Learning Benevolent Leadership in a Heterogenous Agents Economy

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Main research questions

- What is the potential policy value of cheap-talk inflation announcements when
  - no binding commitment is possible
  - the policy-maker has an incentive to deviate ex post from its announcements?
- What is the impact of the policy-maker’s futurity, of the speed of learning of the agents, of the costs of learning?
- What is the impact of noise and of heterogeneity among the agents?
Ingredients

- Kydland-Prescott-type framework with heterogenous boundedly rational agents
- Policy-maker (central bank): individual evolutionary learning a la Arifovic-Ledyard
- Private agents: error correction learning
- INTERTEMPORAL TRADEOFF: A deviation between announced and implemented policy provides short-term gains, but reduces the ability of the policy-maker to influence the private agents in the future.
The one-shot game (Dawid and Deissenberg, JEBO 2005)

- **Actors:**
  - Policy-maker (central bank) $G$
  - Private agents $P^i$, $i \in [0, 1]$

- **Instruments and game sequence:**
  - $G$ announces an inflation rate $y^a$
  - Each $P^i$ independently makes an inflation forecast $x^i$
  - $G$ observes the $x^i$ and chooses an inflation rate $y$
The private agents $P^i$ can choose between two strategies:

- **BELIEVE:**
  \[ x^B = y^a \]

- **BUILD PERFECT ANTICIPATIONS:**
  \[ x^{NB} = y \]

Thus the population consists of $\pi$ believers $B$ and $(1 - \pi)$ nonbelievers $NB$.

$\pi$ is common knowledge.
The one-shot game

- **Economy:**
  - Expectations-augmented Philips curve:
    \[ u^i = u^* - \theta \left( y - x^i \right), \quad u^* > 0, \quad \theta > 0 \]

- **Payoffs:**
  \[
  J^{Pi} = \frac{-1}{2} \left[ (y - x^i)^2 + y^2 \right] \quad \rightarrow \quad \max_{x^i} \\
  J^G = \frac{-1}{2} \left( \pi \left( u^B \right)^2 + \left( 1 - \pi \left( u^{NB} \right)^2 \right) + y^2 \right) \quad \rightarrow \quad \max_{y^a, y}
  \]
The one-shot game - and its bad property

At the Nash equilibrium:

- $y^*$ and $y^a$ decrease with $\pi$
- $J^G$, $J^B$, and $J^{NB}$ increase with $\pi$
- But for all $\pi \in (0, 1)$ \( J^{NB} > J^B \)
- Thus, $\pi = 0$ is the only (symmetric) equilibrium – but a bad one.
A dynamic agent-based extension

- Discrete time \( t = 1, 2, .. \)
- Finite number of private agents
A dynamic agent-based extension - private agents

- In each $t$ the $B$s forecast is as before:
  \[ x_t^B = y_t^a \]

- The $NB$s forecasts are given by their optimal reaction function for the static game plus an (individual or common) error correction term $d_t^i$:
  \[ x_t^{NB,i} = \theta^2 \pi_t y_t^a + \theta u^* + \frac{\theta^2 \pi_t}{1 + \theta^2 \pi_t} + d_t^i \]

- Making a $NB$ forecast costs $c > 0$

- The error correction terms are updated according to
  \[ d_{t+1}^i = d_t^i + \gamma (y_t - x_t^{NB,i}), \quad \gamma > 0 \]
A dynamic agent-based extension - private agents

- All period payoffs are as before – with $u_t^{NB}$ replaced where relevant by $\bar{u}_t^{NB}$
- At the end of each period, agents can switch strategy ($B$ or $NB$) according to a word-of-mouth process:
  - a fraction $\beta$ of agents is chosen randomly
  - the chosen agents meet pairwise randomly
  - they observe the strategy $B$ or $NB$ followed by the partner
  - they imperfectly observe the partner’s payoff
if \( J_{obs}^k > J^i \),

then agent \( i \) adopts the strategy of agent \( k \)

As a consequence

\[
\Delta \pi_t = \pi_{t+1} - \pi_t = \beta \pi_t (1 - \pi_t) \arctan(J_t^B - J_t^{NB}),
\]

After a strategy switch, a new \( NB \) \textbf{either} observes the common \( d_t \) \textbf{or} starts its learning process with \( d_t^i = 0 \)
A dynamic agent-based extension - policy-maker

- At each time $t$, $G$ has a collection of $N$ rules $\{y^a, y\}$.
- For each rule, it computes the hypothetical payoff

$$J^G_j = -\frac{1}{2}[\pi_t(u^B_{hyp,j})^2 + (1 - \pi_t)(u^{NB}_{hyp,j})^2 + y_j^2] + \Omega \Delta \pi^{exp}_j$$

- It selects a rule randomly with probability

$$P(\text{rule}_j) = \frac{J^G_j}{\sum_{i=1}^N J^G_i}$$

- Each element of the rule is changed with probability 0.2 according to (experimentation)

$$\text{new value} = \text{old value} + \varepsilon,$$

- Rules are also subjected to mutation and to tournament selection replication
Simulations: The basic setting

