# NUOVE TEORIE DEI MERCATI:

# L'APPROCCIO SPERIMENTALE

PATRIZIA SBRIGLIA

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# Markets, Rationality and Information

BOUNDED RATIONALITY HYPOTHESES IN IO:

*RULES OF THUMB, TRIAL AND ERRORS, COGNITION CONSTRAINTS, ETC.*

**RESEARCH QUESTIONS IN THIS PAPER:**

A) Is there a model of bounded rationality for markets (oligopoly)?

B) If so, what are the efficiency predictions of this model?

C) Is that a *new* model?

# Markets, Rationality and Information

## CLAIMS:

1) Analyses of experimental evidence show that bounded rationality models predict agents' market behaviour better than alternative models of rationality *(Nash equilibrium; consistent conjectural equilibrium..);*

2) Analyses of experimental evidence on individuals' behavioral rules in market interaction show that strategic information shapes agents' learning behaviour and affects long run efficiency in markets;

3) The "bounded rationality model" (BRM) in markets stems from the early studies of bounded rationality (Simon, 1955; Rothschild, 1947; Cyert and March)

# Markets, Rationality and Information

EXPERIMENTAL MARKETS

Dynamic Oligopolies experiments

(see for reference: Holt 1995; Vriend et al. 2008)

- Quantity, price games;
- Duopolies, triopolies;
- Fixed, random matching;
- Perfect information on demand and costs;
- Various info settings on rivals' choices;

# Markets, Rationality and Information

## PREVIUOS EXPERIMENTAL EVIDENCE ON DYNAMIC OLIGOPOLIES:

*Early studies (Holt, 1995):*

***Nash equilibrium concept is a good predictor for market efficiency. As the number of agents decreases, tacit collusion among sellers increases (fixed matching, best reply behaviour).***

***Recent study (Engel, 2007) RESULTS NOT SO CLEAR-CUT: MANY MORE FACTORS AFFECT LONG RUN EFFICIENCY***

***Stranger-partner designs; information effects on the degree of collusion in markets.***

**ENGEL FINDS THAT THE DEGREE OF COLLUSION IS INFLUENCED NOT ONLY BY THE STRUCTURAL MARKET CHARACTERISTICS: IMPORTANT ROLE PLAYED BY STRATEGIC INFORMATION, TYPE OF INTERACTION, COMMUNICATION AMONG SUBJECTS.**

# OLIGOPOLY MODELS

## THE MODELS USED IN THIS PRESENTATION:

*Price and quantity games; homogeneous and differentiated products, duopolies; triolpolies, fixed and random matching, PERFECT INFORMATION ON COST AND DEMAND*

