The Entrepreneurial State at Work: an Agent-Based Model Exploration

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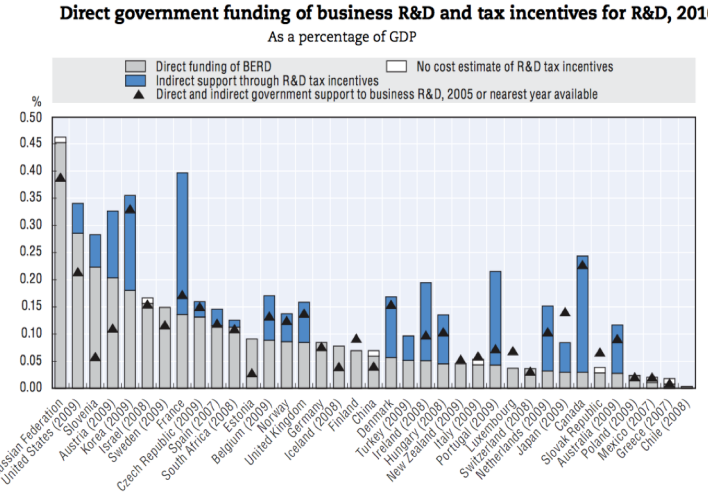
19 March 2018 - Frame Mid-Term Conference, Mannheim

The Role of the State in the Economy

> The road to the free market was opened and kept open by an enormous increase in continuous, centrally organized and controlled interventionism.
>
> (*Karl Polanyi, The Great Transformation, 1944*)

> The important thing for Government is not to do things which individuals are doing already, and to do them a little better or a little worse; but to do those things which at present are not done at all.
>
> (*John M. Keynes, The End of Laissez Faire, 1926*).

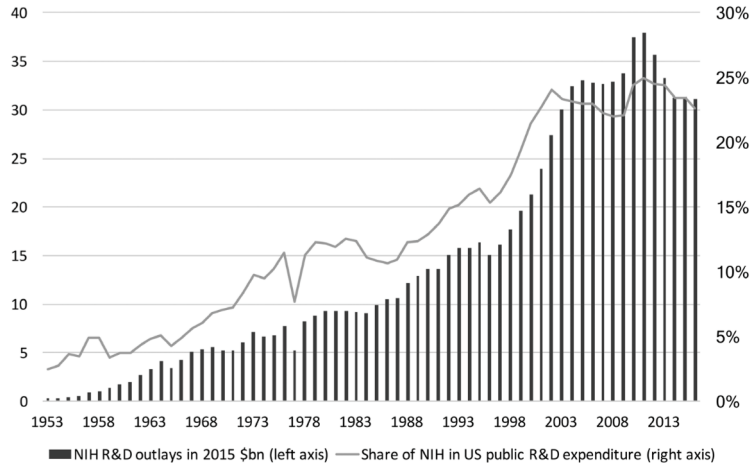
Policies Supporting R&D activities



Source: OECD 2012 http://www.oecd.org/sti/sti-outlook-2012-financing-business-rd.pdf

The Entrepreneurial State

- Directing R&D towards specific issues/technologies



Related Literature

- The State, especially in the US and UK, has covered a much more relevant role than a market-failures fixer
  - Mazzucato 2013; 2015; Mazzucato and Semieniuk 2017. [funding over the whole innovation chain; strategically selecting missions/technologies to be developed, taking risks independently of business cycle]
  - Acemoglu et al. 2016 [from an historical point of view, presence of US State has fostered patenting activities and development]
- Large government spending in research and innovation can foster growth and stability
  - Dosi 1988; Mazzucato 2013. [The US has generously funded R&D and basic research through a variety of programs that contributed to growth and tech leadership]
  - Kokko et al, 2015. [Positive effect of governement R&D spending in EU15, but magnitude less than in US (meta-analysis)]
- Direct vs. indirect interventions
  - Indirect interventions are those based on monetary incentives: tax discounts and subsidies
  - Direct interventions are those where the State actively shapes the investment landscape
  - "Direct interventions that create new technological and industrial landscape tend to crowd-in private investments more than indirect tax incentives do" [Mazzucato 2017]

