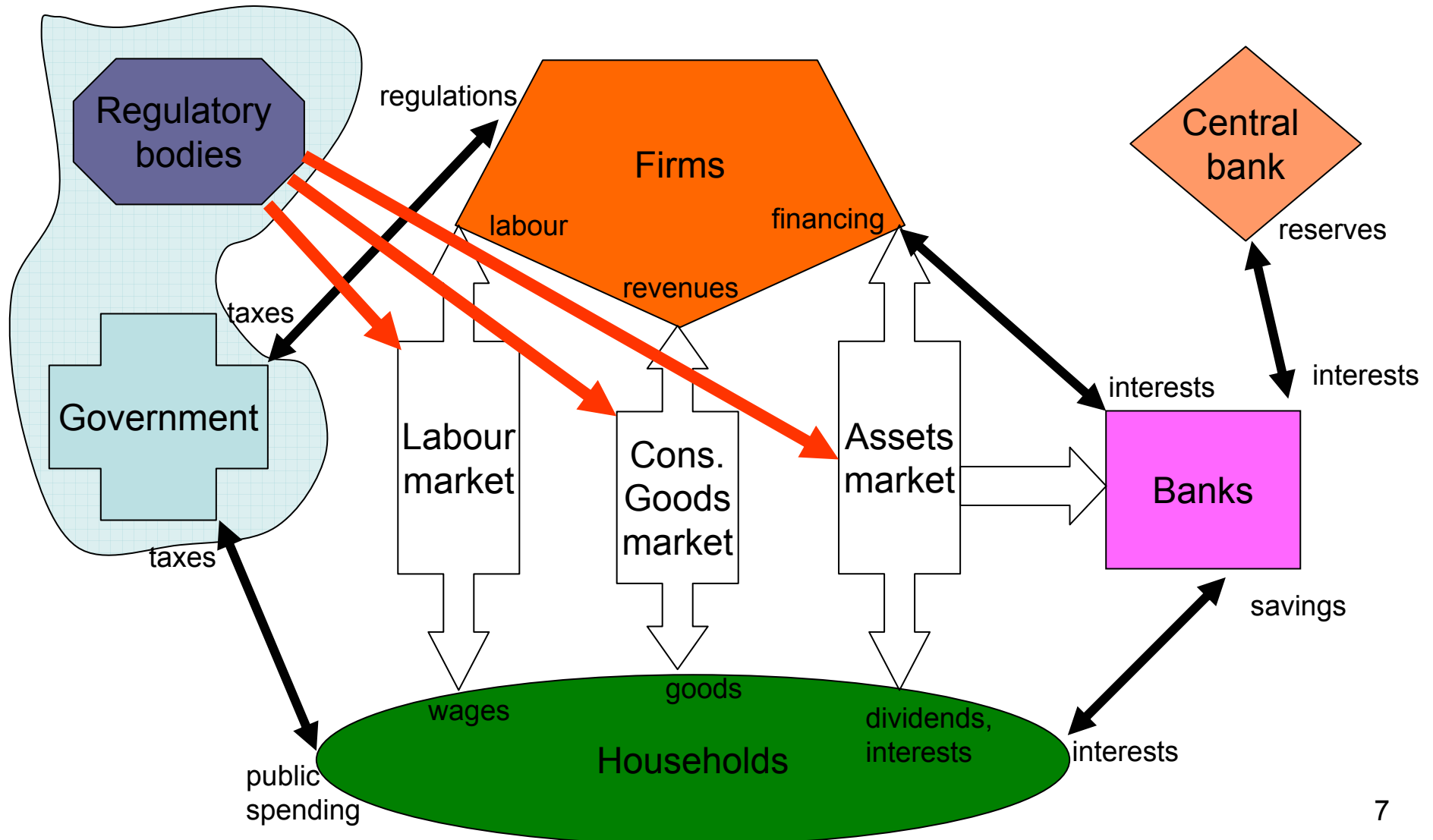


# Related Literature

- ▶ Catch-Up Hypothesis: Gerschenkron (1962), Nelson and Phelps (1962)
- ▶ Empirical Work on Human Capital and Productivity: e.g. Benhabib and Spiegel (1994, 2005), Hall and Jones (1999)
- ▶ Irrelevance Result: Krueger and Lindahl (2001)
- ▶ Increasing Imitative Skills vs. Increasing R&D: Vandenbussche et al. (2006), Aghion et al. (2009)
- ▶ ACE Models of technological change and growth (e.g. Dosi et al. (2009), Silverberg and Verspagen (1995), see survey in Dawid (2006))



# Overview over the EURACE Model





# The Model: Consumption Goods

- ▶ Homogenous consumption goods are produced using (vertically differentiated) capital and labor.
- ▶ Complementarity between quality of investment goods and level of specific skills of workers
  - ▶ Productivity of a given technology level is only fully exploited if workers in the firm have sufficiently high specific skills.
- ▶ Differentiated skill structure: general, specific
  - ▶ General skills heterogeneous within and across regions.
  - ▶ Specific skills attained during employment in firms.
  - ▶ Higher general skills improve speed of attaining specific skills.



