Use of multi-level self-regulating agents to evaluate the impact of innovation policies in socio-economic environments

The case of ICT Procurement in Puglia, Italy

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Main question leading the research

❖How to support policy-makers in defining the actions to improve the performances of a well-defined socio-economic context?

❖How to estimate the full impact of these actions ?

And what is "full impact"?

Theoretical context   1/2

❖The **evaluation** of the impact of innovation policies on economic systems has been at the centre of the research policy debates for several decades.

Methods:

❖Instruments and techniques used to carry out innovation policy impact studies have also been those of classical econometrics and/or qualitative analysis (Fahrenkrog et al., 2002; Shapira and Khulmann, 2003).

❖Quantitative approaches have based their impact assessments "exercises" on the application of linear (or quasi- linear) theory in deterministic environments

❖Qualitative approaches have delved into the particulars of policy evaluation from the implementation phase to longer terms results

Theoretical context   2/2

❖Alternative rationales for **policy making** are emerging, for example:

   ❖the system's failure approach: Metcalfe, 2005, Bleda (RP)

   ❖the approaches of complexity and networks:

   Santa Fe institute, Benjamin and Greene, 2009;

   Cross et al, 2009;

   Buisseret et al, 1995, Metcalfe, 1995...

Ex-ante and Ex-post

But what is missing?

- Ex-ante studies with whatever complex statistical method hardly consider any implication of behavioural change ("all else being equal" HP)

- Ex-post evaluation are of very little use in the phase of policy design (yet very useful for heuristics)

- On-going evaluation have an edge for policy design (but lock-in effect might be encountered and

....well, *it can be expensive*)

Selected case

❖ <u>Problem</u>: The complexity of innovation policy evaluation and the challenges of modelling the system of innovation

❖ <u>Approach:</u> A modelling strategy based on agent–based modelling in complex systems.

  ❖ the theoretical foundation of our a-b model is the Belief-Desire-Intention (BDI) architecture, introduced by Bratman (Bratman 1987, Rao and Georgeff, 1991, 1995, Gagliardi et al. (2014))

  ❖ **The concepts exploits** belief, desire and intentions as mental attitudes, to mimic human actions. These are captured by informational, motivational, and the deliberate attitudes of agents

Regional context

❖**Sector**:

Information and Communication Technologies

❖ **Geographic context:**

the Public Administration - the Regional Government(s) of the Region of Puglia, Italy

❖ **Relevance:**

In Puglia there are more than 3,200 companies engaged in the ICT industry and more than 16,000 employees involved.

❖**Characteristics:**

the administration of the Puglia Region is hierarchical - top: the Regional Government (depending on the central National Government)

+

▪6 Provincial administrations,

▪subdivided in municipalities.