This paper

- We build on the K+S model family (Dosi et al. 2010, 2013, 2015, 2016, 2017; Lamperti et al. 2017)
- We provide an **agent-based macro model** where the role of different government policies towards innovation might be analysed in details
  - R&D subsidies
  - direct government intervention
- Related literature: Wirkierman et al 2017, Botta 2015, Caiani et al 2016, Ciarli et al 2016

A Sneak Preview of the Results

- R&D subsidies to firms increase productivity and GDP growth, but they are very expensive
- Investment tax discount are cheaper, but they have a negligible impact on productivity and growth
- Direct government interventions enlarging technological opportunities provide the best results:
  - better short-run and long-run performance (positive hysteresis)
  - however, they can fail and then having a negative impact on public budget
  - substantial public investment is required to reduce the risk of increasing public deficit
  - public interventions should pursue radical innovations, which enlarge technological opportunities

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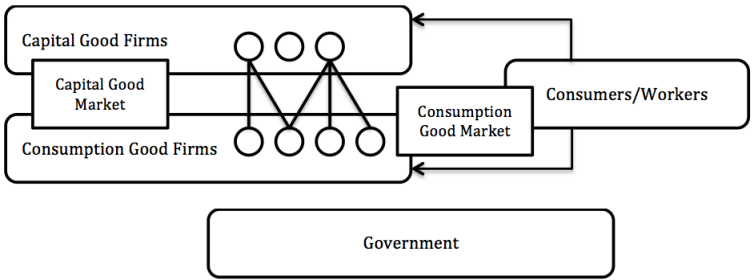
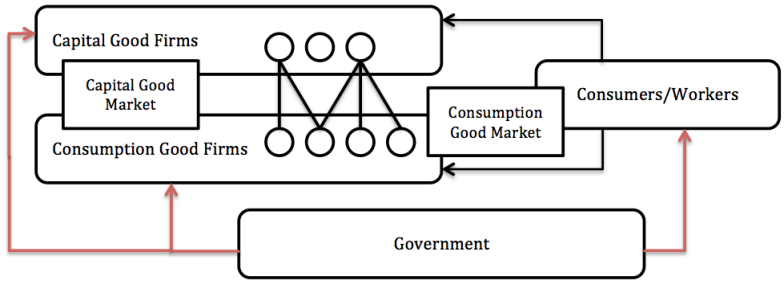
  - substantial public investment is required to reduce the risk of increasing public deficit
  - public interventions should pursue radical innovations, which enlarge technological opportunities
- An **Entrepreneurial State** can substantially improve the short-and long-run performance of the economy, while keeping the deficit/GP ratio under control

The K+S Model



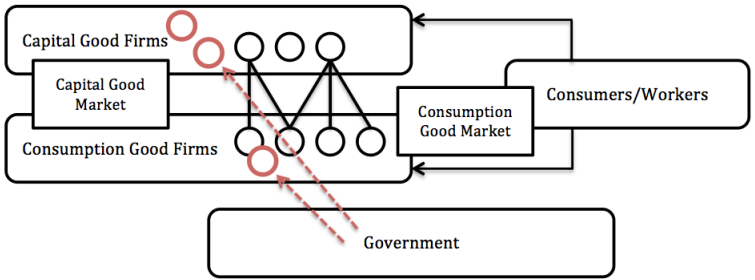
- Which role for the Government/State?

The K+S Model - Role of the State



- Indirect intervention + fiscal policy

The K+S Model - Role of the State



- Direct intervention

The K+S Model - Technical Change I

- **Capital-good firms search for better machines and for more efficient production techniques**
  - $A_{i,k}(t)$: feature of machine manufactured by firm i
  - $B_{i,k}(t)$: feature of production technique of firm i
  - $A_{i,k}(t)$ and $B_{i,k}(t)$ determine the technology of firm i at time t
- **R&D:**
  - R&D investment (RD) is a fraction of firm sales (S):

$$RD_i(t) = \upsilon S_i(t-1) \qquad \upsilon > 0$$

  - capital-good firms allocate R&D funds between innovation (IN) and imitation (IM):

$$IN_i(t) = \xi RD_i(t) \qquad IM_i(t) = (1-\xi) RD_i(t) \qquad \xi \epsilon [0,1]$$