## The Model: Consumption Goods

- ▶ Production Function of a consumption goods producer:

$$Q_{it} = \min[A_{it}, B_{it}] L_{it}^{\alpha} K_{it}^{\beta}, \quad 0 < \alpha, \beta, \alpha + \beta = 1$$

- ▶  $A_{it}$  : average quality of the investment goods employed by firm  $i$
- ▶  $B_{it}$  : average level of specific skills of employees of firm  $i$



# Consumption Goods Market

- ▶ Consumption goods producers offer (and store) goods at selected geographically distributed local market outlets (*,malls'*).
- ▶ CGPs post prices of their goods in all malls they serve.
- ▶ When visiting a mall a consumer collects randomly selected information about prices and inventories of producers serving that mall. Purchasing decision is modelled using a logit approach.
- ▶ **Suppliers on the consumption goods market act globally (without spatial frictions) whereas consumers buy locally.**



# Technological Change

- ▶ Investment goods are supplied at an exogeneously given price  $p_t^{inv}$ .
- ▶ The quality of supplied investment goods ( $q_t^{inv}$ ) increases stochastically over time.
- ▶ Average quality of the capital stock of a CGP ( $A_{it}$ ) is updated as old capital is replaced by new investments.
- ▶ Profits of investment goods producers are uniformly distributed to households.



# Skill Dynamics

- ▶ Specific skills of workers increase due to learning by doing if they are employed:

$$b_{w,t+1} = b_{w,t} + \chi(b_w^{gen})(A_{it} - b_{w,t})$$

- ▶ Average level of specific skills of a CGP (  $B_{it}$  ) is updated accordingly.
- ▶ (Local) knowledge flows and spillovers through the labor market.
  - ▶ Workers transfer specific skills when changing employer.



# Labor market

- ▶ Firms post job vacancies based on planned output.
- ▶ Searching workers send applications based on posted salaries.
- ▶ Firms rank applications **based on general skills** and make offers.
- ▶ Workers rank offers (wage - **commuting costs**), compare best offer to their reservation wage and accept/reject.
- ▶ -> Firms might be rationed on the labor market and there is frictional unemployment.
- ▶ -> **Labor Market is global with spatial frictions**



# Decision Making

- ▶ Strong micro-foundation of decision rules:
  - ▶ Firms and Households act rule-based using backward looking expectations.
  - ▶ Operational decisions of firms are modelled using standard decision rules from the Operations Management literature:
    - ▶ Pricing (markup)
    - ▶ Inventory and Production Planning (newsboy problem)
  - ▶ Savings/consumption decisions of HHs are simplified versions of empirically confirmed rules by Deaton (1991).



## Summary of Main Model Features

- ▶ Markets differ with respect to their spatial extensions and the spatial frictions.
- ▶ Complementarity between quality of capital stock and (specific) skills of workers.
- ▶ Diffusion of technologies are driven by investment decisions of firms and therefore affected by demand effects.
- ▶ Level of skills present in a firm changes due to learning by doing and to new hires.



# Strategy for the Analysis of Model Dynamics and Policy Experiments

- ▶ Calibration of key parameters using empirical data and checking ability of the model to reproduce 'stylized facts'.
- ▶ Running simulation batches for different policy interventions.
- ▶ Formulating hypotheses about the effect of policy induced parameter changes.
- ▶ Carrying out statistical tests to check significance of the hypothesized effects.
- ▶ Gaining a qualitative understanding of the relevant economic mechanisms responsible for the observed phenomena by examining evolution of key variables.



# Old vs. New EU Members

- ▶ Several differences in key economic variables between ‚typical‘ old member (Germany) and new member (Poland) are captured:
  - ▶ General skill distributions (5 IALS levels)
  - ▶ Specific skill levels of workers
  - ▶ Quality of physical capital stock
  - ▶ Size of per capita physical capital stock
  
- ▶ This implies:
  - ▶ Different distances to the frontier
  - ▶ Different initial wages, per capita income etc.



# Setup of the policy experiment

- ▶ Consider 3 levels of distribution of general skills:
  - ▶ Low: current distribution in new member country
  - ▶ Medium: current distribution in old member country
  - ▶ High: fictitious distribution where majority has skill level 5.
  