▪a host of public organisations whose remits are specific and sometimes overlapping.
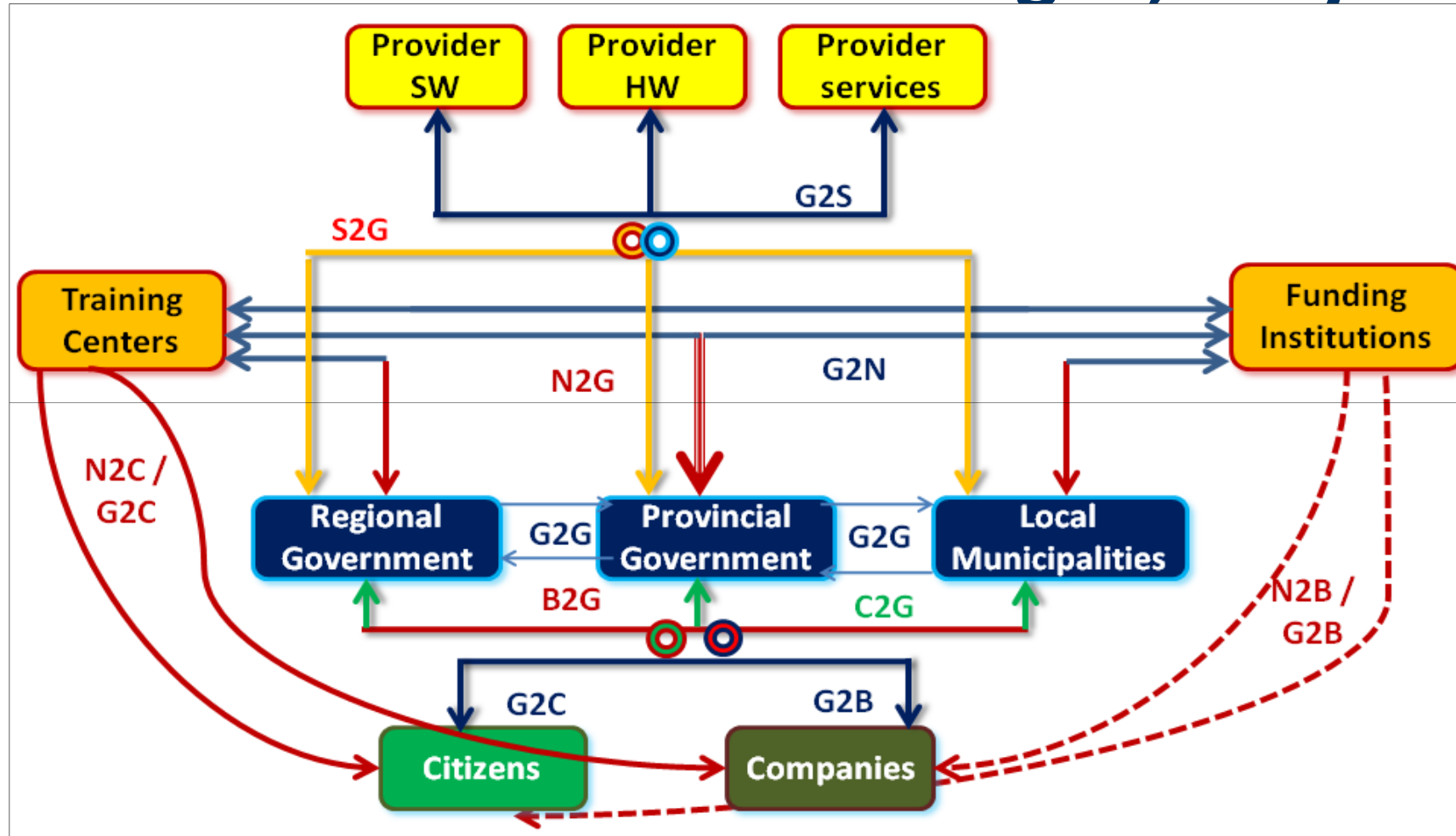
The policy context

typical actions required by the Digital Agenda for Europe:

Policy options:

❖Infrastructure and Broadband

❖The development of a network of services for the private sector (citizens and enterprises).