The K+S Model - Technical Change II

- **Innovation and imitation: two steps procedure**
- **Innovation:**
  1) firm successfully innovates or not through a draw from a Bernoulli($\theta_1(t)$), where $\theta_1(t)$ depends on $IN_i(t)$:
  $$\theta_1(t) = 1 - e^{-o_1 IN_i(t)} \qquad o_1 > 0$$
  2) search space: the new technology is obtained multiplying the current technology by $(1 + x_i(t))$, where
  $x_i(t) \sim$ *Beta* over the support (x_0, x_1) with $x_0 < 0, x_1 > 0$
- **Imitation**
  1) firm successfully imitates or not through a draw from a Bernoulli($\theta_2(t)$), where $\theta_2(t)$ depends on $IM_i(t)$:
  $$\theta_2(t) = 1 - e^{-o_2 IM_i(t)} \qquad o_2 > 0$$
  2) firms are more likely to imitate competitors with similar technologies (Euclidean distance)

The K+S Model - Innovation

- Firms might innovate in two activities
  - **incremental innovation**: finds machines/production techniques with novel technical characteristics
  - **"radical" innovation**: enlarges the search space (technological opportunities)

The K+S Model - Capital-Good Market

- **Capital-good firms:**
  - if they successfully innovate and/or imitate, they choose to manufacture the machine with the lowest $p_i + c_i^1 b$
    - p_i: machine price;
    - c_i^1: unit labor cost of production entailed by machine in consumption-good sector;
    - b: payback period parameter
  - fix prices applying a mark-up on unit cost of production
  - send a "brochure" with the price and the productivity of their machines to both their historical and some potential new customers

- **Consumption-good firms:**
  - choose as supplier the capital-good firm producing the machine with the lowest $p_i + c_i^1 b$ according to the information contained in the "brochures"
  - send their orders to their supplier according to their investment decisions

The K+S Model - Investment

- **Expansion investment**
  - demand expectations (D^e) determine the desired level of production (Q^d) and the desired capital stock (K^d)
  - firm invests (EI) if the desired capital stock is higher than the current capital stock (K):

$$EI = K^d - K$$

- **Replacement investment**
  - payback period routine:
    - an incumbent machine is scrapped if

$$\frac{p^*}{c(\tau) - c^*} \leqslant b, \qquad b > 0$$

    - $c(\tau)$ unit labor cost of an incumbent machine;
    - p^*, c^* price and unit labor cost of new machines
  - also machine older than Λ periods are replaced

Closing the Model: The Macro Framework

- **Fiscal policy and the public budget:**
  - constant tax and unemployment-subsidy rate
  - direct and indirect R&D expenditures
  - the public deficit in each period is:

$$Def_t = SubU_t + IndirectRD_t + DirectRD_t - Tax_t + r_{B,t} Debt_t$$

Indirect, Horizontal Innovation Policies

1. **R&D subsidy**
   - a lump-sum subsidy is given to firms in order to perform R&D
   - it adds to the share of revenues firms allocate to R&D

2. **Tax discounts on investments**
   - firms receive a tax discount linked to their investments
   - if firms invest (in physical capital or R&D, different scenarios are possible), they receive a tax discount corresponding to a fixed share of the monetary amount invested

Direct Interventions

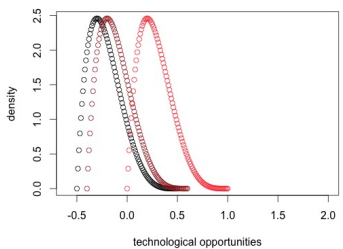
3. **"State" performing R&D**
   - additional firm in the capital good industry
   - it perform R&D as all the other firms, it re-invest all profits into R&D
   - everybody might imitate the state firm (if convenient)

4. **"State" enlarging technological opportunities**
   - State in search for "radical" innovation: i.e. finding a technology enlarging the current opportunity set
   - different scenarios:
     - unintended R&D: State performs R&D to obtain incremental innovation and might occasionally discover a "radical" technology
     - intended R&D: State decides to direct R&D towards "radical" technology (e.g. Bell laboratories)
   - everybody might imitate the state firm (if convenient)

Enlarging technological opportunities

- “Radical” innovations are modelled through a Poisson process depending on the cumulative expenditure in R&D
- When a “radical” technology is successfully discovered, the support of technological opportunities shifts to the right
- After a “radical” innovation is discovered the cumulative R&D expenditure is set to zero

Technological opportunities.