- ▶ Benchmark annual growth rate of technological frontier: 1.4%
  
- ▶ 3 Policy Measures:
  1. HC: Upgrade general skill distribution
  2. R&D: Increase speed of technological frontier (1.4% -> 3.5%)
  3. Only for new member: Adjust quality of physical capital stock to that of old member

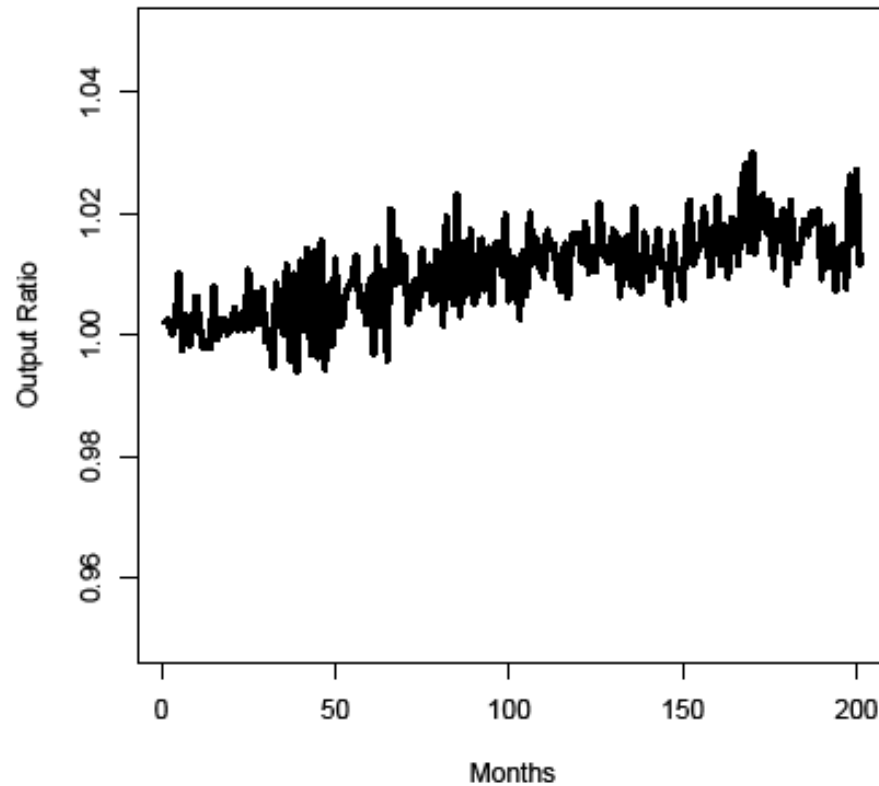


# Setup of Policy Experiment

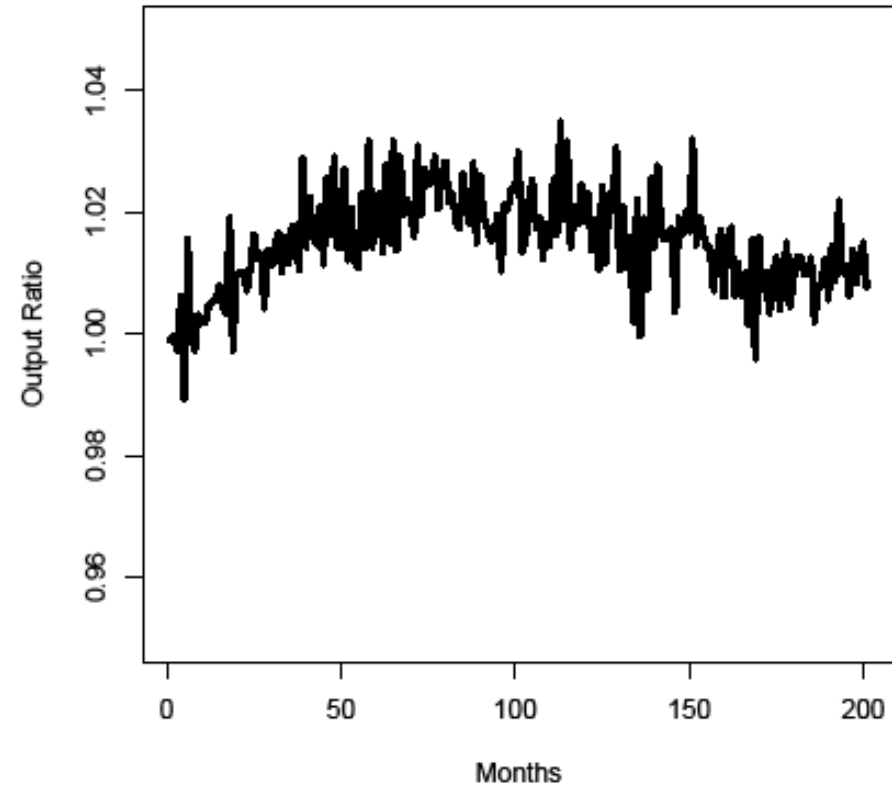
- ▶ HC and R&D policies are applied in new and old member country economies.
- ▶ 20 runs for 250 months carried out for each scenario (policies are applied after 50 months transient period)
- ▶ Time series of ratio of average (real) output with and without application policy are compared for both types of economies.