❖Digital PA and E-Governance

❖the introduction of ICT learning through e-learning programmes.
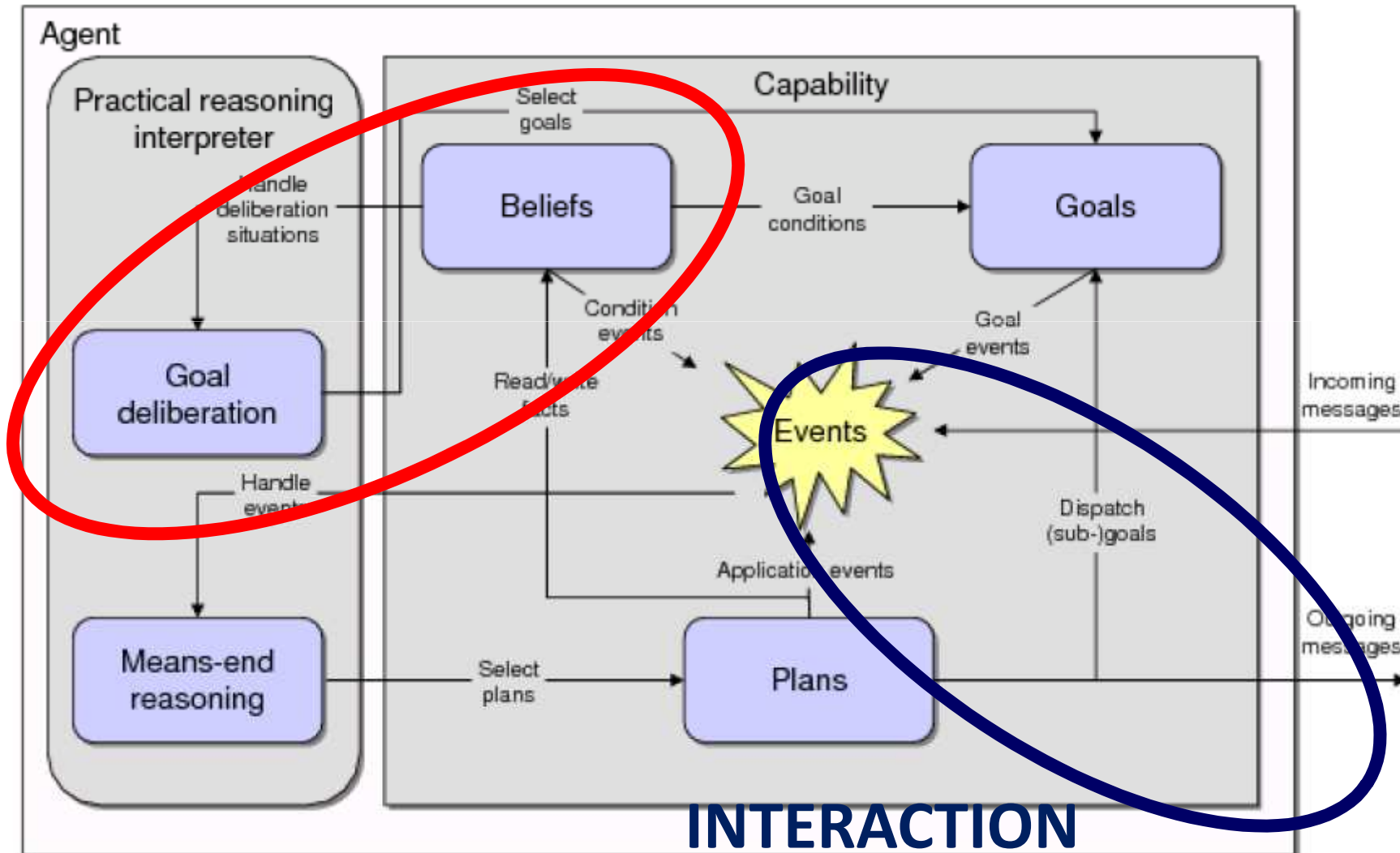
The system:
ICT Procurement in Puglia, Italy

The basic agent behaviour

- Starting point is the 'Book Trading' agent procedure included into the Jadex own libraries
- Agents behave as sellers or buyer of 'books'
- We modified it, accordinlgy to our needs
  - In our case, the 'books' are
    - Information
    - Money
    - Services
    - Products
  - In our case we added variables and built indicators
  - We built hybrid behavioural agents to manage the complexity of the ICT procurement model

JADEX: abstract architecture

REASONING

The variables

❖ information (I), economics (E), services (S), total revenue (R), user satisfaction (D); and a fifth indicator has been added to ascertain the sustainability of the system.

❖*I1 "total information exchanged" = the sum of the information exchanged among agents in the system.*

❖*I2 "innovation & training" = it represents the total added value provided to users (citizens, companies) by the whole system.*

❖*I3 "service penetration" = the level (sum) of adoption of services by end users.*

❖*I4 "user satisfaction" = the level (sum) of the innovation, training and services against the requests of end-users.*

❖*I5 "sustainability" = the capability of the system to preserve Quality of Services and Business as a function that includes also economic parameters and the distributions of I3 and I4.*