- $\beta = 0.05$, $u^* = 5.5$, $\theta = 1$, $c = 0.1$, $\gamma = 0.1$
- $G$ has $N = 100$ rules.
- Simulations are run for 300 periods.
- All data presented = averages over 100 runs.
- All results are statistically significant
- Nash equilibrium: $\pi = 0$, $J^P = -30.25$
Simulation: Emergence of policy announcements and evolution of credibility

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Homogeneous, cost=1, γ=0.1. (a) stock of believers

(b) \( J^G \)

(c) actual and announced inflation

(d) payoffs
Simulation: Impact of omega

but there exists for all $0 < \rho < 1$ an unique value of $\Omega$ that maximizes

$$J^{G, disc} = \sum_{t=0}^{T} \rho^t J^G_t$$
Simulation: Impact of c, gamma

For sufficiently small variations from the base scenario

\[ c \uparrow \text{ or } \gamma \downarrow \implies J^{G,\text{disc}} \uparrow \]

but the two cases are not qualitatively equivalent!

1. \( c \uparrow \implies \pi \uparrow, \ y^a - y \downarrow, \ u^B \uparrow, \ u^{NB} \uparrow, \) but \( u^B < u^{NB} \) and \( \pi \uparrow \) partially offsets this, and \( y \downarrow \).
Thus \( J^{G,\text{disc}} \uparrow, \ J^B \uparrow, \ J^{NB} \uparrow \).

LOW INFLATION SCENARIO

2. \( \gamma \downarrow \implies y^a - y \uparrow, \ y^a \downarrow, \ y \uparrow, \ \pi \downarrow \).
Thus \( J^{G,\text{disc}} \uparrow, \ J^B \downarrow, \ J^{NB} \downarrow \).

LOW UNEMPLOYMENT SCENARIO
THERE EXISTS A (PARETO)-OPTIMAL LEVEL OF $c, \gamma$
Heterogeneity: Basic impact

Fluctuations and inefficiency increase

- Initially, $\pi$ grows faster in the heterogenous case – but declines faster afterwards:
- It is easy to build up a stock of $B$s since the option $NB$ is not very attractive ($d = 0$ after a switch!).
- But this creates a strong incentive for $G$ to exploit this stock later!
Heterogeneity and variations of $c$, $\gamma$

- For the basis parameter values, for sufficiently small increases of $c$, we no longer have lowered inflation but decreased unemployment.
- When $\gamma$ decreases, $y$ and $y^a$ decrease but $y^a - y$ increases.

The unemployment of $B$s therefore increases. But the unemployment of $NB$s also increases since their adaptation speed is lower.

- The impact of sufficiently small changes of $\gamma$ remains unchanged.
- But this reflects just a shit in the domains where (say) an increase of $c$ is beneficial. There are still optimal values of $c, \gamma$.

**Comparison (1st arrow = homo, second arrow = hetero)**

<table>
<thead>
<tr>
<th>$J^G_{disc}$</th>
<th>$\pi$</th>
<th>$y$</th>
<th>$u^B$</th>
<th>$u^{NB}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$</td>
<td>↓</td>
<td>↑</td>
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<tr>
<td>$c$</td>
<td>↑</td>
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\begin{itemize}
  \item $G$ is able to learn a Pareto-superior outcome by making inflation announcements that are not respected.
  \item For this, it is necessary that:
    \begin{itemize}
      \item $G$ is sufficiently patient ($\Omega$ must be sufficiently large)
      \item the private agents learn sufficiently fast and sufficiently accurately at sufficiently low costs: this prevents $G$ from exploiting the believers too much.
    \end{itemize}
  \item The economy exhibits recurrent fluctuations in announced and actual inflation as policy-maker repeatedly builds up and exploits the proportion of believers.
\end{itemize}
Conclusions

- Changes in different parameter values lead to different policy responses.
- In the heterogeneous case the variance of nonbelievers’ expectations makes policy-making less efficient.
Conclusions

- Large forecast errors of nonbelievers can come from slow speed of adjustment of the error correction term and/or from heterogenous expectations.
- It is in the interest of the policy-maker to facilitate the information flow among nonbelievers so that an agent who switches to nonbelieving can build on the experience of the other nonbelievers.
- Making too much data publicly available may however reduce the costs $c$ of being a nonbeliever, which is not desirable for the policy-maker.
EXPLICIT CONSIDERATION OF HETEROGENEITY IS NEEDED IN POLICY-MAKING ANALYSIS!

THE POLICY-MAKER HAS A NON-TRIVIAL TASK:

- TO REDUCE LARGE EXPECTATION ERRORS AMONG THE NBs
- BUT, AT THE SAME TIME, TO KEEP THE INCENTIVES FOR TAKING POLICY-ANNOUNCEMENTS AT FACE VALUE AS STRONG AS POSSIBLE!
Final words

- The full paper is R&R at JEDC
- It is available as a GREQAM WP


(or ask me, christophe.deisslenberg@univmed.fr)
THANKS FOR YOUR ATTENTION

THANKS TO GUIOMAR AND ALL THE ORGANIZERS FOR A MOST LOVELY MEETING AT A DELIGHTFUL PLACE!