# Human Capital Upgrading



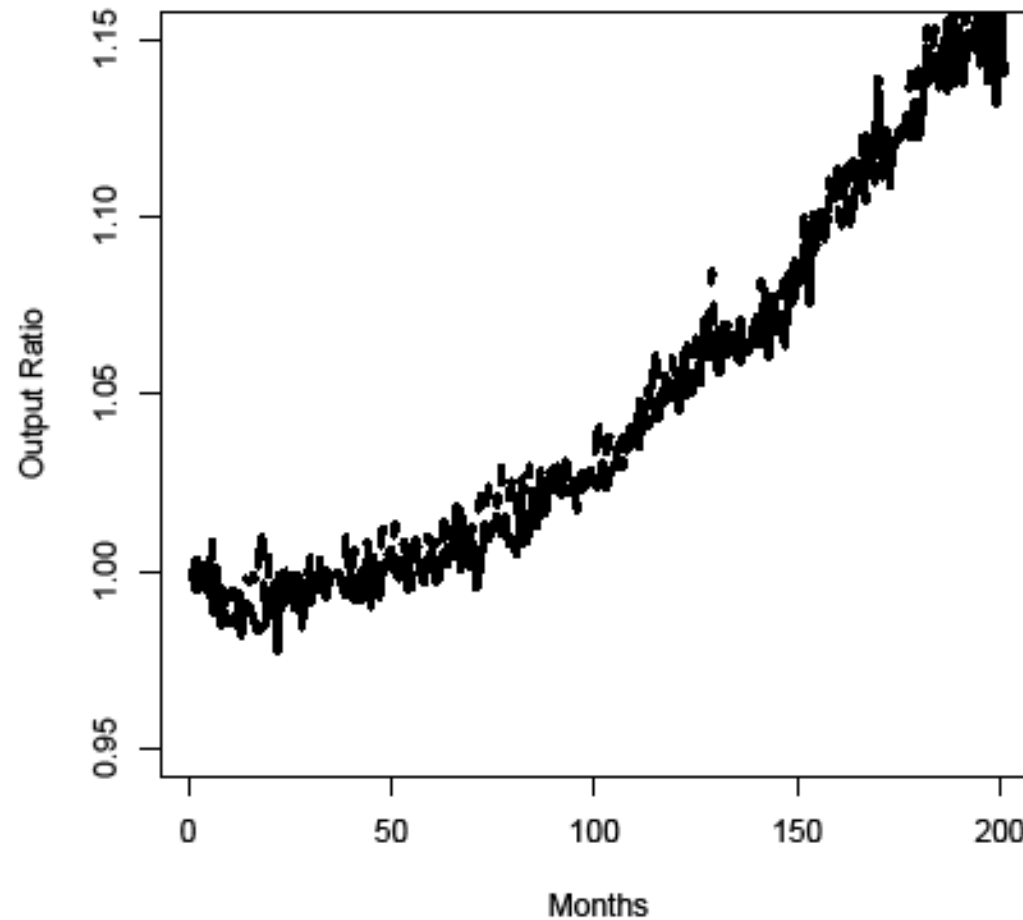
medium->high for old member



low-medium for new member



# Effects of R&D Policy



old member (solid), new member (dashed)