The Agents - JADEX

JADEX technology -> to implement BDI
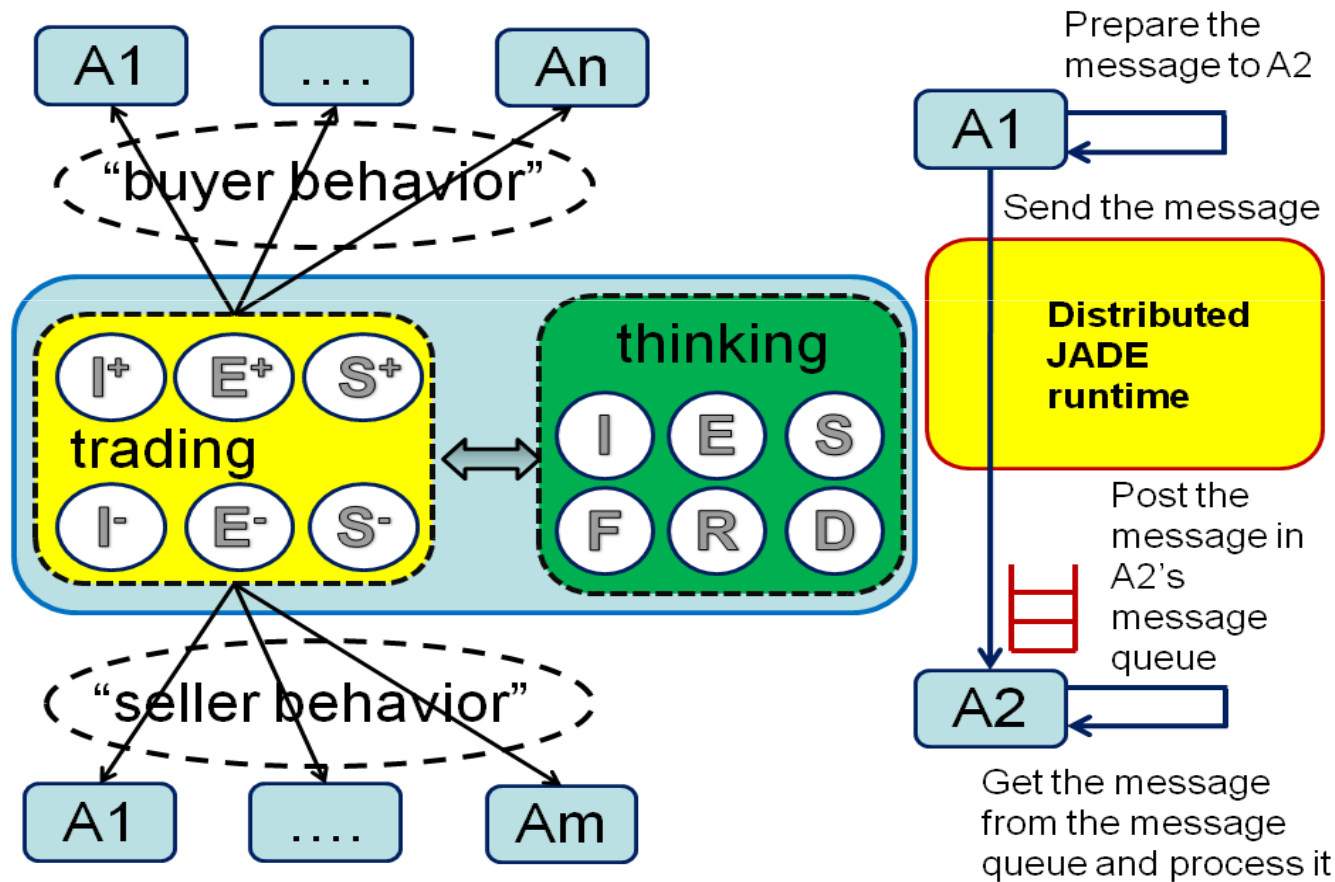
Policy options

❖ **The operating variables:**

- Increase of investments in ICT through Public Procurement for Innovation (HD, SW, Training)