## THE DATA

*Holt, 1985; Fouraker and Siegel , 1963; Altavilla, Luini, Sbriglia, 2006;*

## SUBGAME PERFECT EQUILIBRIUM

*1) HOMOGENEOUS QUANTITY COMPETITION*

*2) DIFFERENTIATED PRICE COMPETITION*

*3) DIFFERENTIATED PRODUCTS ( QUANTITY CASE)*

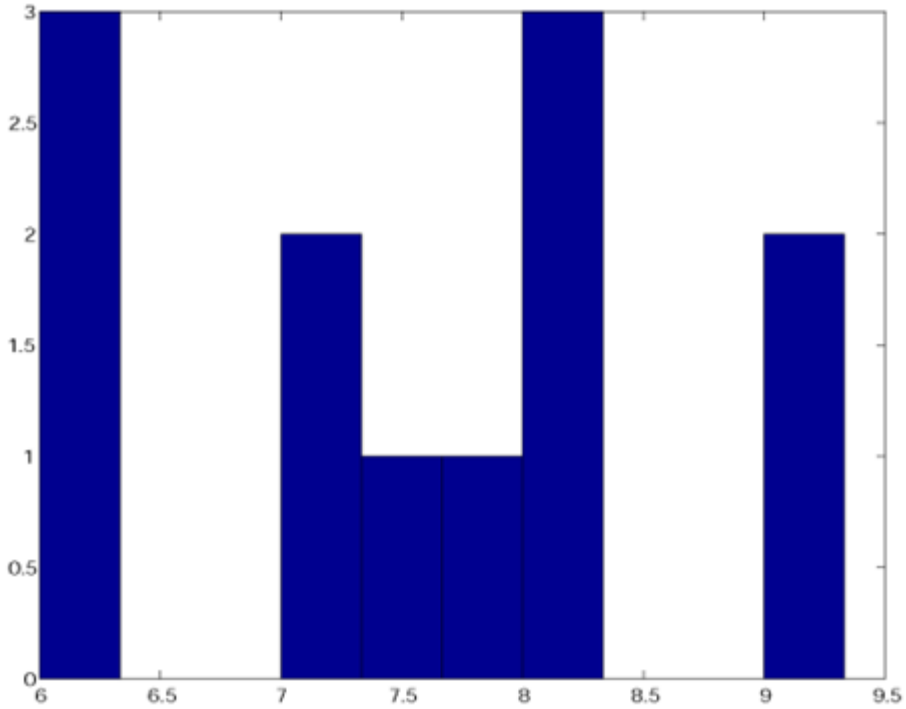
# EQUILIBRIUM POINTS

| | (1) | (2) | (3) |
|---|---|---|---|
| **NASH** | $\frac{a-c}{3b}$ | $\frac{a-c}{b(2+\theta)}$ | $\frac{\alpha-c}{\beta(2-\theta)}$ |
| **WALRAS** | $\frac{a-c}{2b}$ | $\frac{(a-c)}{2b}$ | $\frac{a-c}{3}$ |
| **JPM** | $\frac{a-c}{4b}$ | $\frac{a-c}{b(2+2\theta)}$ | $\frac{a-c}{2}$ |

# CLAIM 1) COMPARISON BETWEEN BRM AND ALTERNATIVE RATIONALITY MODELS (data sources: Holt, F&S)

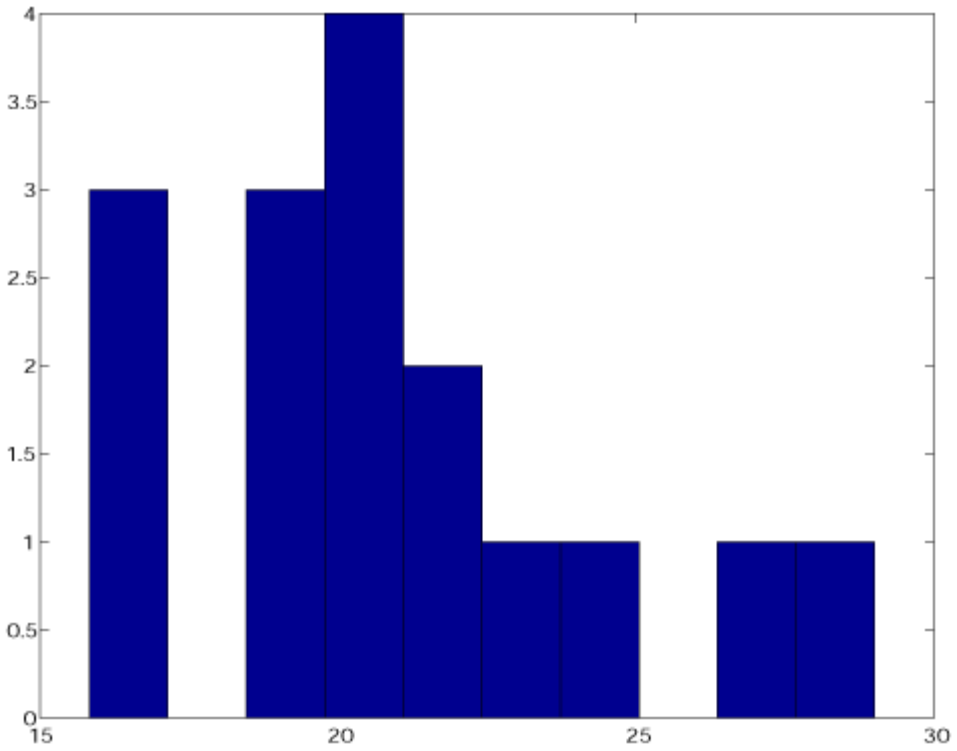
OBSERVED FREQUENCIES IN THE EXPERIMENTS; ENDPOINTS; (1); q=8 NE:

**HOLT:**



# CLAIM 1) COMPARISON BETWEEN BRM AND ALTERNATIVE RATIONALITY MODELS (data sources: Holt, F&S)

F&S – (1) q = 20 NE;



## MAIN RESULTS IN OLIGOPOLY EXPERIMENTS:

## *NASH EQUILIBRIUM IS A ROBUST PREDICTOR OF BEHAVIOUR*

*H1: CAN BOUNDED RATIONALITY MODELS EXPLAIN RESULTS IN EXPERIMENTS?*

PROCEDURE (see Lupi-Sbriglia 2003a):

A) COMPUTE A REPLICATOR DYNAMICS MODEL **(BRM)** FOR HOLT AND F&S EXPERIMENTAL SETTINGS;

B) COMPARE REPLICATOR DYNAMICS WITH ALTERNATIVE MODELS;

**ACCELERATED REPLICATOR DYNAMICS MODEL (1):**

$$x_i(t+1) = x_i(t)\frac{\pi(i,\mathbf{x}(t))^{\alpha}}{\sum_{j\in S} x_j(t)\pi(j,\mathbf{x}(t))^{\alpha}}.$$

# CLAIM 1) COMPARISON BETWEEN BRM AND ALTERNATIVE RATIONALITY MODELS (data sources: Holt, F&S)

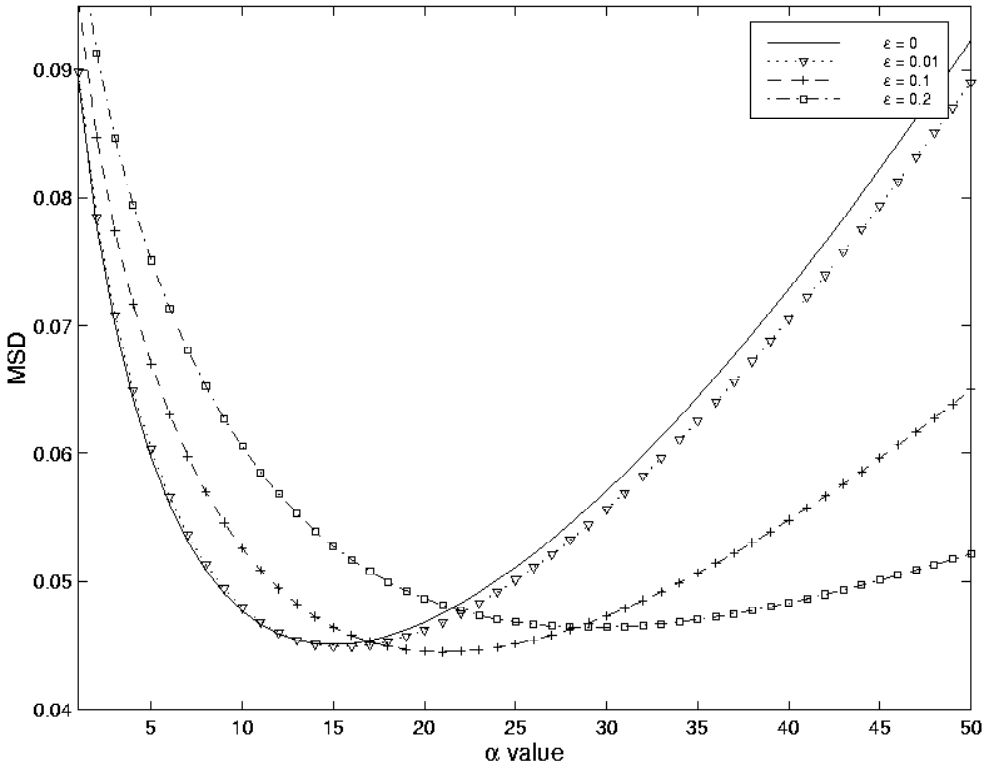
Consider a noisy version of (1) – introduce ***ε***.