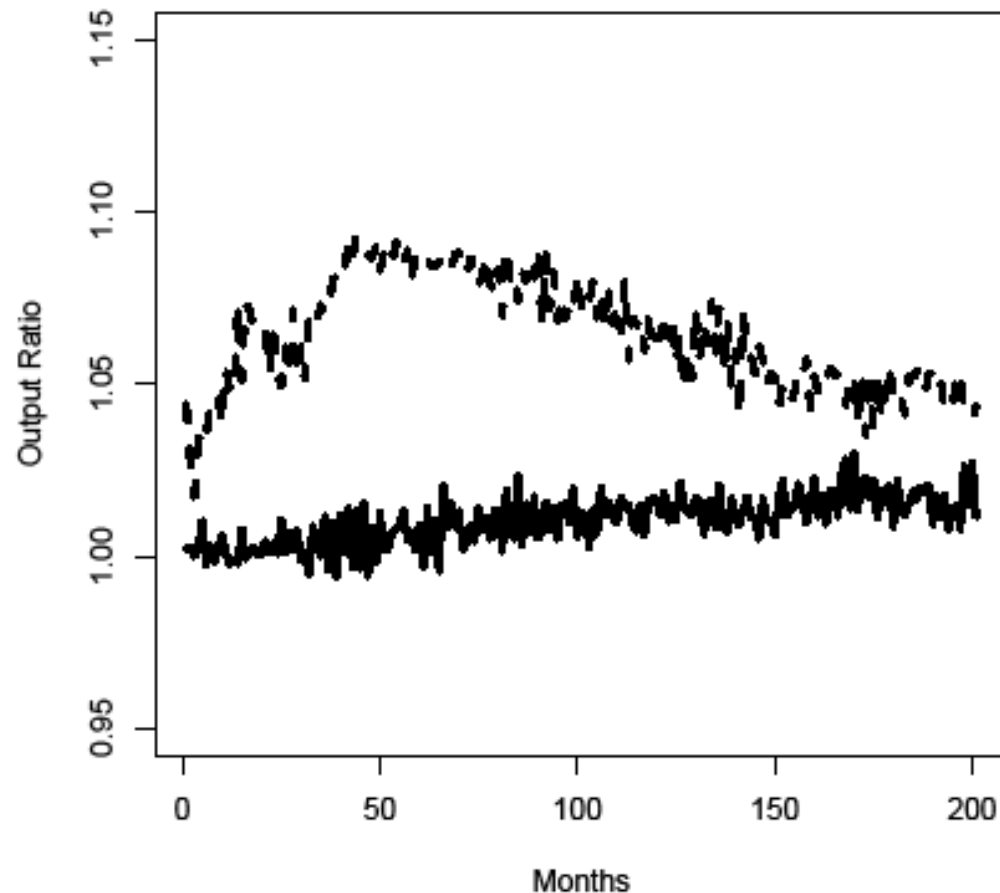


# Comparison of HC Policies

- ▶ New and old member countries differ both with respect to physical and human capital.
- ▶ When comparing HC policies different types of skill upgrading effects have to be compared (medium-> high vs. low-> medium).
- ▶ To allow for direct comparison thought experiment is carried out:
  - ▶ Compare effects of medium -> high for economies whose **physical capital** endowment is characterized by old vs. new member economies.



# Comparison of identical HC Policies

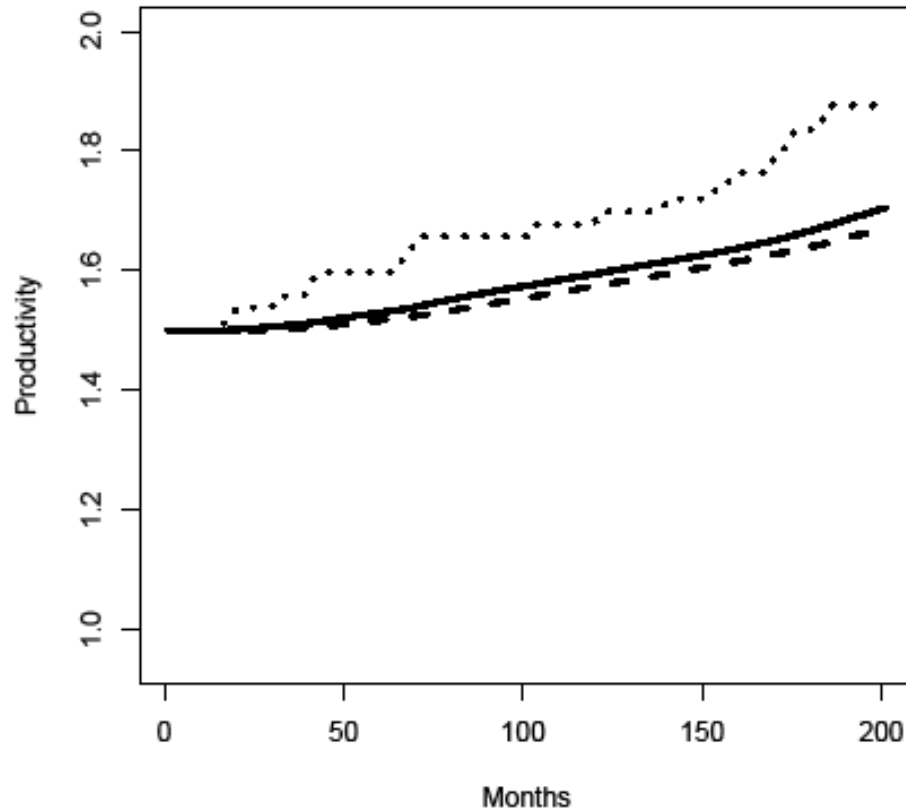


effect of medium- $\rightarrow$ high for old member (solid), and new member (dashed)