- Infrastructure and Broadband; Digital Citizenship; Digitale Enterprises; Digital Public Administration and e-Services; e-Governance (DGR n. 508 del 23 febbraio 2010)
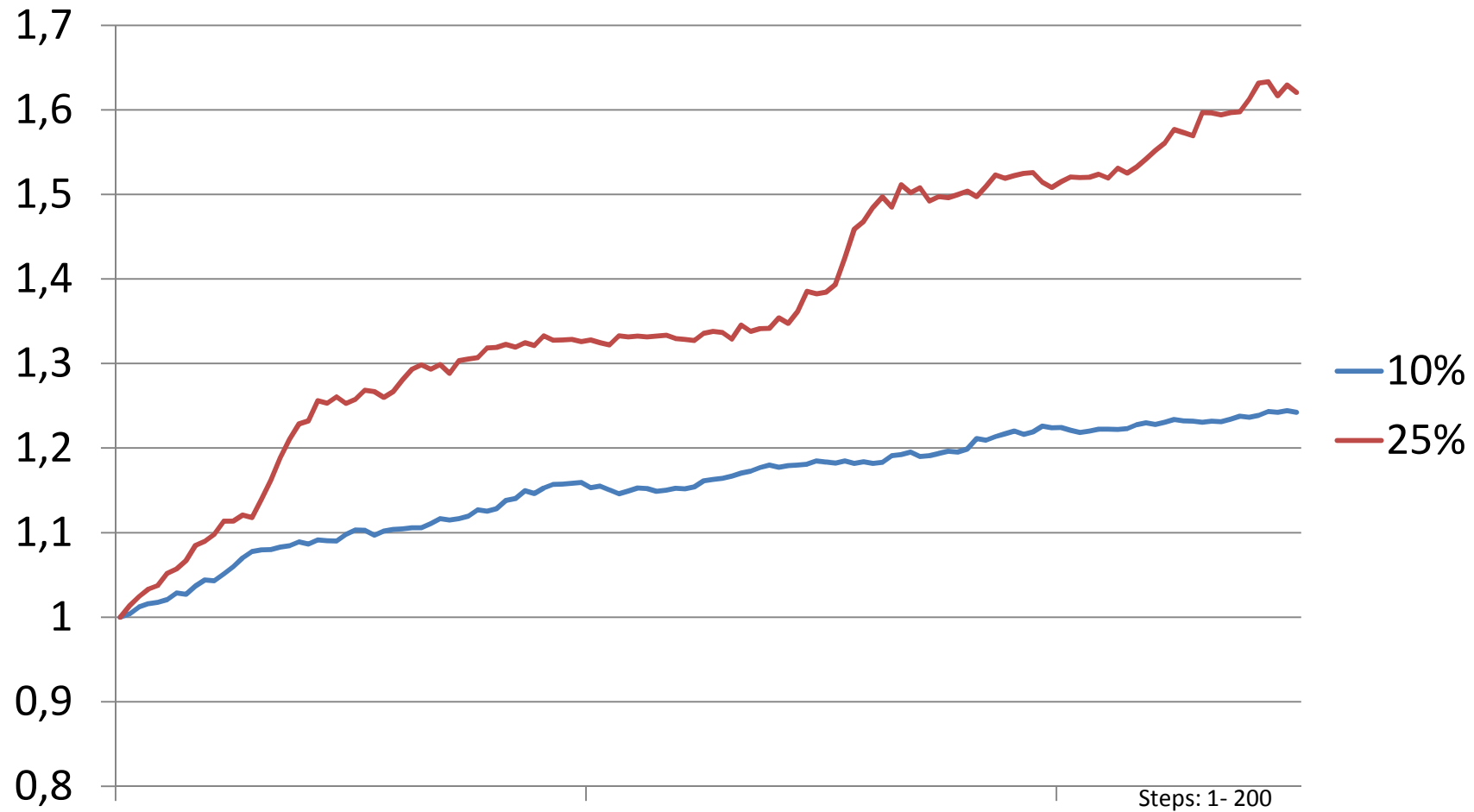
❖ **The options:**