ESTIMATES OF BEST *α* PRODUCED MINIMISING DISTANCE BETWEEN EMPIRICAL AND THEORETICAL DISTRIBUTIONS, FOR GIVEN LEVELS OF THE NOISE PARAMETER, ε.

(*MSD measure – see Selten, 1991*). HOLT (*α = 21; ε=0.1*):

$$\sum_{i=1}^{K}\left(x_{it}-\hat{x}_{it}\right)^2$$

# CLAIM 1) COMPARISON BETWEEN BRM AND ALTERNATIVE RATIONALITY MODELS (data sources: Holt, F&S)



# CLAIM 1) COMPARISON BETWEEN BRM AND ALTERNATIVE RATIONALITY MODELS (data sources: Holt, F&S)

TABLE 2 COMPARES REPLICATOR DYNAMICS (BRM) AND ALTERNATIVE RATIONALITY MODELS FOR HOLT AND F&S DATA SETS (MSD MEASURES)

| | **CCE (MSD)** | **NASH (MSD)** | **TACIT COLLUSION (MSD)** | **RD (MSD)** |
|---|---|---|---|---|
| **Holt** | 0.0702 | 0.0263 | 0.0307 | 0.0078 |
| **Fouraker and Siegel** | 0.0453 | 0.0303 | 0.0303 | 0.0030 |

# CLAIM 1) COMPARISON BETWEEN BRM AND ALTERNATIVE RATIONALITY MODELS (data sources: Holt, F&S)

*NB: CCE = CONSISTENT CONJECTURAL EQUILIBRIUM;*

*RESULT 1: IN ABSENCE OF STRATEGIC INFORMATION AS IN OLD EXPERIMENTS*

***THE REPLICATOR DYNAMICS OUTPERFORMS THE NASH MODEL, ALONG WITH ALL ALTERNATIVE RATIONALITY MODELS UNDER TEST IN THE ORIGINAL PAPERS.***

***THEREFORE:***

***DEVIATIONS FROM NASH IN OLIGOPOLY EXPERIMENTS CAN BE BETTER EXPLAINED AS BOUNDED RATIONAL BEHAVIOUR OF AGENTS IN MARKETS***

# CLAIM 2) STRATEGIC INFORMATION SHAPES AGENTS LEARNING BEHAVIOUR AND AFFECTS LONG RUN EFFICIENCY IN MARKETS

## THE MODEL OF DYNAMIC INDIVIDUAL CHOICE:

*BRM → compatible with many rationality dynamic rules (all rules which lead to dynamics that are payoff monotone; see Fudenberg and Levine, 1998).*

*EXPERIMENTAL TESTS ON MARKETS:*

- ***Trial and Error; Stimulus- Response (Lupi, Sbriglia, 2003b; Huck et al. 2004)*** → More Collusion: weak evidence?
- ***Myopic Best Reply.... (Rassenti et al., 2000; Huck et al, 1999, etc.)*** →Nash: more evidence.
- ***Imitation models ("asking around") (Huck et al, 2000; Vriend et al. 2003; Altavilla et al., 2006; Apesteguia et al. 2005, 2007, 2009, etc…)***→overwhelming evidence that efficiency in markets is affected by the *level* and *the type* of strategic information (***social, "observational" learning***).