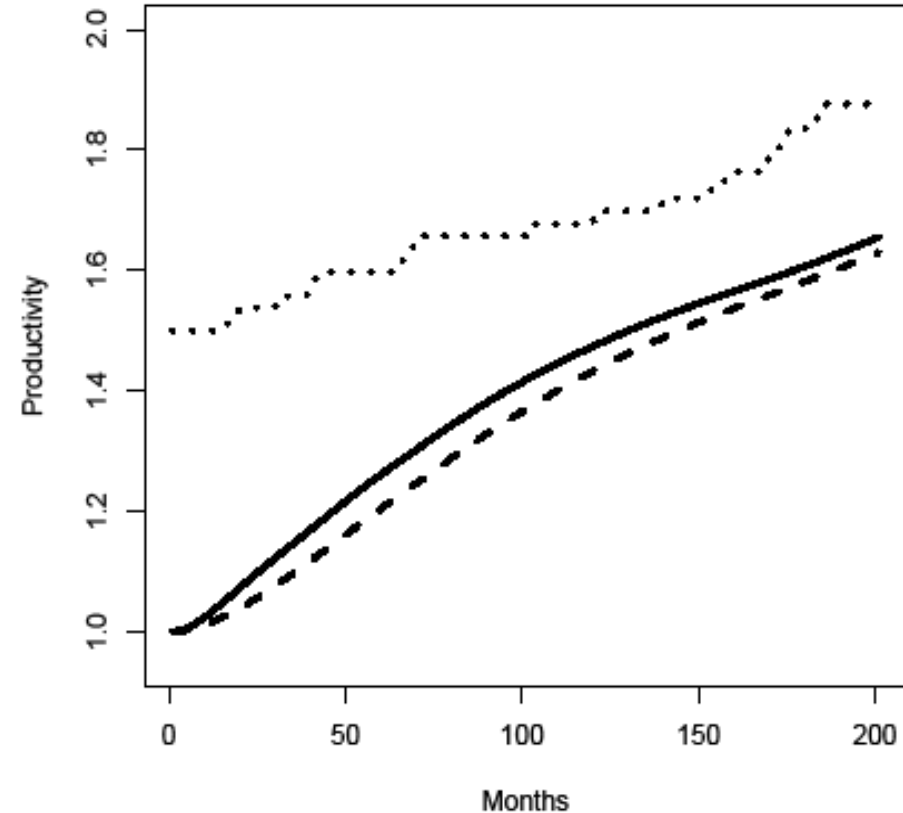
physical capital endowment



# Comparison of identical HC Policies



old member

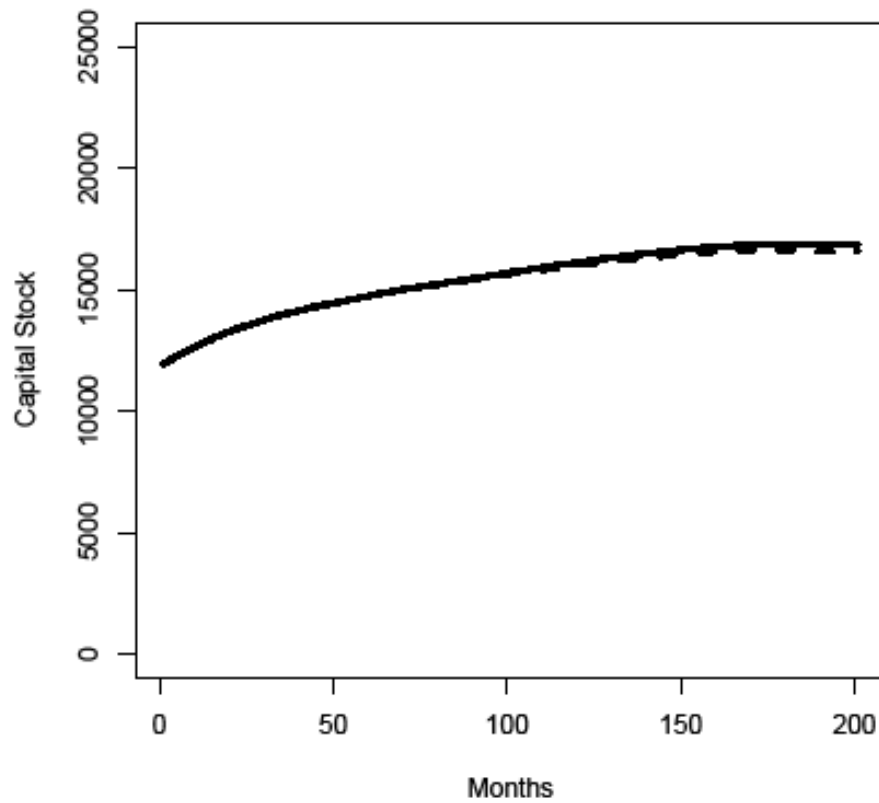


new member

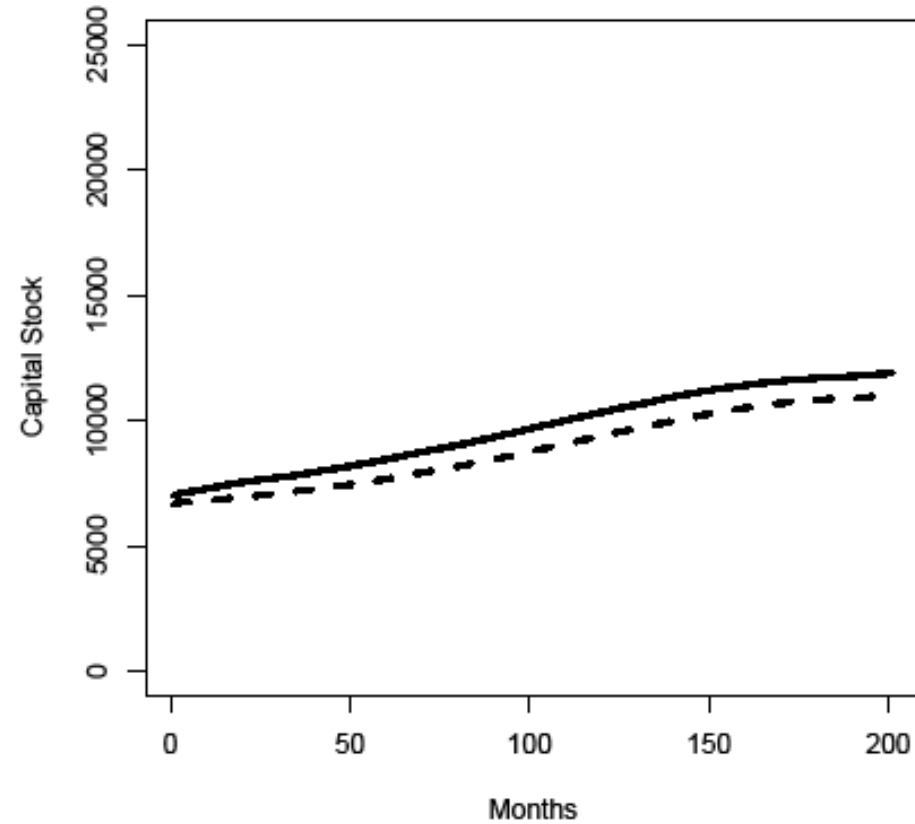
Average specific skills for high (solid) and medium (dashed) general skills