- 2 scenarios - 10% and 25%

naive policy implementation

Results – step by step
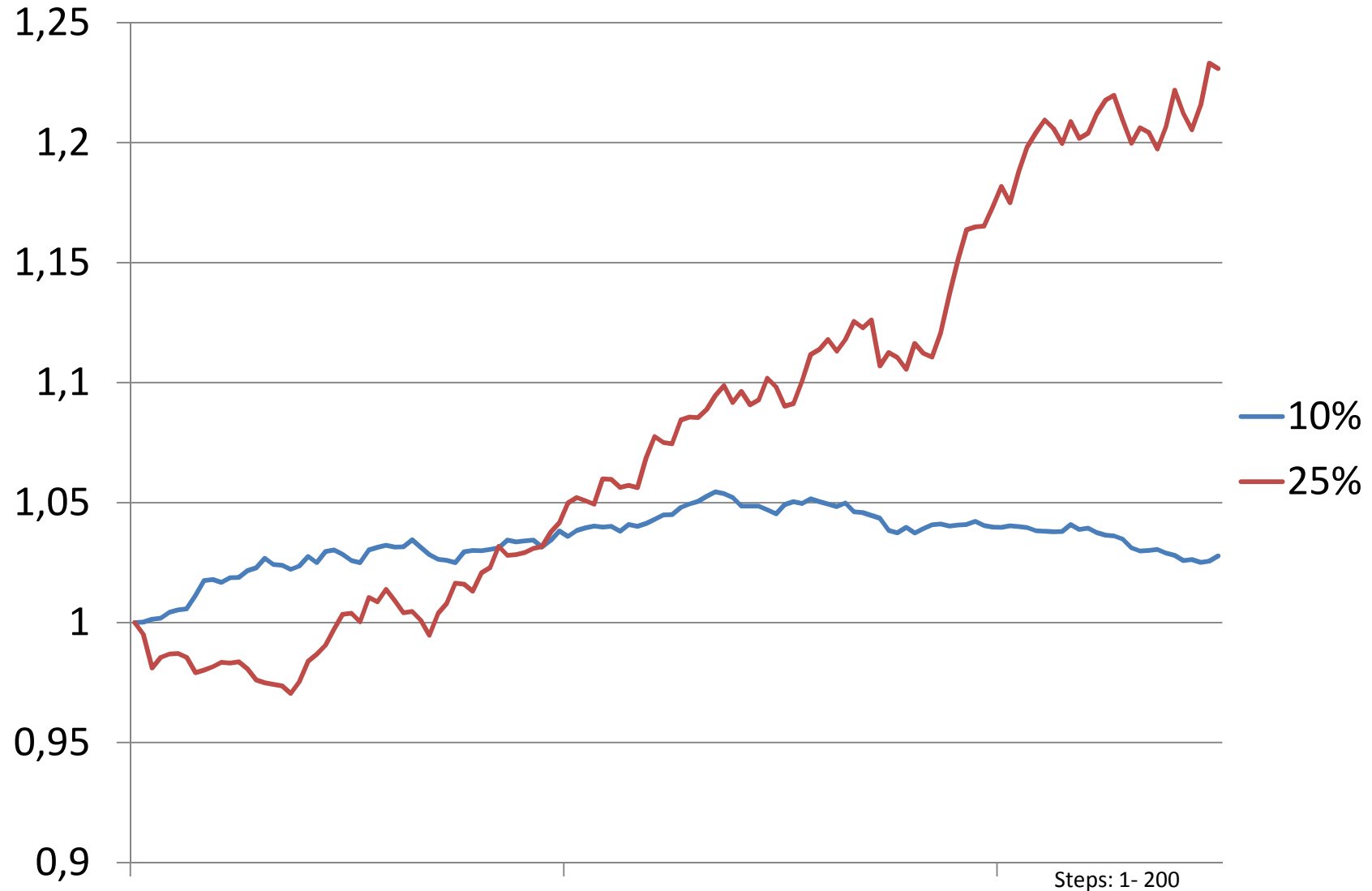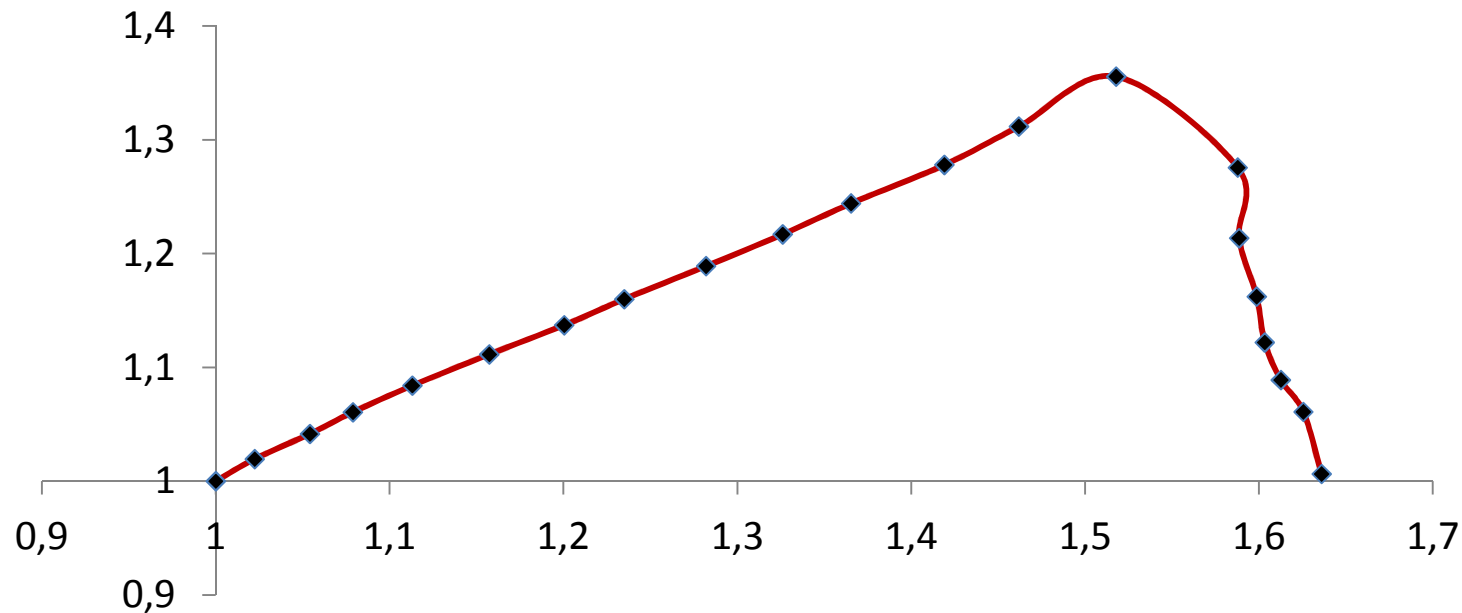
Services provided by the P.A.