- *If individuals are boundedly rational, they imitate rather than follow best reply rules.*

# CLAIM 2) STRATEGIC INFORMATION SHAPES AGENTS LEARNING BEHAVIOUR AND AFFECTS LONG RUN EFFICIENCY IN MARKETS

## IMITATION THEORIES

*Schlag, 1998; Vega Redondo, 1997; Palomino et al., 1998; Dixon, 2000, etc.*

*PLENTY OF EXPERIMENTAL TESTS ON IMITATIVE BEHAVIOUR!*

- “Imitate the best”;
- “Imitate the average” (Dixon, Oechssler);
- “Imitate the best performer in the same role in different markets”;
- “Imitate the winner”

# CLAIM 2) STRATEGIC INFORMATION SHAPES AGENTS LEARNING BEHAVIOUR AND AFFECTS LONG RUN EFFICIENCY IN MARKETS

## EXPERIMENTAL TESTS ON “IMITATION” IN MARKETS

(Data source: *Altavilla et al. 2006; Dixon et al. 2006*)

- MARKET MODELS (1), (2) AND (3).
- RANDOM MATCHING;
- INFO DESIGN: A) INFO ON CO-PLAYER CHOICES; B) INFO ON AVERAGE MARKET PROFITABILITY;
- ONE-PERIOD MEMORY;

(1) Control Groups.