# Comparison of identical HC Policies



old member

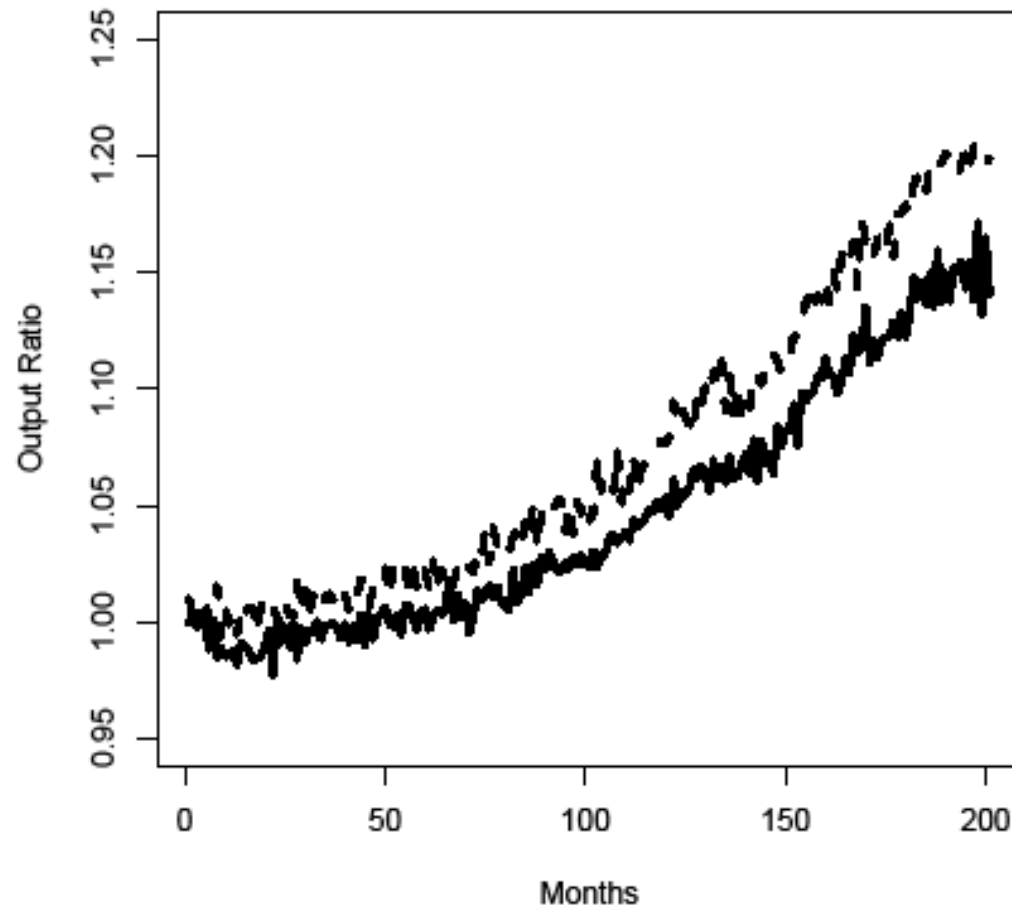


new member

Physical capital stock: high (solid) and medium (dashed) general skills



## Effects of R&D Policy if gap in general skill levels has been closed

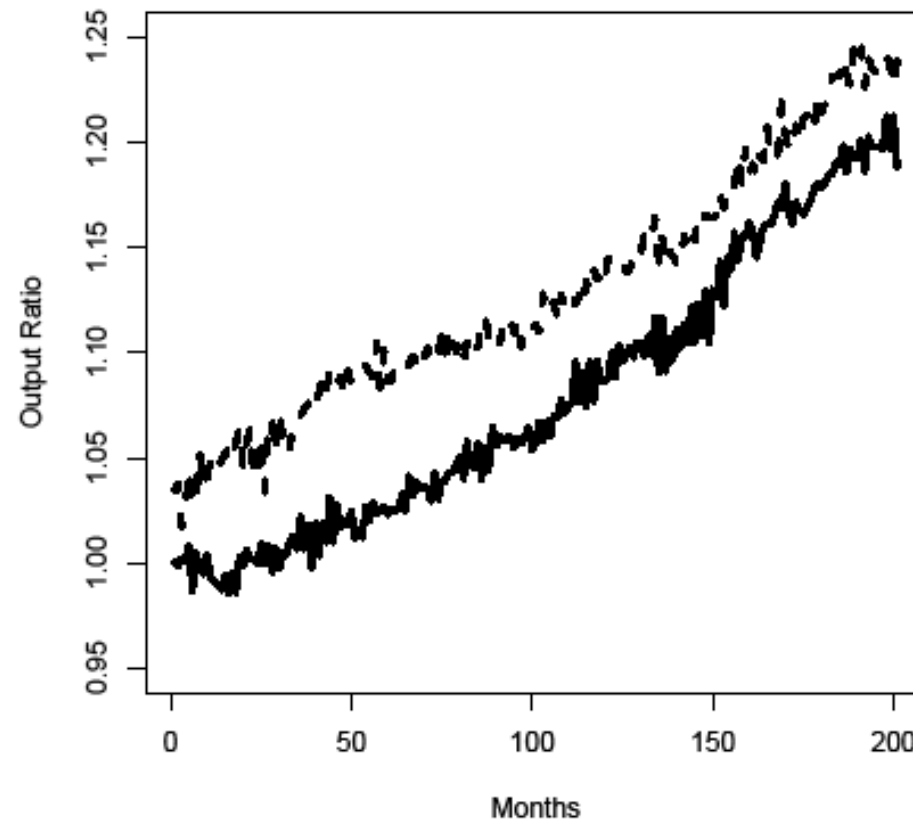


old member (solid)

new member with medium general skill level (dashed)



# Combination of Policy Measures



R&D + HC (medium- $\rightarrow$ high) policy:  
old (solid), new (dashed) member



# Effects of Worker Flows

- ▶ Local HC endowment might also change through regional worker flows.
- ▶ Openness of labor markets for foreign workers plays crucial role.
- ▶ Effects of different sizes and dynamics of spatial frictions on the labor market has been studied in an additional set of experiments in the EURACE framework with two regions characterized by old and new member properties.
- ▶ It turns out that normative implications differ between
  - ▶ Old and new member perspective
  - ▶ Household and firm perspective



## Conclusions

- ▶ The agent-based EURACE macro-model has been used to explore several issues directly relevant to the Lisbon strategy.
- ▶ Distance to frontier plays an important role for importance of HC vs. R&D policy, but more refined consideration of the reason for the gap is needed.
- ▶ Differences in policy effects between old and new members depend qualitatively on considered time-horizon.
- ▶ Link between demand effects and diffusion of new technologies matters (although ignored in standard new growth models)



Thank you for your attention!

More on the EURACE Project: <http://www.eurace.org>



## Direct Estimation: Examples

Labor intensity of production	$\alpha = 0.662$	German Stat. Office
Price-markup of consumption good producers	0.2	Small (1997)
Annual depreciation rate of capital	0.12	German Stat. Office (2006)
Marginal propensity to save	0.1	German Stat. Office
Fraction of on-the-job searchers	0.1	Pissarides and Wadsworth (1994)



# Parameterization of the model

## Calibration:

- ▶ Some parameters are chosen in order to stabilize the simulations and yield plausible outcomes:
  - ▶ Examples:
    - ▶ Parameters in demand forecasting rules
    - ▶ Parameter governing wage offer increases triggered by rationing on the labor market
    - ▶ Speed of adjustment of firm's planned capital stock
    - ▶ Parameters in the consumer's logit model
  
- ▶ Based on evaluations of effects of variations of these parameters on key macro and meso variables
  - ▶ Output, GDP, growth rate of GDP, unemployment, prices, demand, firm-stocks, commuters etc.