Steps: 1- 200

10%
25%

Results – example, a variable

Revenues

Legend: 10%, 25%

Steps: 1- 200

Other results – correlation between Exchange of Information vs. Services provided

Exchange of information amongst the agents at first increases with the increase of the number of services provided up to a point where it virtually ceases

Conclusions

The problem we approached was to consider both

1) **relationships amongst variables** and

2) **systemic effects**

A-B modelling allowed us to extend the analysis of the links between variables based on the knowledge of "real-world" actor (mimicked by agents) in order to understand possible policy outcomes

Simon [1998] - The science and the artificial (pag 52 – 53) *paraphrasing*: human behaviour, contextualised within the complexity of a system, can be explained by simple/predictable behaviours. The reason or the behaviour can be based on an infinitely complex cumulative memory, motivations or emotions, yet the end result or behaviour of an adaptive being will be somehow predictable and reflecting the characteristics of the outer environment (in the light of the goals set).

-This argument is very similar to Metcalfe et al (2012) and Metcalfe (2012)
http://www.openloc.eu/page/?/working-papers/

Considerations

❖Policy

   ❖easy-to-use platform for the evaluation of alternative policy scenarios.

   ❖it has given encouraging preliminary results.

   ❖appropriate to describe and analyse non-deterministic dynamics of complex systems

   ❖Statistically sound (testable)

❖Technology

   ❖it is easily scalable

   ❖allows validation even with sparse data

❖It works well on regional contexts (Gagliardi, Niglia and Battistella, TFSC 2014) BUT we need a model for each economic system we analyse

Thank you!

Comments and suggestions are more than welcome

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