Descriptive Statistics - baseline configuration

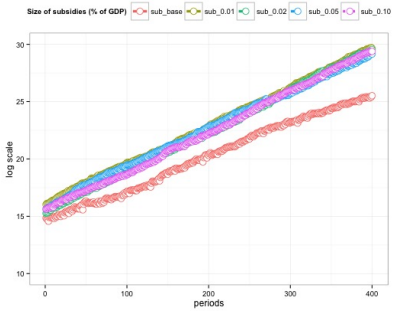
Variable	Average	St. Dev	Variable	Average	St. Dev
GDP growth	0.0244	0.0016	Unemployment	0.0714	0.0327
GDP volatility	0.0789	0.0007	Productivity growth	0.2506	0.0015
Deficit on GDP	-0.0810	0.0530	HHI Cap. Good sector	0.6280	0.0512
Likelihood of crises	0.171	0.0415	HHI Cons. Good sector	0.0029	0.0001

(All statistics refer to a Monte Carlo experiment of size 100)

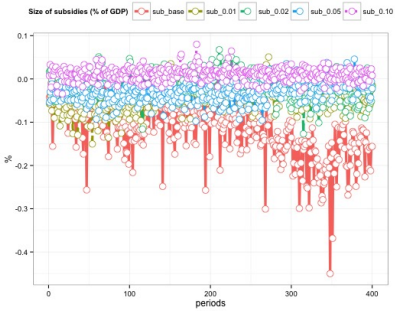
Exp. 1 - R&D Subsides

- Subsidies induce higher growth, but worsen the deficit to GDP ratio
- However, there is a upper bound to their impact on growth

(a) GDP



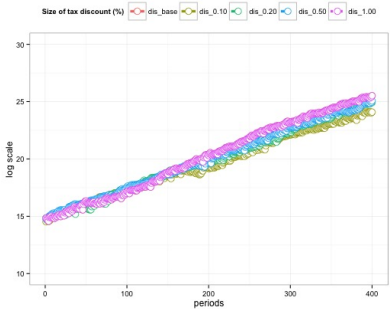
(b) Deficit on GDP



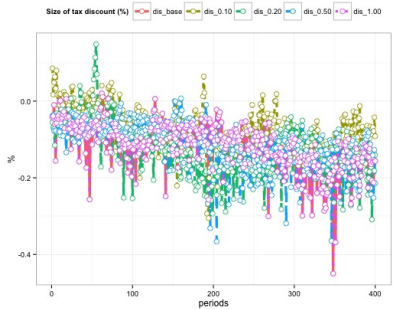
Exp. 2 - Investment Tax Discount

- Tax discount on physical investments has little impact on GDP growth
- The negative effect on the deficit to GDP ratio is also rather weak

(a) GDP



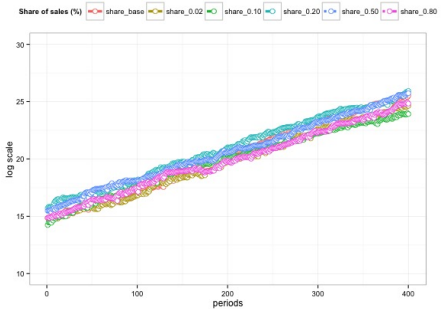
(b) Deficit on GDP



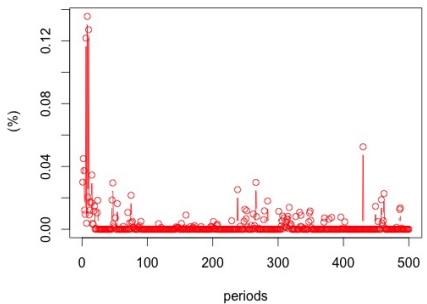
Exp. 3 - Publicly-Owned Firm Performing R&D

- State conducts R&D and allows diffusion of discovered technologies
- If State-discovered technology does not diffuse there is no effect on growth and publicly-owned firm remains uncompetitive