# CLAIM 2) STRATEGIC INFORMATION SHAPES AGENTS LEARNING BEHAVIOUR AND AFFECTS LONG RUN EFFICIENCY IN MARKETS

**“IMITATE THE BEST”**

*THEORY: F. VEGA REDONDO, PALOMINO ET AL., etc.*

**THEORETICAL PREDICTIONS:**

*PRICE AND QUANTITIES →WALRAS*

**“IMITATE THE AVERAGE”**

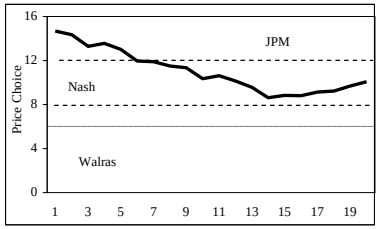
*THEORY: DIXON, 2000; OECHSSLER, 2002;*

**THEORETICAL PREDICTIONS:**

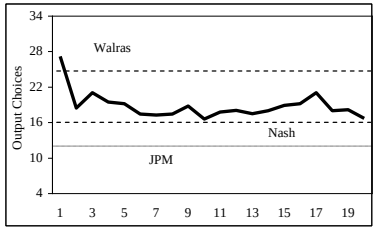
*PRICE AND QUANTITIES →JPM*

# CLAIM 2) STRATEGIC INFORMATION SHAPES AGENTS LEARNING BEHAVIOUR AND AFFECTS LONG RUN EFFICIENCY IN MARKETS

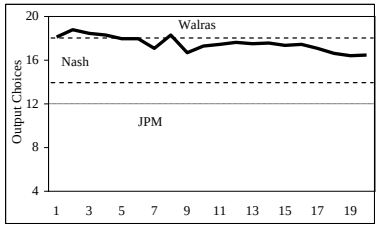
Bertrand Market (D.P.) - ED 1



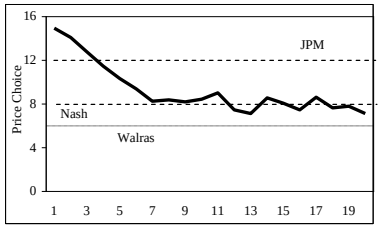

Cournot Market (H.P.) - ED 1



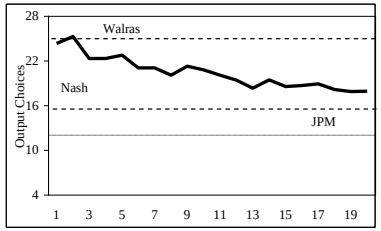

Cournot Market (D.P.) - ED 1



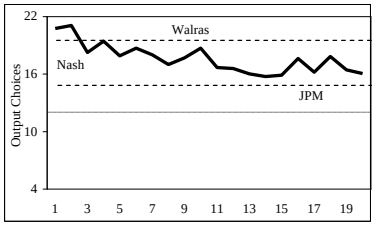

Bertrand Market (D.P.) - ED 2



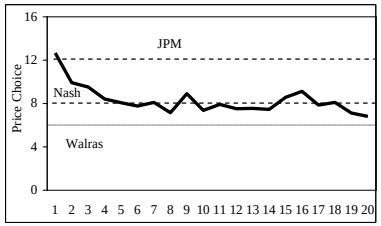

Cournot Market (H.P.) - ED 2



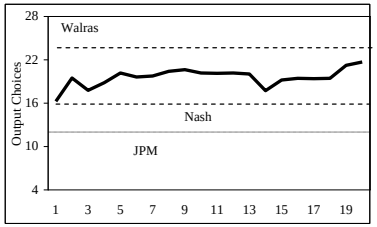

Cournot Market (D.P.) - ED 2



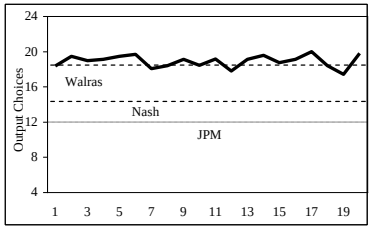

Bertrand Market (D.P.) - ED 3




Cournot Market (H.P.) - ED 3




Cournot Market (D.P.) - ED 3



# CLAIM 2) STRATEGIC INFORMATION SHAPES AGENTS LEARNING BEHAVIOUR AND AFFECTS LONG RUN EFFICIENCY IN MARKETS

MAIN RESULTS:

- INFO ON RIVALS LEAD TO MORE COMPETITION→WALRAS EQUILIBRIUM IN THE LONG RUN (“IMITATE THE BEST”)

- INFO ON AVERAGE TO MORE COLLUSIVE BEHAVIOURS →NOT SO MUCH CLEAR EVIDENCE ON LONG RUN CONVERGENCE TO THE PARETO OUTCOME (“IMITATE THE AVERAGE”).

## CLAIM 2) STRATEGIC INFORMATION SHAPES AGENTS LEARNING BEHAVIOUR AND AFFECTS LONG RUN EFFICIENCY IN MARKETS

*See Dixon et al. 2006 for more evidence of convergence to Collusion in Cournot Markets..*

HOWEVER:

INDIVIDUAL RESPONSE TO STRATEGIC INFO: in Altavilla et al., 2006 Markov switching autoregressive models are estimated in order to assess the relative importance of the different rules. ***The results show that rules such as "imitate the average" are adopted by a larger share of the population compared to the "imitate the best" rules.***

# CONCLUSIONS

THREE QUESTIONS:

A) IS THERE A “UNIQUE” BRM MODEL IN MARKETS ABLE TO EXPLAIN AGENTS’ BEHAVIOUR?

In other words:

Do these various analyses on social learning provide a unified framework to study markets under the BRM?

*See Apesteguia et al. 2007 JET….generalised model of imitative behaviour in markets:*

*(Vega Redondo, Schlag)*

***2 RESULTS**: 1) INDIVIDUAL INCENTIVE TO IMITATE INCREASES IN PAYOFF DIFFERENCES; 2) IT’S THE INFORMATION SETTING THAT MATTERS BEHAVIOURAL RULES ARE COMMON TO ALL TYPES OF IMITATION.*

# CONCLUSIONS

SECOND QUESTION (B):

IS THE BRM MODEL – STEMMING FROM THE EVOLUTIONARY GAME THEORY RESEARCH – “NEW”?

*See Glenn Ellison, 2007 and the early studies in IO and BRM*

*THE IMITATION MODELS (SUPPORTED BY THE EXPERIMENTAL EVIDENCE) FORMALIZE MANY OF THE INITIAL HYPOTHESES OF THE BR LITERATURE (SIMON, ETC.)*

*NASH RATIONALITY IS ONE OF THE EXISTING BEHAVIUOR IN MARKETS – EFFICIENCY IS RELATED TO THE EXISTING INFORMATION SET.*

# CONCLUSIONS

THIRD AND FINAL POINT:

CAN BRM INFLUENCE POLICIES ISSUES?

ANTITRUST REGULATION OF INFO.

***POLICY REGULATIONS TAKE INFORMATION ISSUES MORE SERIOUSLY THAN THEORIES DO (SEE STIGLER).***