(a) GDP



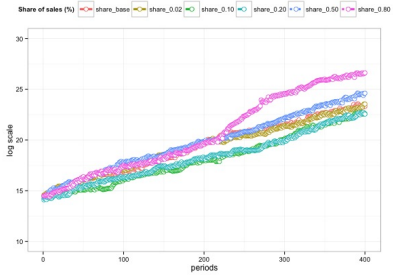
(b) Publicly-owned firm's market share



Exp. 3 - Publicly-Owned Firm Performing R&D

- State conducts R&D and allows diffusion of discovered technologies
- When State-discovered technology diffuse there is a structural break in the growth process (positive hysteresis)
- State firm becomes dominant only temporarily (just during the diffusion process)

(a) GDP.



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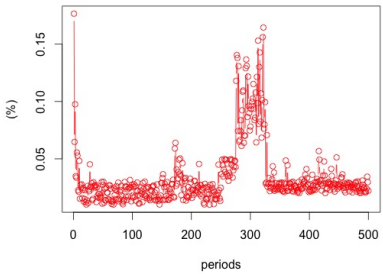
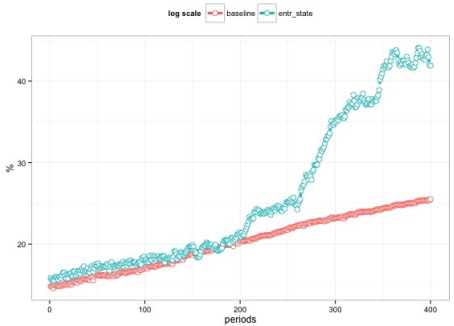


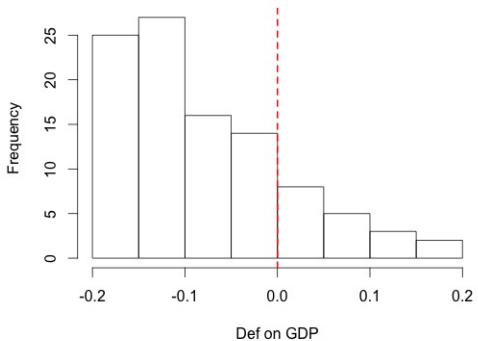
Exp. 4 - Publicly-Owned Firm Looking for Radical Innovation

- State performing R&D to enlarge technological opportunities ("radical" innovation)
- When State firm diffuses superior technology growth process shifts to higher growth trajectory (super-hysteresis)



Exp. 4 - Publicly-Owned Firm Looking for Radical Innovation

- However, Government policies may not be succesfull
- In that case, growth does not benefit and deficit to GDP substantially increases



Aggregate Performances under Each Experiment

Experiment	GDP growth	Unemployment	GDP volatility	Deficit on GDP	HH1
Baseline	1	1	1	1	1
R&D sub - 1%	1.26***	0.84***	0.99	1.34***	1.05
R&D sub - 2%	1.37***	0.77***	1.05	1.45***	1.19*
R&D sub - 10%	1.87***	0.68***	1.08	2.23***	0.97
Tax disc - 10%	1.00	1.01	0.98	1.01	1.00
Tax disc - 20%	1.02	0.99	0.96	1.05	1.01
Tax disc - 100%	1.05**	0.93*	0.89	1.06*	0.97
Entr. State. R&D - 2%	1.07*	0.90	1.13	1.25***	1.09
Entr State R&D - 50%	2.46***	0.63***	1.45***	1.10**	1.27***
Entr. State - tech opps 2%	1.05	0.88***	1.09	2.51***	1.25
Entr. State - tech opps 5%	2.89***	0.59***	1.84***	0.88***	1.38***

(Numbers express performance relative to the baseline: e.g. 1.2 indicates that given variable is, on average, 20% higher than in the baseline)

Summing up - Policy Experiments Results

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What about mission-oriented policies?

Sustainable Growth: A Possible Mission-Oriented Project

- Extend the model to account for energy production, GHG emissions, temperature dynamics, and heterogenous (catastrophic) climate shocks
- Energy taxes and subsidies proved poorly effective in inducing a transition [Lamperti et al. 2017]
- What if the Government would embrace the goal of fighting climate change through a Mission Oriented project?